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Low Stress Algorithms for Children with Difficulty in Mathematics

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Low Stress Algorithms for Children with Difficulty in Mathematics

BY

Amanda B. Boyer

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF


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Abstract

The purpose of this research was to examine the effectiveness of low-stress algorithms with third and fourth grade students who struggle with mathematics. It is important to study mathematics interventions because math is a neglected area of research (Gersten & Chard, 1999). This research examined the effectiveness of low-stress addition and subtraction instruction for low-achieving students compared to a control group of students receiving traditional instruction in the regular classroom. Additionally, half of the students in the experimental group (low-stress) self-monitored the number of problems they correctly completed. Results indicate that low-stress addition did not result in an increased number of digits correct from baseline. However, low-stress subtraction post-test scores indicate an increase in the number of digits correct, but the increase was similar to the students in the control group. Self-monitoring results indicate a lack of effectiveness when students self-monitored the number of problems correctly completed. Results and future directions are discussed.

Low Stress Algorithms for Children with Difficulty in Mathematics

Since the late 1970's the most noticeable advances in the field of learning disabilities have been in reading interventions and research. Mathematics is a neglected area of special education research, and little advancement has been made in the field of mathematics (Gersen & Chard, 1999). Many students who are labeled with a learning disability have deficits in both reading and math (Fleischner & Manheimer, 1997). Additionally, the poor math performance of American students has fueled the intense debates on math instruction in our schools. Therefore, it is important to identify evidence-based methods of math instruction with documented, proven success for diverse students (Harniss, Stein, & Carnine, 2002). The purpose of this study was to assess the efficacy of low stress algorithms for teaching basic math skills to children with learning problems.

Children with learning problems are usually either diagnosed with a learning disability in a certain area or considered a slow learner. However, there appears to be a marked difference between these two groups, in terms of diagnostic criteria as well as documented services. Children with a learning disability in math, for instance, often have math achievement scores that are significantly lower than their intelligence would predict (Steele, 2002). For instance, their scores on a standardized math achievement test would be significantly lower than their full scale intelligence (IQ) score on a standardized intelligence test; as well as perform at a much lower level on a curriculum-based measurement than a norm-based sample of same aged peers. These children also do poorly in school.

There have been numerous attempts to explain learning disability. A learning disability refers to a particular kind of academic learning problem caused by inherent weaknesses in underlying cognitive processes. These weaknesses may be tied to the neurobiological functioning of the child and not a result of a lack of instruction. However, one complete theory of a learning disability contains three levels (Robinson, Menchetti, & Torgesen, 2002). The first level is the behavioral component of the disability. The learning or performance problem must be carefully described at a specific level. The second level is the identification of the deficient cognitive processes that explain the behavioral aspect of the disorder. The third level must specify the weaknesses of the central nervous system that cause the cognitive processes to improperly work. An additional level considers the cause of the disability (Robinson, Menchetti, & Torgenson, 2002).

Another theory of learning disabilities involves deficits in metacognitive thinking. Borkowski (1992) argues that self-regulation and motivational beliefs associated with strategy use are the major components of the metacognitive theory that are relevant to our understanding of a wide range of learning difficulties. In his theory lie two important assumptions. Every important cognitive act has motivational consequences, and these consequences provide future self-regulatory actions. For example, as students become more strategic and recognize the importance of this ability, they begin to associate success to their skills and ability rather than luck or ease of the task. Over time, children begin to enjoy learning for its own sake and become task-oriented. Additionally, their own actions increase their mental competencies, and they develop theories about the growth of the mind (Borkowski, 1992). The fundamental characteristics of learning

disabilities are (1) psychological processing disorders that present obstacles for some individuals to understanding and interpreting information that they see or hear; (2) difficulty in learning that is not brought on by another primary disability such as mental retardation, behavioral disorders, or sensory impairments; and (3) discrepancy between potential and performance, or underachievement, in at least one academic area (Steele, 2002).

On the other hand, slow learners also do poorly in school, but are not eligible for special education services. These are children with intelligence test scores between 70 and 85. This group makes up 14% of all children nationwide and over 70% of dropouts are slow learners. If a general education teacher cannot provide extra help either because of lack of resources or a personal choice, a slow learner may suffer lifelong consequences (Shaw, 1999).

Students can be classified as low achieving for many reasons. The definition of low achieving is, in fact, very inconsistent. Some researchers feel that it is the sole responsibility for teachers to nominate students based on classroom performance and classify those as low achieving. Yet, others feel that students who do not quite meet the requirements for special education services, but would benefit from some remedial services in a certain subject area, meet the definition of low achieving.

Much of the problem with instruction for slow learners is a split between special education and general education. There is an inaccurate tendency to believe that children in schools are either learning disabled or they are not. The students labeled disabled receive special education services and assistance, whereas the rest of the students are expected to perform successfully without any additional help. Therefore this leaves the

slow learners without the additional educational assistance they typically need (Shaw, 1999).

In a 1996 assessment of the nation's educational progress in mathematics, only 21% of fourth graders performed well enough to be labeled proficient. More astonishing is that this number dropped to 16% for high school seniors (Reese, 1996). Unfortunately a majority of American students are graduating without sufficient proficiency in mathematics, hindering higher education and future job performance (Harniss, Stein, & Carnine, 2002). On the other hand, students who receive the necessary math instruction are three times more likely to attend college and earn more money as a result. These students look forward to going to school, and they believe that success in math is the key to future career successes (NEA Today, 1998).

Unlike reading disorders that have a comprehensive theory regarding process deficits, such as phonological processing weaknesses; math is a neglected field of research, and no theories are as coherent as the reading theories (Robinson, Menchetti, & Torgesen, 2002).

Robinson, et al (2002) developed a theoretical explanation of the difficulties shown by many children in acquiring fluent knowledge of number facts. The two factor theory of math fact learning suggests that difficulties in learning math facts may result from weaknesses in phonological processing or a weakly developed number sense. In terms of phonological processing, the auditory, phonological features associated with the individual numbers and the number facts are weakly encoded and a student who attempts to retrieve a fact from memory has less memory representation from which to draw. Thus, retrieval for a student with this deficit would be much more difficult than for a

student who does not have deficits in phonological processing. In terms of number sense, the weakness in encoding is meaning based rather than phonologically based and therefore, hinders later retrieval. The numbers themselves are less meaningful to the student attempting to memorize the facts. They appear to the student as random, isolated units, rather than interrelated meaningful wholes (Robinson, et al., 2002).

It is possible for a child to have deficits in both phonological processing and number sense. If this is the case, the learning disability would be more severe and difficult to overcome. This particular child's disability would be more profound than one who has a deficit in just one area (Robinson, et al., 2002).

Russell and Ginsburg (1984) investigated the informal and formal mathematical knowledge of children suffering from mathematical difficulties. Their findings suggest that one of the most severe difficulties displayed by children with mathematics difficulties involved knowledge of addition facts. Furthermore, children with mathematics difficulties were not seriously deficient in mathematical concepts and skills. They seem to have elementary concepts of base ten notation, but experience difficulty in related enumeration skills especially when large numbers are involved. Children with mathematics difficulties display calculation errors that often result from common error strategies. Additionally, they can perform simple word problems but have difficulties with more complex word problems (Russell and Ginsburg, 1982).

The National Council of Teachers of Mathematics (NCTM) presented standards for curriculum and evaluation for school mathematics in 1989. The council asserted that the present Kindergarten through fourth grade curriculum is narrow in scope, fails to foster mathematical insight, reasoning, and problem solving and emphasizes rote

activities. Children become passive receivers of rules and procedures rather than active participants in creating knowledge (NCTM, 1989).

The five overall goals presented by the council are (1) learn to value mathematics, (2) become confident in one's own ability, (3) become a mathematical problem solver, (4) learn to communicate mathematics, and (5) learn to reason mathematically. It is important to stress these goals at a young age, because the mathematical ideas children acquire in grades K-4 form the basis for all further study of math. The NCTM also stresses that how well children understand mathematical ideas is far more important than how many skills they acquire. The success children have later greatly depends upon the foundation established the first five years of their schooling (NCTM, 1989).

The NCTM's first standard promotes that mathematics emphasize problem solving so that students can develop and apply strategies to solve a wide variety of problems, verify and interpret results with respect to the original problem, and acquire confidence in using mathematics meaningfully. Other standards promote that students believe that math makes sense and can be used in other curriculum areas and their daily lives. The NCTM also supports the notion that students model, explain, and develop reasonable proficiency with basic facts and algorithms, and that they select and use computation techniques appropriate to specific problems and determine whether or not the results are reasonable (NCTM, 1989).

In order to remediate cognitive and theoretical deficiencies and uphold mathematics standards, schools have attempted various strategies. These are programs different from services for students labeled learning disabled. *Chapter 1* is one such strategy. It was the intention of this program to help disadvantaged students by providing

a less challenging curriculum and limiting achievement goals. These services include curricula that stresses basic skills in reading and mathematics, vocation rather than academic programs, and a slower instructional pace. Unfortunately, this approach decreases the ability of low achieving students to develop thinking skills, lowers their learning expectations, and stigmatizes them as inferior. Chapter 1 typically “pulls out” students to focus on reading and mathematics, and therefore, these students miss classes, such as social studies and science. Improvement scores may be noted in math and reading, but the program fails to monitor overall achievement (Passow, 1990).

A good educational program provides learning opportunities in both cognitive and affective areas. There must be an opportunity for students to learn how to learn and how to be a student. Chapter 1 often focuses on raising students’ achievement scores on standardized tests, but fails to help students learn how to work independently and develop coherent mental representations for school work in general. It is important that low achieving students be taught cognitive strategies such as memory, elaboration, self-questioning, rehearsal, planning and goal setting, comprehension, problem-solving, hypothesis generating and study skills. However, these skills are not a key aspect of Chapter 1 services (Passow, 1990).

Remedial mathematics programs often fail to provide opportunities for cognitive development. These programs fall into three broad categories. First, *enrichment programs* aim at providing low-income students with experiences that middle class students have. Secondly, *differential programs* treat disadvantaged students differently from middle class students and use computers and other aids as management tools, use standardized tests as assessment instruments, or use direct drill methods to teach

arithmetic skills emphasizing correct answers rather than appropriate processes. Third, *developmentally based programs* are focused to the level of the child's conceptual thoughts after his or her cognitive functioning has been determined. The fragmentation of mathematics, such as done in these programs, is not as successful as providing children with an opportunity to learn mathematics by emphasizing the interdependence of ideas and the use of reasonable procedures to arrive at an answer (Passow, 1990).

Another attempt at remediating children's difficulties in school has been through the method of tracking. *Tracking* is the practice of separating students into different courses or course sequences based on their level of achievement or proficiency as measured by some set of tests or course grades. Unfortunately, research has not supported tracking as a successful remediation technique. One outcome of tracking is a widening of the gap between high achievers and low achievers. Furthermore, the tracking tradition in math is also a sorting process with unsettling social consequences (Passow, 1990). Students who planned to attend college performed significantly higher in mathematical achievement than students in general and vocational programs. In fact, the latter group's average scores were barely above the level to successfully understand material introduced in the 7th grade. Additionally, students in the United States who are higher achieving often do not perform at an advanced level as compared to other nations' students. Therefore, students in the United States do not leave schools prepared in mathematics, and the traditional practices used by schools in an attempt to remediate mathematical difficulties are not successful (Passow, 1990).

In order to achieve mathematics goals and standards and for students to achieve a proficient level of mathematics, many students must receive additional assistance in a

regular education setting. There are many instructional interventions developed to aid in this project such as reduced work load, adult tutors, and cover, copy and compare (Rathvon, 1999). Some have solid research support, while others are simply popular techniques with no evidence base. However, it is important that effective interventions are available for students who struggle with learning mathematics.

First, it is important to obtain an understanding of the current, most frequently used interventions for students having difficulty in mathematics. These interventions range from curriculum adjustments to peer assistance. Some have been proven to be effective, while others still need further research. It is important to remember that there is no single approach to math instruction or remediation. It is crucial that teachers have a large repertoire of strategies and techniques to meet the needs of all of their students (Fleishner & Manheimer, 1997).

Providing Students and Teachers with Data and Recommendations

One of the interventions used to increase students' proficiency in mathematics is to provide data or recommendations to teachers and students regarding student performance. The data can be provided by other teachers or personnel. In some cases computers have generated recommendations about what types of problems to work on or how many problems to work on a given topic. In a meta-analysis of research regarding mathematics interventions, Baker, Gersten, and Lee (2002), found that when teachers or students received information on their effort or performance in solving mathematics problems or received recommendations from the teacher or computer regarding the number of problems they should compute in a given time compared to a group that did not receive performance feedback, the effect size was .57, significantly different from

zero. This method proved to be effective for these students in this group (Baker, Gersten, & Lee, 2002).

Another study investigating the effects of computer generated or teacher provided recommendations included two experimental groups and one control group. The two experimental groups took weekly tests on items that reflected state content standards. The students' performance over time was depicted on individualized graphs given to both the teachers and the students. Teachers also received a performance summary of all of the students in the class. In the control group, the teachers created their own techniques to monitor student progress. The difference between the two experimental groups is that in the more complex experimental group, the teachers received computer-generated recommendations regarding what content to teach the class in the upcoming lessons based on class-wide performance (Baker, Gersten, & Lee, 2002).

Results indicate that there was a small effect size when teachers systematically monitored and graphed the progress of their low-achieving students. However, when combined with computer-generated recommendations, the effect size was moderate, .51, and significantly greater than zero. This suggests that just providing the teacher with data regarding student performance may not be sufficient and including specific instructional recommendations may also be necessary in conjunction with the performance data (Baker, Gersten, & Lee, 2002).

Peer-Assisted Learning

Another mathematics intervention with empirical support is peer-assisted learning. Peer-assisted learning enables students to provide each other with feedback and support. There are many reasons for the support of students working with each other to

learn mathematics. When students are working independently on a problem, teachers are not often available to help each individual student. Peers can help to provide the answers or provide suggestions that help students solve the problems themselves. Research also suggests that peer tutors help to increase task persistence (Baker, Gersten, & Lee, 2002).

In one study, peer assisted mathematics interventions led to positive effects on student achievement. The average effect size based on the meta-analysis of six studies was a .62, significantly greater than zero. The effect size was greater on computation rather than general math ability. A safe conclusion is that peer-assisted learning approaches demonstrated a consistent, moderately strong positive effect on the computation abilities of low achievers. However, the advantages of peer-assisted tutoring in other areas of mathematics are unclear (Baker, Gersten, & Lee, 2002).

Class-wide Peer Tutoring

Class-wide peer tutoring (CWPT) applies simultaneous tutoring throughout the entire class. Each week individuals are paired and the assignments are established. Similar to peer-assisted learning both individuals play both roles as tutor and tutee. An interdependent social reward structure is implemented for both individualized and team performance. The goal of CWPT is to maximize academic engaged time in the classroom, promote high levels of mastery, and ensure sufficient content coverage. Results of this research indicate that students achieve at rate commensurate with same-aged peers and maintain this achievement at least two years later (Harniss, Stein, & Carnine, 2002).

strong effect on the mathematics achievement of at-risk students (Baker, Gersten, & Lee, 2002).

Direct instruction (DI) similar to explicit instruction includes organizational structure, systematic teacher preparation, guided and frequent practice with feedback, and a system for monitoring student and teacher performance. DI explicitly teaches not only algorithms for computation, but also generalizable rules and strategies for solving problems. An evaluation of this program yielded positive results. Low income, primary grade students who received DI for the full three to four years outperformed students who were taught using other approaches. However, in a follow up study, only skills that were generalizable, such as problem solving skills were maintained (Harniss, Stein, & Carnine, 2002).

Contextualized teaching emphasizes the use of real-world applications. In a meta-analysis of these studies, some or all of the instruction in the experimental group was contextual. The purpose was to teach students about mathematical thinking, arguing a more vigorous emphasis on concept development would foster a deeper understanding of the material. However, the effect size of the experimental groups in these studies was near zero, not much different from the control groups. Furthermore, students in the contextualized instruction group scored higher on word problems presented in a contextualized format. The findings of the studies involving contextualized mathematics instruction present a complex puzzle of findings, open to multiple interpretations (Baker, Gersten, & Lee, 2002).

Providing Parents with Information Regarding Their Child

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Providing Parents with Information Regarding Their Child

Other studies examined in this meta-analysis investigated the effects of providing parents with information regarding student successes. This intervention is typically used as an add-on to an already existing intervention in the classroom, such as peer-tutoring. It was designed to increase the parents' role as motivator and supporter of students' academic progress and success. It did not produce a statistically significant effect size, but it may be a low-cost intervention with potential (Baker, Gersten, & Lee, 2002).

Missouri Mathematics Effectiveness Project

Another mathematics instructional intervention is the Missouri Mathematics Effectiveness Project. There are five key instructional features to include in this model: daily review, development, seatwork, homework assignment, and special reviews. When teachers were provided with an inservice explaining the implementation of this intervention, most teachers cooperated and implemented this procedure. Research provided evidence that this project was effective in increasing mathematics achievement as measured by both standardized and criterion referenced mathematics tests (Harniss, Stein, & Carnine, 2002).

Self-Management

McDougall and Brady (1998) found that self-management increased math fluency, academic productivity and engagement during independent practice. Additionally, participants' fluency, productivity and engagement continued to increase when components of the full self-management treatment packages were faded. The self-management treatment package included both self-graphing and self-management, such as audio-cued self-monitoring, self-determination of reinforcement, and self-administration of reinforcement. At the end of each math class, the primary observer told

participants how many correct and incorrect digits they had in their work. The participants then graphed the data and determined if their math fluency was increasing. They also determined if they had earned any token points, and if they could exchange points for reinforcers. The primary observer promoted individual accomplishments and reminded the students that they were rewarded based on personal achievement according to the increase of digits correct and the decrease of digits incorrect. The self-management components were slowly faded and were eventually back to baseline (McDougall & Brady, 1998).

The Use of Calculators

The National Council of Teachers of Mathematics (NCTM) has supported a calculator as an intervention tool. The NCTM states that calculators must be accepted at the K-4 level as valuable tools for learning mathematics. The use of calculators enables children to explore number ideas and patterns to have valuable concept developing experiences, focus on the problem solving process, and investigate realistic applications (NCTM, 1989). Students should be taught systematically to use calculators to verify answers after they have estimated a response (Fleischner & Manheimer, 1997).

However, calculators do not replace the need to learn basic facts, to compute mentally, or to do reasonable paper-and-pencil computations (NCTM, 1989). Furthermore, students should be taught and understand algorithms used to calculate mathematical problems for increased accuracy and in the event that a calculator is not available (Fleischner & Manheimer, 1997).

The programs described above are examples of service delivery models used to help students. However, these programs do not seem to systematically teach addition and

subtraction skills. Low stress algorithm is a technique used to teach students specific skills to address difficulties in math. Further, low stress algorithms can be used in addition to or as a part of the other programs.

Low-Stress Algorithms

When determining what intervention to implement, it is important to remember the characteristics of the individuals within the particular group and the requirements of the intervention. Researchers have argued that the human mind has a limited capacity to process information, and if too much energy goes into figuring out what 9 plus 8 equals, then little is left over to understand the additional complexities in multi-digit problems (Gersten & Chard, 1999). Research indicates that using low-stress algorithms has three advantages; a reduction in the time required for mastery, an increase in computational power, and a sharp reduction in the stress that occurs when challenging computations are performed (NCTM, 1976). An algorithm is simply a procedure for solving a problem. Hutchings (1975) indicates that all low-stress algorithms have two distinct mechanical characteristics. The first one is a concise, definable, easily read, supplementary notation that is used to record every step of the problem. The second characteristic is that the student can perform any middle step of the same kind rather than switch from one step to another and then back again (Hutchings, 1975).

Low-stress addition, also known as “scratch-math” (Phillipp, 1996) uses a half-space notation to record each individual step, and the numerals are written one-half the height of the numerals in the problem. The units portion of the sum of two digits is written at the lower right of the bottom digit, and the tens portion is written at the lower left of the bottom digit. The student can recall and record all addition facts and then

perform all necessary regroupings. When performing multicolumn problems, larger spaces should be included between the columns to allow room for the special notation. Students never have to know any addition facts higher than $9+9$, which reduces the cognitive requirements of the task. Furthermore, specific errors can be located easily because each step and procedure is documented (NCTM, 1978). It also allows students to work faster because they do not have to carry numbers mentally, and they do not have to record all the complete partial sums (Randolph & Sherman, 2001).

Low-stress subtraction involves a two-step process. First, a student must record all upward regrouping of places by a half-space “1” placed at the upper left of numerals occupying such places. The second step is to write the regrouped minuend above its subtrahend. This helps to organize and read their work. After these two steps, all subtraction can be completed without interruption (NCTM, 1978; Hutchings, 1975). The focus is on organization and efficiency, and the student looks ahead before getting consumed with details (Randolph & Sherman, 2001). When regrouping with zeros, the zeros can be skipped and then replaced with 9. This also reduces the cognitive requirements especially for students with moderate to severe learning problems. Errors can also be located easily with this technique as well (NCTM, 1978, Hutchings, 1975).

The most urgent need for low-stress addition and subtraction is for students requiring extreme remediation. This can be used as a supplement to conventional algorithms as well as a mechanism in double-checking students' work. When compared to conventional algorithms, low-stress addition and subtraction leads to a great reduction in the demands on memory and imaginary manipulation. Mental work is nearly eliminated with the use of low-stress algorithms (NCTM, 1978). As stated elsewhere,

slow learners are students with a slower processing speed, reduced cognitive ability, and reduced memory capacity and may benefit from this intervention. However, further research must be conducted to support low stress addition and subtraction for students having difficulty in mathematics.

Statement of the Problem

The use of low-stress algorithms is an intervention without empirically based support. This study attempted to provide evidence that the use of low-stress addition and subtraction can improve the computational skills of low-achieving students. It was hypothesized that students who have learning problems in math and who receive additional instruction in low stress addition and subtraction would show a significant increase in their scores from a pre-test to a post-test measure, when compared to students who received traditional classroom instruction (i.e., practice). Studies show that mathematics competency requires many skills, and students who struggle with mathematics appear to lack these skills (Mercer and Mercer, 1998). The independent variable is the type of instruction, and the dependent variable is the increase in scores from pre- to post-test in both addition and subtraction. It was also hypothesized that students who self-monitored accuracy would have a significantly higher increase in scores from pre- to post-test measures compared to students who did not self-monitor. Studies indicate that students who self monitor increase academic productivity, academic accuracy and on-task behavior (Dunlap and Dunlap, 1989; Levendoski and Cartledge, 2000).

Method

Participants

Seventy-one third and fourth-grade students, low achieving and learning disabled, from a Midwestern city, were randomly assigned to two groups, an experimental and a control group. The control group consisted of 94% White students (n=31) and 6% Black students (n=2); and 64 % male and 36% female student (n= 21 and n=12, respectively). The Experimental Group consisted of 79% White students (n=30), 13% Black students (n=5), and 8% Multi-racial students (n=3). Thirty-nine percent were boys (n=15) and 61% were girls (n=23).

Procedure

Permission was obtained from the school principal and participating teachers agreeing to the procedures. Permission included the ability to remove thirty-eight children from various classrooms for a period of twenty minutes a day for two weeks. Parents also gave permission for their children to participate. For a student to participate, a parent had to fill out and sign a consent form (Appendix A) that outlined the procedure and gave background information. Furthermore, parents were given access to speak with the researcher regarding the project at any time during the study.

To assure confidentiality, each participant was given a code number and a list was maintained until the end of the study. Initially each third and fourth grade teacher administered a Curriculum Based Measurement Probe in both multi-digit addition and multi-digit subtraction with regrouping to each student. Students scoring in the bottom 40 percent were asked to participate. Additionally, a class of 11 students, designated as slow-learners, were asked to participate.

Once permission was obtained for the participating students in the Experimental Group, an addition and subtraction pre-test was given to both the Experimental and

Control Group. The Control Group was given the pre-test in the regular education setting with the entire class to determine the current levels of addition and subtraction skills. The same procedure (post-test) was repeated after one week of addition and one week of subtraction intervention to determine if the student had acquired the skills. Two weeks after the post-test, a follow-up test was conducted to determine if the student had retained the skills. The pre-, post-, and follow up test were identical and in the form of a Curriculum Based Measurement (CBM).

Instruments

Curriculum-based measurement (CBM) has been thoroughly studied in reading assessments. However, less is known about its effectiveness in measuring mathematics achievement. Curriculum based measurement of mathematics includes activities where students write answers to standardized computation tasks drawn from the annual general curriculum on tests that vary from two to five minutes. It was developed to address the need for ongoing progress monitoring in mathematics (Thurber, Shinn, & Smolkowski, 2002). For this particular study, time was a difficult factor to control in the regular education setting. Therefore, a modified curriculum based measurement, assessing only digits correct, not digits correct per minute, was utilized.

Curriculum based assessment (CBA) has been proven a reliable and valid instrument (Thurber, Shinn, and Smolkowski, 2002). In terms of content validity, it measures precisely the actual curriculum students are being taught. Criterion validity can be established by comparing the results to norms developed within a district or between average and lower achieving students. CBA can be highly effective in determining which student will pass or fail high stakes testing and predicts school achievement as well.

Additionally, parents, teachers, and other school personnel understand this procedure very well, and it can be repeated over time (Thurber, Shinn, and Smolkowski, 2002).

The curriculum-based probes consisted of six addition and six subtraction problems (Appendix B). Five problems have been suggested as an acceptable minimum number for reliable diagnosis (Brueckner and Elwell, 1932, as cited in Cox, 1975). Fewer than five test items may not give a reliable indication of systematic error performance.

Low stress addition allows the student to recall and record all of the necessary addition facts in an uninterrupted sequence and then perform all of the necessary regroupings. *Low stress subtraction* allows the student to record all of the upward regrouping of places by a half-space “1” placed at the upper left of the numerals occupying such places and writing the regrouped minuend directly above its subtrahend, which helps some children in reading and organizing their work (NCTM, 1978; Hutchings, 1975). The students in this particular study were taught addition using the “scratch-math” method (Phillipp, 1996) and subtraction using Hutching’s description (Hutchings, 1975).

Self-monitoring has been proven to be an effective way to increase the achievement of students. McDougall and Brady (1998) found self-monitoring to increase math fluency and engaged time, match or exceed normative levels of math fluency of peers, and generalize improvements in other areas of mathematics computations.

After the experimental procedures were completed all students, parents, and teachers received a debriefing statement (Appendix C), which gave them the opportunity to ask questions and receive the results of the study.

Design and Analysis

Thirty-seven students were assigned to the addition experimental group and thirty-eight students were assigned to the subtraction experimental group. The addition control group had 33 students, while the subtraction control group included 31 students. The experimental group received two weeks, 10 school days, 20 minutes per day of mathematics instruction. These groups received instruction in low-stress addition for one week and low stress subtraction for the second week (see Appendix D and E). The control group received regular classroom instruction.

Another experimental component was also added to the groups. For the thirty-seven students in the experimental addition group and the thirty-eight students in the experimental subtraction group half were randomly assigned to monitor their accomplishments on a final worksheet given the last 5 minutes of the trial. The number of problems correct were graphed by each individual student on a daily basis to monitor progress.

The addition and subtraction control groups were given traditional instruction in addition and subtraction in the regular education setting from their classroom teacher. Traditional instruction included repetition of facts and practice worksheets in their typical classroom setting, and students did not self-monitor.

It was hypothesized that students who received instruction in low-stress algorithms would perform significantly better than children who received traditional instruction in the regular education classroom setting. Further, those who self-monitored

would perform better than those who did not. The independent variable was the type of instruction, and the dependent variable was the change in the score from the pre- to post-test on the addition and subtraction problems.

Results were analyzed using frequencies, such as differences between the mean scores of the groups.

Results

Addition

Baseline curriculum-based measures indicated that students in the Experimental Group had an average of 25.11 digits correct. The students in the Control Group had a baseline of 23.13 digits correct. After one week of Low-Stress Addition instruction, the Experimental Group's mean decreased to 23.76 digits correct. The Control Group's mean increased to 25.97 digits correct. The Experimental Group was then given a follow-up test and means increased to near baseline levels of 25.57. It appears that most students reverted to the traditional addition method (see Figure 1).

Self-Monitoring

Students in the Addition Experimental Group who self-monitored their daily progress had an average baseline score of 24.53 digits correct which was similar to an average of 24.50 digits correct at post-test evaluation. However, the group that did not self-monitor had a baseline of 25.72 digits correct which decreased to 24.50 at post-test measures (see Figure 3).

Subtraction

Results were more positive for the subtraction group. Students in the Experimental Group had an average baseline score of 20.05 digits correct. After one

week of Low-Stress subtraction instruction, the average number increased to 25.68 digits correct. Follow up tests revealed a regression, but still an increase, over the baseline with a mean of 22.40 digits correct. All students used the Low-Stress method on the follow-up test (see Figure 2).

Students in the Control Group had an average baseline score of 20.57 digits correct. After one week of traditional instruction in the classroom, the average score at post-test increased to 26.17 digits correct (see Figure 2).

Self-Monitoring

Students in the Subtraction Experimental Group who self-monitored had a baseline of 20.74 digits correct and at post-test increased to 26.00 digits correct. However, the Experimental Group that did not self-monitor saw similar improvements. Their baseline was 19.37 digits correct which increased to 25.38 digits correct at post-test measures (see Figure 3).

Discussion

The purpose of this study was to provide evidence that low-stress algorithms can improve the addition and subtraction computation skills of low achieving students. Results show that students in the addition experimental group did not see a significant increase in scores when compared to the control group. Students in the subtraction experimental group did have increased scores, but similar increases occurred for the control group as well. Additionally, self-monitoring did not seem to have a positive effect on scores either. Thus, the hypotheses of the study were not supported.

Many factors may have influenced the outcome of this study. Research indicates that students are often resistant to changing methods they have used for an extended

period of time (Dembo and Seli, 2004). Hattie, Biggs, and Purdie (1996) reported that it is very difficult to change the study skills students have acquired over time, and older students are less willing to change their habits. The students participating in this study had already been introduced to the traditional method of multi-digit addition with regrouping and were required to use that in the classroom. When the addition sessions initially began, it was very difficult to change what they had been taught in the classroom. Many students complained about the new method (low stress algorithms), and some even refused to use the new method at first. However, at post-test all students attempted to use the low stress method. Overall means indicate a drop in scores, and therefore, this method did not successfully improve their skills. Furthermore, follow-up tests indicate an increase back to near baseline. Most students reverted back to the traditional method of multi-digit addition with regrouping. The skills did not generalize. Garner (1990) found that training is situational and that most students will not use strategies in contexts other than the ones in which they were taught. This may explain why, at follow-up, the students used the conventional method previously taught in the classroom. Therefore, although it seemed as though low-stress addition had lowered the students' addition skills, most reverted back to their old method and were once again at baseline.

Because of logistics, the students in the Low-Stress Addition Experimental group were essentially only given 100 minutes of instruction and practice. This may not have been a sufficient amount of time to learn the new method. Mercer and Mercer (1998) point out that students with a learning disability or considered slow-learners learn at very individual rates. Some students pick up new concepts much quicker than other students.

However, students classified as slow-learners often take much more time understanding, grasping, and applying new information and techniques. The population in this study, the bottom 40% of the third and fourth grade students, included learning disabled, slow-learners, and some regular education students with difficulties in math. The pace at which the low-stress addition was taught, 20 minutes per day, 5 school days, may not have been sufficient for some of those students.

Additionally, the time provided in this study may not have been sufficient in changing the addition habits already previously established. Dembo and Seli (2004), when discussing why students do not change, indicate that students may not have had enough time to practice the new strategy. Therefore, the students in the Addition Experimental group may not have had sufficient time to become comfortable with the new strategy and, ultimately, use it proficiently.

The Subtraction Experimental Group had more positive results. The students seemed to be less resistant to change their methods. Some students already used a similar technique where all the upward regroupings were done ahead of time, first, and then the subtraction was performed. Although improvements were noted for the experimental group, the students in the Control Group made similar gains.

Analysis of individual students' scores showed that there was a particular population of students who made a ten point or more jump of digits correct from baseline to post-test. The majority of these students had consistent math grades that were Cs over time. Furthermore, record review showed that on the Cognitive Abilities Test the majority of the students had scores in the low 30s out of 48. In fact, a third of these students were in a classroom specifically for students who had been classified as slow-

learners, which may suggest or indicate that low stress algorithms may benefit students considered slow-learners. Additionally, one particular student with a diagnosed math learning disability made a jump of 20 digits correct. At follow up, the same student had lost 15 digits correct. A recommendation was made to the regular education and LD resource teacher to continue using the low-stress method for subtraction for this particular student. This may have some implication for students labeled LD in math.

Another component of the study investigated the use of self-monitoring. In this particular study, students self-monitored the number of correct answers. Results indicate that self-monitoring did not increase the number of problems they answered correctly. Research on self-monitoring indicates that self-monitoring is often effective in increasing the number of problems completed and increased attention (Levandoski and Cartledge, 2000; Wood, Murdock, and Cronin, 2002; Mathes and Bender, 1997). However, less is known about the effect on accuracy of the problems completed (Levandoski and Cartledge, 2000). Research also indicates that self-monitoring improves the completion of or attention to the tasks with which students are already familiar (Reid, 1996). When asked to self-monitor on concepts that are new, self-monitoring did not show positive results. Furthermore, if there is no increase in skills, self-monitoring will not work (Reid, 1996). For the students in the Addition Experimental Group, there were no increases in skills which might have decreased the likelihood that self-monitoring would increase scores as well.

Dunlap and Dunlap (1989) found that students with a learning disability had success with subtraction problems when they self-monitored the steps necessary to successfully complete multi-digit subtraction problems with regrouping. Although the

results were varied, post-test scores were consistently higher than pre or baseline scores. Self-monitoring checklists helped the students respond correctly and remember the necessary steps needed to successfully complete the subtraction problems (Dunlap & Dunlap, 1989; Brown & Frank, 1990).

Wood, Murdock and Cronin (2002) suggested that for at-risk middle school students self-monitoring improved on-task behaviors, but less is known about the impact on academic performance, specifically grades. Their results indicate academic performance (grades and behavior) improved once they began to self-monitor. However, the amount of improvement differed for each of the four students in the study. They concluded that further research should investigate the impact of self-monitoring on grades (Wood, Murdock, and Cronin, 2002).

Research on low-stress algorithms is very limited. Although the results of the study do not indicate positive results, it is important to keep in mind that it may be successful on an individual basis. Hutchings (1975) states that low stress algorithms are effective with different types of learners. Students who do well with traditional methods may enjoy the low-stress method as a new challenge and use it in varied situations based on need (Hutchings, 1975). Mercer and Mercer (1998) state that students with a learning disability or considered slow-learners often have very individual styles and paces of learning. Therefore, using the low-stress techniques on an individual basis may prove more successful. It may be more beneficial to implement the low-stress method on an individual basis with students already receiving special help or with students struggling to learn multi-digit addition and subtraction in the traditional method, as well as slow learners and students with a learning disability in math.

Future studies may want to implement the intervention for a longer period of time, such as two weeks. The students may benefit from increased exposure to the technique and may be more willing to change their habits. It may be interesting to investigate the amount of time it would take for different groups of students (i.e., slow learners and students with a learning disability in math) to become proficient in the low-stress methods.

Low-stress algorithms may be useful for younger students, specifically first and second grade, who are just beginning to learn multi-digit addition and subtraction. This technique could be taught by the regular classroom teacher along with or in place of the traditional method. Students can acquire and master the skills early in their academic careers.

Further studies may also want to investigate the effects of self-monitoring on accuracy when students monitor the individual steps they must take to successfully complete a problem. Specifically, when using low stress algorithms, monitoring the individual steps necessary for success may increase accuracy by providing a reminder and increase the likelihood of correctly using the method.

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Figure 1. Average digits correct for addition intervention.

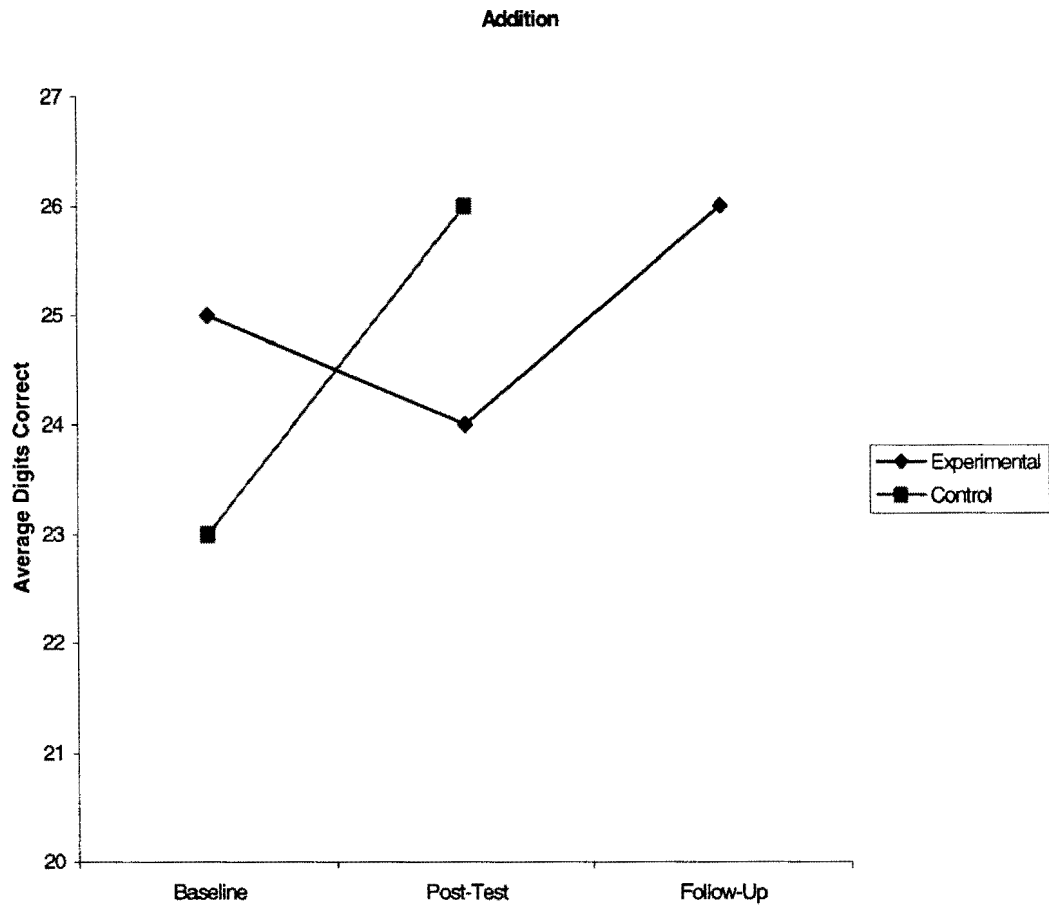


Figure 2. Average digits correct for subtraction intervention.

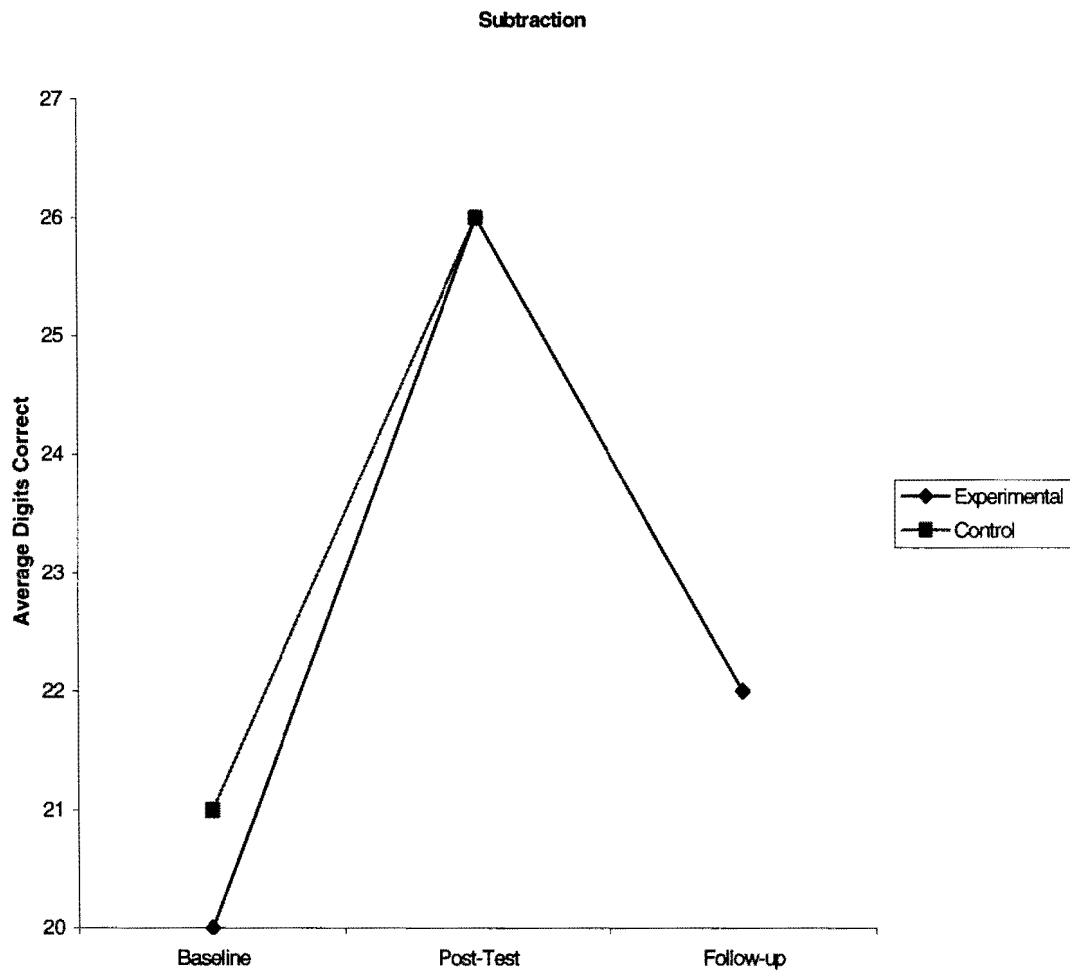
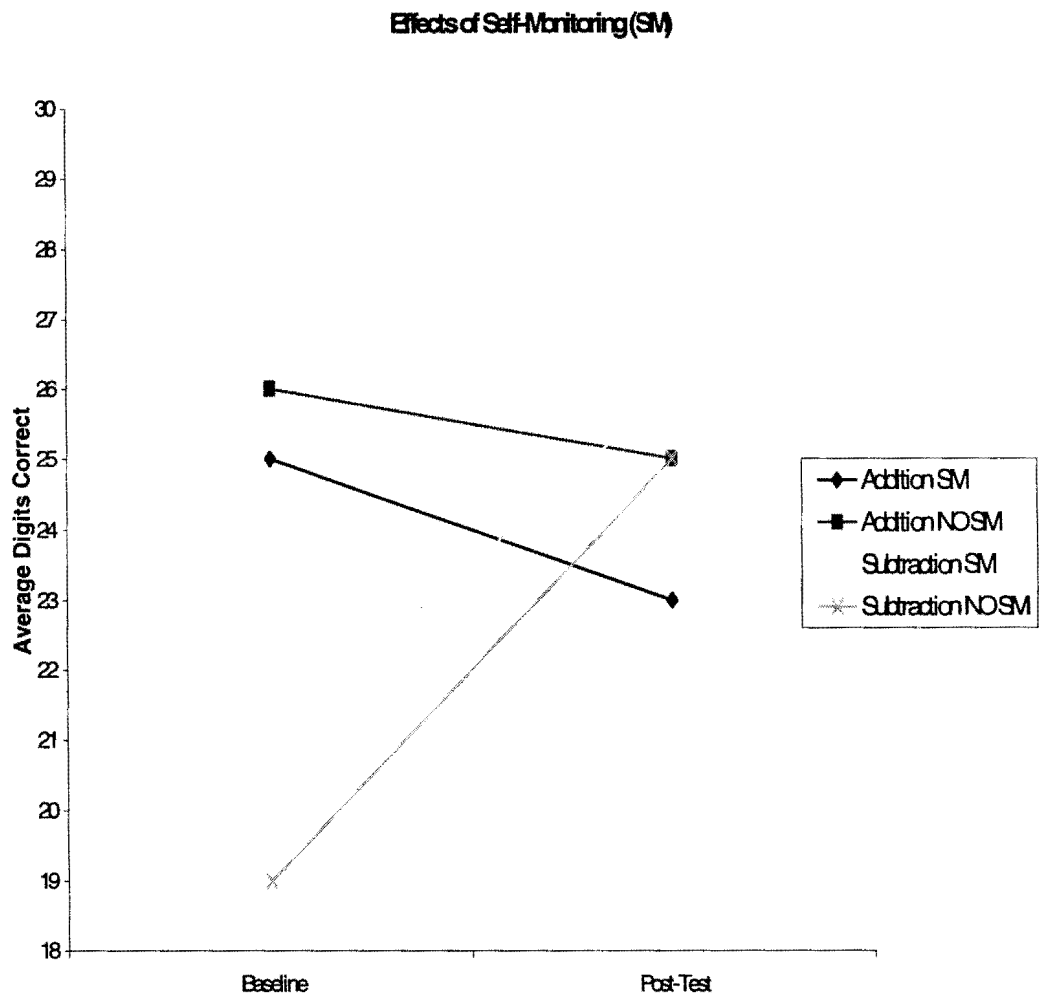


Figure 3. Average digits correct for self-monitoring intervention.



Appendix A

Information Summary and Informed Consent

Project Title: Low Stress Math

Investigator: Amanda Boyer

I, _____ hereby certify that I have been informed by Amanda Boyer either formally or in writing, or both, about the research on Low Stress Math. If I decide for my child to participate, he or she will be asked to commit 20 minutes a day for two weeks to learn addition and subtraction skills. The sessions will be conducted by the researcher on school premises, outside of the regular classroom.

I understand that all information about my child is confidential and no identifying information about my child will be used.

I understand that participation is voluntary, and if I choose to withdraw my child from the study or my child decides not to participate, we can do so, without any penalties.

I understand that I have the right to ask questions at any time and that I should contact Amanda Boyer (217-444-3208) or Dr. Assege HaileMariam (217-581-6615) for answers about the research.

I attest that I have read and understand the above, and freely consent to participate and have my child take part in the research project.

Child's Name

Parent's Signature

Date

Appendix B

Addition Examples

$$\begin{array}{r}
 194 \\
 7743791 \\
 +187966 \\
 \hline
 1876
 \end{array}$$

$$\begin{array}{r}
 46904 \\
 1847609 \\
 +19396143 \\
 \hline
 2363
 \end{array}$$

$$\begin{array}{r}
 24904 \\
 378860 \\
 +19697868 \\
 \hline
 1678
 \end{array}$$

$$\begin{array}{r}
 469919 \\
 17984217 \\
 1419782996 \\
 +1297327 \\
 \hline
 1277
 \end{array}$$

$$\begin{array}{r}
 677808 \\
 14183869 \\
 234289598 \\
 +3682089 \\
 \hline
 1609
 \end{array}$$

$$\begin{array}{r}
 180954 \\
 11878718 \\
 23859759 \\
 +25630754 \\
 \hline
 1504
 \end{array}$$

Subtraction Examples

$$\begin{array}{r}
 93 \\
 9^{1}2^{1}2 \\
 -73 \\
 \hline
 29
 \end{array}$$

$$\begin{array}{r}
 477 \\
 4^{1}6^{1}5^{1}7 \\
 -59 \\
 \hline
 488
 \end{array}$$

$$\begin{array}{r}
 723 \\
 6^{1}2^{1}2^{1}4 \\
 -346 \\
 \hline
 348
 \end{array}$$

$$\begin{array}{r}
 579 \\
 5^{1}7^{1}7^{1}6 \\
 -137 \\
 \hline
 588
 \end{array}$$

$$\begin{array}{r}
 257 \\
 25^{1}6^{1}2 \\
 -437 \\
 \hline
 248
 \end{array}$$

$$\begin{array}{r}
 673 \\
 6^{1}7^{1}2^{1}1 \\
 -287 \\
 \hline
 495
 \end{array}$$

Appendix C

Debriefing Statement

The purpose of this study was to examine the usefulness of low stress math in teaching children basic math skills. Your children were taught math in two different ways, and we will try to determine which strategy was more effective.

Thank you for allowing your child to participate. You have contributed to our knowledge of how to teach basic math. If you should have any questions about this study or you would like to receive a summary of the results, please feel free to contact Amanda Boyer at 217-444-3208.

Sincerely,

Amanda Boyer
School Psychology

Appendix D

ADDITION

	Low Stress Algorithms	Traditional Mathematics
With Implementation of Self-Monitoring		
Without Implementation of Self-Monitoring		

SUBTRACTION

	Low Stress Algorithms	Traditional Mathematics
With Implementation of Self-Monitoring		
Without Implementation of Self-Monitoring		

Appendix E**Experimental Procedure
Addition: Week 1**

Day 1	Group 1	Self-Monitoring	Group 2
Low Stress	9:20-9:40	9:40-9:50	10:00-10:20

Day 2	Group 2	Group 1	Self-Monitoring
Low Stress	1:35-1:55	2:05-2:25	2:25-2:35

Day 3	Group 1	Self-Monitoring	Group 2
Low Stress	9:40-10:00	10:00-10:10	10:20-10:40

Day 4	Group 2	Group 1	Self-Monitoring
Low Stress	9:20-9:40	9:50-10:10	10:10-10:20

Day 5	Group 1	Self-Monitoring	Group 2
Low Stress	9:20-9:40	9:40-9:50	10:00-10:20

Subtraction: Week 2

Day 1	Group 2	Self-Monitoring	Group 1
Low Stress	9:20-9:40	9:40-9:50	10:00-10:20

Day 2	Group 1	Group 2	Self-Monitoring
Low Stress	1:35-1:55	2:05-2:25	2:25-2:35

Day 3	Group 2	Self-Monitoring	Group 1
Low Stress	9:40-10:00	10:00-10:10	10:20-10:40

Day 4	Group 1	Group 2	Self-Monitoring
Low Stress	9:20-9:40	9:50-10:10	10:10-10:20

Day 5	Group 2	Self-Monitoring	Group 1
Low Stress	9:20-9:40	9:40-9:50	10:00-10:20