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An Evaluation of the Effects of Session Distribution on the Acquisition, Retention, and Endurance of Material Learned Using Precision Teaching

Elizabeth G. Hasbrouck

University of South Florida, ergarnett@gmail.com

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An Evaluation of the Effects of Session Distribution on the Acquisition, Retention, and Endurance of Material Learned Using Precision Teaching

by

Elizabeth G. Hasbrouck

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts
Department of Child and Family Studies
College of Behavioral and Community Sciences
University of South Florida

Major Professor: Timothy M. Weil, Ph. D., BCBA
Raymond G. Miltenberger, Ph. D., BCBA
Kimberly A. Crosland, Ph. D., BCBA

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Keywords: Fluency, REAPS, Education, Standard Celeration Chart

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# TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................................................ iv

LIST OF FIGURES ........................................................................................................................................ vi

ABSTRACT .................................................................................................................................................... vii

CHAPTER ONE: INTRODUCTION ........................................................................................................... 1
  REAPS-Retention Endurance Application Performance Standards .................................................. 2
  Precision Teaching in Education ........................................................................................................... 5

CHAPTER TWO: PURPOSE .......................................................................................................................... 11

CHAPTER THREE: METHOD ...................................................................................................................... 12
  Participants and Setting ........................................................................................................................ 12
  Materials ............................................................................................................................................. 13
  Experimental Design .......................................................................................................................... 13
  Dependent Variable and Data Collection ............................................................................................. 14
    Dependent variable ........................................................................................................................... 14
    Data collection ................................................................................................................................... 14
  Interobserver Agreement ..................................................................................................................... 14
  Procedure ............................................................................................................................................. 15
    Inclusion assessment ......................................................................................................................... 15
    Baseline ........................................................................................................................................... 16
    Pre-training .................................................................................................................................... 17
    Precision teaching .............................................................................................................................. 17
      Percentile Schedules ....................................................................................................................... 18
    Endurance Probes ............................................................................................................................. 20
    Retention Probes ............................................................................................................................... 20

CHAPTER FOUR: RESULTS ....................................................................................................................... 21
  Participant 1 (JR) ................................................................................................................................... 21
    Total Timings to Mastery ................................................................................................................... 21
    1 Day Per Week ............................................................................................................................... 22
      Correct responses ............................................................................................................................ 22
      Incorrect responses ......................................................................................................................... 22
      Retention ...................................................................................................................................... 22
      Endurance ................................................................................................................................... 23
    5 Day Per Week ............................................................................................................................... 23
      Correct responses ............................................................................................................................ 23
<table>
<thead>
<tr>
<th>Participant</th>
<th>Total Timings to Mastery</th>
<th>Endurance</th>
<th>Retention</th>
<th>Incorrect responses</th>
<th>Correct responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 2 (CK)</td>
<td>1 Day Per Week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
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<td></td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>Participant 3 (JM)</td>
<td>1 Day Per Week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
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<td>3</td>
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<td></td>
<td></td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Participant 4 (CF)</td>
<td>1 Day Per Week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td>36</td>
<td>36</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Participant 5 (WN)</td>
<td>1 Day Per Week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>38</td>
<td>38</td>
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<td></td>
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<td>39</td>
<td>39</td>
<td>39</td>
<td>39</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>JR Total Timings to Mastery</td>
<td>21</td>
</tr>
<tr>
<td>Table 2</td>
<td>JR Results Summary One Day Per Week</td>
<td>22</td>
</tr>
<tr>
<td>Table 3</td>
<td>JR Results Summary Five Days Per Week</td>
<td>24</td>
</tr>
<tr>
<td>Table 4</td>
<td>JR Results Comparison</td>
<td>25</td>
</tr>
<tr>
<td>Table 5</td>
<td>CK Total Timings to Mastery</td>
<td>26</td>
</tr>
<tr>
<td>Table 6</td>
<td>CK Results Summary One Day Per Week</td>
<td>26</td>
</tr>
<tr>
<td>Table 7</td>
<td>CK Results Summary Five Days Per Week</td>
<td>28</td>
</tr>
<tr>
<td>Table 8</td>
<td>CK Results Comparison</td>
<td>29</td>
</tr>
<tr>
<td>Table 9</td>
<td>JM Total Timings to Mastery</td>
<td>30</td>
</tr>
<tr>
<td>Table 10</td>
<td>JM Results Summary One Day Per Week</td>
<td>31</td>
</tr>
<tr>
<td>Table 11</td>
<td>JM Results Summary Five Days Per Week</td>
<td>32</td>
</tr>
<tr>
<td>Table 12</td>
<td>JM Results Comparison</td>
<td>34</td>
</tr>
<tr>
<td>Table 13</td>
<td>CF Total Timings to Mastery</td>
<td>34</td>
</tr>
<tr>
<td>Table 14</td>
<td>CF Results Summary One Day Per Week</td>
<td>36</td>
</tr>
<tr>
<td>Table 15</td>
<td>CF Results Summary Five Days Per Week</td>
<td>37</td>
</tr>
<tr>
<td>Table 16</td>
<td>CF Results Comparison</td>
<td>38</td>
</tr>
<tr>
<td>Table 17</td>
<td>WN Total Timings to Mastery</td>
<td>38</td>
</tr>
<tr>
<td>Table 18</td>
<td>WN Results Summary One Day Per Week</td>
<td>39</td>
</tr>
<tr>
<td>Table 19</td>
<td>WN Results Summary Five Days Per Week</td>
<td>42</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1: JR One Day Per Week SCC .................................................................................. 23
Figure 2: JR Five Per Week SCC ...................................................................................... 25
Figure 3: CK One Day Per Week SCC ............................................................................... 27
Figure 4: CK Five Per Week SCC ..................................................................................... 29
Figure 5: JM One Day Per Week SCC ............................................................................... 31
Figure 6: JM Five Per Week SCC ..................................................................................... 33
Figure 7: CF One Day Per Week SCC ............................................................................... 35
Figure 8: CF Five Per Week SCC ..................................................................................... 37
Figure 9: WN One Day Per Week SCC ............................................................................... 40
Figure 10: WN Five Per Week SCC ................................................................................... 41
ABSTRACT

Precision Teaching (PT) is a data-based educational tool that allows individual changes to be made to educational programs based specifically on the needs of the learner. The purpose of this study was to evaluate the effect of session distribution on the material learned in the context of a PT intervention program. Typical children, ages 3- to 5-years-old, whom were enrolled in a church-based child development program, participated. The goal of this study was to assess if the administration of PT sessions one day-a-week or five days-a-week effected the acquisition, retention, and endurance of material learned. Results indicate that there was minimal difference in the rate of acquisition, retention, and endurance on the material learned between session distributions for four of the five children.

Keywords: Fluency, REAPS, Education, Standard Celeration Chart
CHAPTER ONE:
INTRODUCTION

According to the United States Department of Education (Kutner, Greenberg, Jin, Boyle, Hsu, & Dunleavy, 2007), 14.5% of Americans over the age of 16 are unable to read or understand information presented in the English language. However, this deficit is not due to barriers of verbal expression and understanding of the language, rather, their lack of ability to read. In *The Precision Teaching Book*, Kubina and Yurich (2012) state that if the recent trends in educational achievement continue, the United States will produce individuals that are “ill-prepared for the job market and ill-suited for full participation in a technologically based and information laden society” (p.2). Many improvements have been suggested as solutions to the downfall of the education system, such as merit-based pay and enhanced supervision for teachers, school choice and overhauling of the current curricula. However, these suggested solutions are not looking at the basis of the problem: the academic proficiency of the students.

To identify the proficiency or lack thereof, Precision Teaching, which is a measurement and decision making tool, can be used to measure and guide decision making based on the performance of the student. Precision Teaching (PT) is identified as a precise and systematic method for measuring, monitoring, and analyzing behavior on a standardized chart. PT is not a specific educational program, rather it is a tool used to make current educational programs more effective. Strategies need to be changed when the abilities of the student change; thus PT allows
for immediate, data-based decisions to be made based on the individual performance of the learner. Kubina and Yurich (2012) state that PT can be applied to any curricula resulting in improved performance on directly trained and related skill sets. The foundation of PT is “basing educational decisions on changes in continuous self-monitored performance frequencies [frequency of responding] displayed on ‘standard celeration charts’” (Lindsley, 1992, p.51).

PT consists of building frequency (i.e., count per min) to levels that allow the learner to produce accurate and effortless responding (Kubina & Morrison, 2000; West, Young, & Spooner, 1990). Said another way, fluency is defined as speed plus accuracy in responding, and it focuses on building component skills that provide the foundation for the student to move through the learning process from a skill’s component behaviors to the composite behavior (Milyko, Berens, & Ghezzi, 2013). Fluency in component skills allows more time to be spent on complex reasoning skills and less time on component responses of a behavior. With fluent component and composite skills, the student is now able to apply these behaviors to new material, as well as apply this knowledge to new situations where the students encounter the same material. Other benefits of a fluent repertoire are maintenance and endurance when the response requirements are increased.

**REAPS-Retention Endurance Application Performance Standards**

In addition to educational gains, PT learners may see three potential advantages of performing fluently. The first benefit is the possible increased skill retention following extended periods where the behavior is not performed. Retention, otherwise referred to as maintenance, is of crucial importance in the continuation of educational curricula. A second benefit involves endurance of the behavior over time. That is, when the response requirement is increased over training conditions, if fluent, the behavior should occur at similar rates at these longer intervals.
Building endurance may also enhance student performance by decreasing distractibility. The third benefit involves application of the skill set to other composite/component responses. This generalization effect may result in a concomitant increase in the likelihood of learners continuing to excel in and pursue advanced coursework during their secondary or post secondary education (Binder, 2003).

Support for these performance standards is exemplified through a three-part study conducted by Berens, Boyce, Berens, and Kenzer (2003) which examined the relationship between response frequency and REAPS. For all three parts of this study, participants were given an introduction to the skill followed by frequency building at time intervals of 15-s, 30-s, or 1-min timings. Participants were given verbal praise during the timing for correct responses and corrective feedback for incorrect responses following the timing. Correction trials were used to ensure mastery of this skill. Upon meeting response requirements, the participants earned verbal, tangible, or edible rewards.

The first phase of this study focused on retention. The participants were five students enrolled in the Center for Advanced Learning and the target behavior was see/say math facts. The authors analyzed the amount of material retained after a one-month break from practice following performance at pre-defined fluent levels (aim). The aim was set at 65 responses per min. To test for retention, “retention probes were conducted on mastered and non-mastered skills” (Berens et al., 2003, p. 24). The results of the retention probes indicated that there was a “positive relation between median training frequencies and the proportion of previous performance retained after a 1-month period without practice” (Berens et al., 2003, p. 25). The study results suggests that after one month, students whose data reached the fluency aim had better retention over time than the non-mastered skills.
The second phase of this study examined the endurance of participants' performance in the PT experimental group. This study consisted of the students orally reading Arabic numbers with an aim set at 100 responses per min. The endurance probes were conducted following reaching mastery (aim). It is important to note that, whereas training occurred during 1-min timings, the endurance probes were extended to 5 min. The results of this study show “a positive relation between median training frequencies and frequency of responding during a 5-min probe session” (Berens et al., 2003, p. 28). The authors suggest that it is not the total number of times the behavior is practiced, but the frequency at which they are responding during the practice timings that effects endurance.

The third phase of this study evaluated application. The authors examined if the students would be able to move to a more difficult level (component skill) of a skill and reach the aim more rapidly once component skills were learned at the optimal aim range. The participants orally identified place values for a series of numbers that were presented on a sheet. Application probes were administered when the aim of 90 responses per min was reached. The application probe was conducted on the next level of the skill to identify if the mastered behavior from the previous skill generalized to the new composite skill. The results of this study suggest that “as participants achieved fluency at the various milestones on skills targeted during training, their performance on higher-level, untargeted skills also increased” (Berens et al., 2003, p. 30).

Research and case studies involving PT that are produced in academic settings have shown repeatedly that there are advantages to teaching skills to fluency. Due to these findings, there are a number of private schools and charter schools that have been built to incorporate fluency as a primary teaching method. One such school, Morningside Academy, was developed as a learning center focused on tutoring students on a weekly basis in areas such as
“psychoeducational and vocational assessment, training for human service personnel, teaching time management and study skills to college learners and improving the academic skills of children and adults” (Johnson & Layng, 1994). Morningside began as a tutoring center then developed into a school dedicated to the implementation of PT as its main academic tool. Unfortunately, there are few well-controlled studies in PT, the field opting instead to produce a strong basis of case studies across a myriad of skill sets. This inductive approach has built developmental profiles of component/composite skill sets trained through various learning channels (see-say; see-write; hear-say; etc). What follows are provided as further exemplars of research in the area of PT and educational interventions.

**Precision Teaching in Education**

Stemming from the success of Precision Teaching at Morningside Academy, a pilot test of the Morningside model was implemented at Malcolm X College in Chicago (Johnson & Layng, 1992). The pilot consisted of a training program for tutors in the Academic Support Center and a summer program to prepare students for college. Classes were Monday through Thursday for 3 hours a day for 6 weeks. As a result of the summer program the students achieved dramatic grade level gains as well as “exceeded the state PCI goal of a 2.5/4.0 GPA and achieved some of the highest within and semester-to-semester retention rates in the college” (Johnson & Layng, 1994). However, as is common of the PT literature, procedure and detailed results sections are usually found wanting. Of considerable interest herein is the implementation of daily timings at Malcolm X College. It is not clear what effects would be observed had the implementers stacked all timings on a single day during the week.

As mentioned earlier, it appears the addition of PT to current school curricula is beneficial in increasing scores in varying academic areas; two particular areas of interest are
reading fluency and comprehension. Kubina, Commons, and Heckard (2009) conducted a study combining PT and Direct Instruction (DI) in a public school to target reading mastery. The participants of this study were 203 elementary school age students from five elementary schools who were attending a summer school program. The students included in this study were ranked at or below the 25th percentile on their state standardized assessment. PT and direct instruction were implemented during a 6 week intervention program that was run 4 days a week during summer school.

The reading/assessment materials were prepared from Reading Mastery Rainbow Edition (Engleman & Bruner, 1995). The study utilized pre- and post-test scores as the measure of evaluation for reading mastery using the Woodcock Reading Mastery Test-Revised-NU in a pre-experimental, one-group pre-test/post-test design. Additionally letter sound fluency, orally decoding words fluency, and oral read were informally measured intermittently throughout the study. By “informally” the authors mean that the assessments were conducted in the context of the learning environment—however, these assessments were the daily data collected on speed and accuracy across three areas: letter sounds fluency, oral decoding of words fluency, and reading fluency. Behavior analytically, we would consider these probes to be formal assessments of behavior given appropriate reliability measures (which were found to be lacking in this study).

Each classroom had a teacher trained in teaching Reading Mastery, PT and an assistant teacher. Students practiced the informal targets in student pairs, and the level of their worksheets corresponded to their current Reading Mastery level. Letter sounds were practiced daily using a letter sound worksheet. The oral decoding of words was practiced by sounding out the words and saying them quickly. Passage fluency used passages previously read in their Reading Mastery.
All timings lasted for 20 s to 1 min and timings began and ended when the teacher indicated. The students recorded their correct and incorrect responding and graphed it on the SCC.

The results for this study indicate that over the 6 week summer program the celeration (acquisition rate) increased; however, the authors did not report on the actual celeration values. Further, the authors suggest performance on the standardized measures significantly increased and that there were statistically significant improvements from pre- to post-test performance in the primary measure of the study (Woodcock Reading Mastery Test-revised). Kubina, et al. (2009) found that the results had a less than .05% chance of being the result of random effects and such were shown to be the effect of the procedure implemented. It can be suggested from this study that the combination of PT and DI may improve the reading deficits seen in children who score poorly on standardized tests. However, this study has limitations due to the pre-/post-test measures in that it does not allow for individual analysis of the behavior. It would have been beneficial if the researchers presented data showing skill acquisition. This would have allowed for additional analyses with respect to level, trend, and variability of the data. Additionally, IOA and treatment integrity data were not presented for this study. These data are necessary to ensure the study results are valid and reliable.

In a study conducted by Ascah (2009), PT and DI were implemented for a 5-year-old kindergarten student on an average of 5 days per week across 8 weeks. Data was collected on letter sounds. Specifically, the learner was exposed to instruction and practice involving see/say blending and segmenting as well as see/say letter sounds. Letter sounds were practiced two times each day in 10-s timing intervals using a worksheet with letters printed on it. An error correction procedure was used for incorrect responses. Additionally, reinforcement was provided contingent on following directions (stickers). This study showed a X1.8 celeration for correct letter sounds.
and reported a decreasing celeration for incorrect responding but did not provide a celeration value. To reach aim of 100 see/say real words per min, she needed 8 weeks of instruction and 7 weeks of practice trials. The author suggests that the combination of PT and DI was highly effective for the participant. These results were similar to those observed in Kubina, et al. (2009). As mentioned from the previous study, this study did not present data on IOA or treatment integrity and as such, it is difficult to ascertain the effects of intervention versus uncontrolled extraneous factors. Additionally, this study presents data for one student and results cannot be assumed representative of results for all learners. Finally, there is no within-subject control to show that other letter sounds were not being acquired from her typical classroom instruction.

Finally, a study by Morrell, Morrell, and Kubina (1995) was conducted to determine if DI sight word acquisition could be accelerated by the addition of PT. Three students in second grade received sessions 5 days a week for 30 mins each day. DI was used to introduce each of the words to the students followed by fluency practice using flash cards three to five timings per week. Timings were 1 min in length. The results of this study indicate celerations of X1.5, X1.7, and X1.4 on correct responding for the participants.

The purpose of this study was to identify if using PT would make learning sight words faster than with just DI alone. However results were only reported using DI and PT. There was no report on using DI alone. Due to the lack of control in this study, it is not possible to make a comparison of the rate of acquisition of the combination of PT and DI versus DI alone. Further, there was no indication if the authors tested for other outcomes of fluency such as retention or endurance. Increasing speed is a desired goal of PT; however, should not be the only result evaluated. Going fast does not ensure retention, endurance or application of a targeted skill, which are the true measures of fluency. An additional potential limitation for this study is the use
of flash cards; this limits the number of words the student is contacting at one time and could lead to sequencing effects if the cards were not shuffled within the timing, according to the authors shuffling only occurred between timings. This study, like the others, did not report on IOA or treatment integrity and as such, it is difficult to ascertain the true independent variable much less the fidelity with which it was implemented.

These studies show support for the contention that PT can affect change in targeted behaviors. While the populations in each study differ, they were all students performing below the average or the recommended level for success. With the implementation of timings and changes made to the learning program based on the data of the individual graphed on the SCC, positive change resulted. Unfortunately, like most published data in PT, these studies have limited procedural detail as well as no IOA or treatment integrity reported. They also tend to be case studies lacking experimental designs to assess experimental control. This limits the ability to determine if the treatment package was the actual cause of the behavior change.

These studies further lack systematic implementation of PT. For instance, there is no indication in the PT literature what the most effective number of timings per session is, what the optimal timing length is, or how many days a week PT sessions should be conducted. Given varying exposures to the materials via different timing lengths and number of sessions per week, it is difficult to know what amount of exposure is best for what type of learner. Lacking systemization may limit the use of PT clinically, but further, makes analysis of effects dubious at best. Additionally, the failure to provide clear procedural detail makes replication of these studies difficult for the practitioner or researcher who is not explicitly trained in PT.

According to Potts, Eshleman, and Cooper (1993), “Precision Teaching resides among a handful of effective behavior-change technologies to which students have a right” (p. 178).
Binder and Watkins (1990) suggest that PT “in regular and special classrooms may be capable of eliminating America’s current ‘basic skills crisis’ if broadly adopted” (p. 74). However, as seen through the studies discussed earlier there is no indication of the best way to implement PT. The studies cited indicate that the research is lacking in procedural detail, statistical and experimental analysis of results, IOA, treatment integrity, control for extraneous variables, within subject control, clear identification of IV’s, and the fidelity of implementation. Of particular interest to this study, there is no indication of the most effective number of days that skills using PT should be practiced. It is common clinical practice to recommend distributing sessions across several days per week to allow for manageable units of timelines per day, and to ensure minimal loss due to long delays without exposure to practice. However, there currently is no scientific evidence to support recommendations for having PT sessions distributed throughout a week. Therefore, there is a need for an analysis of how the distribution of sessions affects, differentially or otherwise, the acquisition of targets.
CHAPTER TWO:

PURPOSE

The purpose of this study was to investigate the effects of the distribution of timings per week on the rate of acquisition and the subsequent effects on probes for retention and endurance. The goal of this study was to determine if administering five learning sessions per week with three timings per session or one learning session per week with fifteen timings would show a differential rate of acquisition and the effects on retention and endurance.
CHAPTER THREE:

METHOD

Participants and Setting

Recruitment occurred at Family of Christ Child Development Center in Tampa, Florida (see appendix A for letter of support). Recruitment included the use of flyers sent home to parents via the classroom teachers and flyers placed on the classroom doors (see appendix C). Flyers contained contact information of the primary investigator so that interested parents were able to contact the experimenter by phone to discuss participation in the study and to set up an opportunity to meet at the school to proceed through the consent process.

Six participants were recruited and five participants completed this study. All five children were typically developing and had no known developmental delays as reported to the primary investigator by the children’s parent(s). The five participants consisted of one female and four males. JR was a 5-year-old female who was in the full time VPK class. CK was a 5-year-old male who attended the full time VPK class. JM was a 5-year-old male who attended the full time VPK class. CF was a 4-year-old boy who attended the full time VPK class. WN was a 4-year-old boy who attended the full time VPK class. All participants spoke English as their first language, responded vocally, and attended to letters presented to them on flashcards and worksheets. All participants responded below 50% accuracy on their inclusion assessment and their teachers and parents indicated that they may benefit from extra practice on letter sounds.
The criteria for children to be involved in this study were they 1) must have been able to attend to an activity for a minimum of 15 s, 2) scored below a 25% accuracy level when expressively identifying letters in the English alphabet, 3) not exhibit problem behaviors that interfered with the 15-s timings, 4) not have a diagnosed disability or receive accommodations for special education, and 5) not have a history of excessive absences.

The study was completed at Family of Christ Child Development Center. The sessions were conducted in a small teacher break room with two tables and four chairs. The window and door blinds were closed to decrease distractions. The participant and the researcher would sit at the child size table. The only materials placed on the table were materials necessary for the timing to decrease distractions. All other materials were placed under the table and out of sight and reach of the participants.

Materials

The materials used during this study were: digital timer, SCC (daily, weekly, timing or computerized daily and weekly per min charts), data collection sheet, flash cards (three sets of four cards), manual clicker, academic worksheets, sheet protectors, three ring binders, calculators, and a ruler. Additionally, reinforcers such as edibles and small tangibles were provided.

Experimental Design

An alternating treatments design was used for this study. All experimental participants were exposed to the following phases: Baseline, Pre-Training, Precision Teaching, Endurance, and Retention. The PT phase consisted of exposure to one letter set, five days per week with three timings per day. A second letter set was trained one day per week with 15 timings per day.
Finally, a third letter set remained in continuous baseline with three timings per day one day per week.

**Dependent Variable and Data Collection**

**Dependent variable.** The dependent variable in this study was the production of correct phonetic English letter sounds. The DV was measured across training sessions and probes utilizing rate measures (i.e. frequency over time). The measures used in this study were 1) rate of English Alphabet letter sounds identified, 2) rate of retention of letter sounds, and 3) rate of performance on an endurance probe when timing length is increased to 1 min. These measures took place in training as well as probe phases.

**Data collection.** Timing length in the baseline, PT, and retention phases was 15 s. The timing length was determined based on the timing length used in clinical settings and is seen as falling within developmental expectations. Data were collected and displayed on a daily per min (Dpmin) Standard Celeration Chart (SCC). A Dpmin was used to record all data from the timings per min (Tpmin) SCC and allowed for an analysis of overall (as opposed to within session) celeration of the learner.

**Interobserver Agreement**

A research assistant observed 56.8% of all sessions via videotape, across all phases for all participants. Data were collected on the correct and incorrect responses during each 15 s timing. IOA was computed by comparing the data on each response (correct and incorrect responses) from each observer for each timing (see appendix G). For example, on any one timing the number of correct, incorrect, and total responses were recorded. An agreement (+) was marked if both the correct or incorrect responses for both observers were the same. A disagreement (-) was marked if the correct or incorrect responses for both observers were different. Agreement was
computed based on number of agreements divided by number of agreements plus disagreements and multiplied by 100%.

Overall, 56.8% of sessions across participants were independently observed and scored by a research assistant. Agreement was 97.25% overall with a range of 92.5% and 100%

**Procedure**

Participants completed all phases. Each participant received three letter sets. Letter set A was trained five days a week with three timings per session. Letter set B was in training one day a week with 15 timings per session. The number of timings for Letter set B was yoked to the performance of Letter set A to ensure consistency of timings between the two conditions. Lastly, letter set C was in continuous baseline. All letters remained in training until mastery was reached on one letter set or until data was collected for a minimum of 4 weeks with out reaching mastery.

**Inclusion assessment.** After the parents contacted the primary investigator, a meeting was scheduled to discuss participation in the study and to sign the consent form. At this meeting, it was verified that the child met inclusion criteria to be included in the study. Additionally, the requirements for this study were discussed as well as the potential length of time of the study. Following this conversation, if consent was obtained from the parent, he/she filled out a reinforcer survey for the child. The child was then asked what he/she wanted to earn. Lastly, the primary investigator conducted an initial inclusion assessment, assessing the number of letter sounds that were currently in the child’s repertoire to verify that the child’s responding was within levels specified to participate in this study (see Participants section).

During this assessment, the child was told that he/she was going to say as many letter sounds as he/she could until the timer went off. He/she was then instructed to read the worksheet from left to right and an arrow was placed in front of the line on the sheet that the participant
started to read. The child was instructed to go as quickly as possible and to say as many letter sounds as he/she could. The primary investigator then modeled for the child how he/she should respond. At least three 15-s timings were conducted to ensure all stimuli were contacted. The timer was started immediately following the initiation of the first letter sound. When the timing ended the experimenter recorded correct and incorrect responses and provided the child with praise for completing the timing. There was no discussion of the results of the timing. Baseline timings was repeated for a total of three timings during the initial assessment phase.

Following this assessment, specific worksheets were developed that included the specific stimuli used for each participant.

**Baseline.** Participants entered the room in which the session was conducted and sat at a table with the experimenter. The experimenter explained to the participant that he/she was going to be working on learning letter sounds. The participant was then shown a worksheet with letters on it (see Appendix J) corresponding to the letters he/she incorrectly answered during his/her pretest. Each participant’s letters were contingent on the incorrect responses from his/her individual pretest to ensure that we were targeting letters currently not in his/her repertoire. Each set of letters consisted of three consonants and one vowel. The experimenter marked the line that the participant was to read by drawing an arrow next to it. The experimenter indicated to the participant that he/she should say the letter sounds and go as fast as he/she can until the timer went off and that he/she can start when he/she was ready.

At the first emission of a letter sound, the timer began and correct, incorrect, and skipped stimuli were recorded by the experimenter and charted on a SCC immediately following the timing. When the timing concluded, the experimenter gave praise for completing the timing but did not provide feedback with regards to accuracy. The participant then moved on to the next
timing. Baseline continued until all baseline-timings were complete. The participant did not receive contingent reinforcement for their correct responses; however, he/she was given access to a selection of small tangible and edible items and was allowed to select one as a reinforcer for completing the session. The participant was then told that the session was over and then taken back to class. After the participant completed fifteen baseline timings across five days for five-day-a-week letter set and fifteen baseline line timings a session for three days for one-day-a-week letter sounds, he/she moved into the Pre-Training phase. Initial baseline timings for all letter sets were administered on the first day of baseline. Letter set three remained in continuous baseline for the remainder of the study.

**Pre-training.** The pre-training phase consisted of the experimenter presenting the participant with the pre-training worksheet (see Appendix K) with all letters from the target set written out. The experimenter told the participant that he/she is going to learn the sounds for these four letters. The experimenter pointed to a letter, stated the letter sound, and had the child repeat each letter sound. After all four letter sounds had been repeated the experimenter had the child independently state all the letter sounds. If errors occurred the experimenter stopped the participant and indicated the correct sound again and had the participant repeat the sound. Pre-training continued until the participant identified all four letter sounds correctly with no prompting from the experimenter. Following pre-training, the participant moved into the PT phase.

**Precision teaching.** After the baseline timings and pre-training were completed, the participant moved into the PT phase. When the first session of the PT phase began, the participant entered the room in which the session was conducted and sat at a table with the experimenter. The experimenter explained to the participant that he/she was going to continue to
work on learning letter sounds. Then, the reinforcement schedule was explained to the participant.

**Percentile schedules.** The reinforcement schedule that was used in this study was a K5 percentile schedule. This schedule provided reinforcement that exceeded roughly 50% of the last 10 timings in which a participant engaged. The rationale for using a percentile schedule of reinforcement was that it allowed for a systematic approach to shaping behavior while maintaining procedural integrity within and across participants. Additionally, it allowed for individuality of programming for participants, because the density of reinforcement was based on the needs of each learner, and finally it could provide an objective and scientific means to reinforce.

To identify the criterion for reinforcement, the previous 10 timings were identified. The five lowest scores of the last 10 were counted and the participant needed to exceed that score by at least one response to receive reinforcement. For example if the last 10 scores were 11, 15, 8, 13, 10, 9, 12, 14, 17, 16 the scores would be ordered from least to greatest; 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and the lowest five scores would be counted; the fifth score would be identified and one would be added. In this example, the criterion to receive reinforcement would be 13 because the fifth score was 12 and 1 was added. Before 10 timings had been completed reinforcement was given if the frequency of the timing exceeds 50% of the previous timings frequencies.

The timings for PT were conducted exactly as baseline with the exception of reinforcement delivery. When the timing was completed, the experimenter immediately gave praise and indicated to the participant if he/she received reinforcement. Following the delivery of reinforcement, the experimenter also indicated to the participant the letters that were incorrect or
skipped. A correction procedure took place for those letters identified incorrectly. The
participant was asked again to identify the letter and if he/she was unsure or answered incorrectly
the experimenter told them the correct sound of the letter and asked the participant to repeat the
sound. Following the review of the letters, the participant moved on to the next timing. For the
remaining timings, the line where the participant was reading from was moved to the next
available line where no letter sounds had been read. This ensured a variable display of letters to
control for sequence effects. All remaining timings were conducted in this same manner. After
all timings for that day were completed, the participant was given access to a selection of small
reinforcers and was allowed to select one as a reinforcer for completing the session as well as
given the reinforcers earned during the timing. He/she was then taken back to class.

After the completion of each PT session, the SCC was evaluated. This evaluation
involved examining the level, trend, and variability in data and looked to see if there was a
necessity to make a change to the program, the reinforcement schedule, or both. A change was
made to the program or reinforcement schedule if the data indicated a decrease in celeration or
slow learning. These changes were decided on an individualized basis, based on the needs of
each learner and were not known until the evaluation of the chart took place. If there was no
indication that a change should be made, the program continued as is.

If a change was not indicated as necessary from the evaluation of the SCC, sessions
continued to be conducted as stated above until the aim of 60+ responses per min was achieved.
This aim indicated that the participant’s score met the criterion for mastery. The mastery
criterion consisted of two phases: Qualifying and Mastery. The first phase was the qualifying (Q)
phase. The participant must engage in a timing resulting in a frequency at or above the aim of
60+/min for two consecutive timings within one session. This stability criterion ensured
consistent responding at the aim. After the participant emitted two successive frequencies at or above the aim within the same session, he/she qualified for the next phase and a “Q” was written above that day’s timings on the SCC.

The second phase of the mastery criterion, titled “Mastery” required the participant to engage in a timing yielding a frequency at or above the aim on the first timing of the session following Q. This was a slight retention check to ensure high rate responding following a brief period of no practice. If the participant’s frequency of saying letter sounds was at or above the aim, he/she mastered the program and an “M” was written above that day’s timing on the SCC. If the participant did not meet the criterion for mastery on the session immediately following receiving Q, the participant would again work to qualify for mastery and final mastery.

**Endurance probes.** Throughout the PT phase of the study endurance probes were conducted to ensure that true fluency was being obtained. Endurance probes were conducted in the same manner as the normal 15-s timings; however they were extended to 1 min (4 times the original timing length). Endurance probes were conducted once a week at the end of the session. For endurance probes, reinforcement was provided contingent on engagement in the timing session rather than contingent on correct or fast responding.

**Retention.** Retention probes began immediately following Mastery of a letter sounds set. Retention probes were run weekly following mastery of the material. The retention probes were run in the same manner as the baseline timing and reinforcement was given for engaging in the timing session rather than contingent on correct or fast responding.
CHAPTER FOUR:

RESULTS

To analyze the results of this study, analyses were conducted to identify the total number of sessions completed to reach mastery. The rate of responding during endurance probes was analyzed to see if the participant was able to respond at the same rate when the timing length was increased by x4 to 1 min. Also the level of responding was analyzed following periods of no practice (Retention). In addition, analyses were done on the celeration, the variability in the data (bounce), change in level between two frequencies (frequency multipliers), and the difference between the rate of celeration in different phases (celeration multipliers).

Participant 1 (JR)

Total Timings to Mastery. To reach mastery criteria on material presented one day per week, JR required 32 timings across three weeks. To reach mastery criteria on material presented five day per week JR required 40 timings across three weeks. The difference between the numbers of timings to reach mastery between the two distributions was 8 timings.

Table 1. JR Total Timings to Mastery

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Total Timings</th>
<th>Total Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/week</td>
<td>32</td>
<td>3</td>
</tr>
<tr>
<td>5 day/week</td>
<td>40</td>
<td>3</td>
</tr>
</tbody>
</table>
1 Day Per Week

Correct responses. JR’s correct responding during baseline was at low levels with a celeration of X1.0. During baseline, there was also low variability in her responding with a bounce of X1.0 indicating her data was stable at zero correct responses per min. Following DI, there was a jump up in level for correct responding with a frequency multiplier of X6. The frequency multiplier indicates that from the final data point in baseline to the first data point in the PT phase her responding increased at a X6. Her correct responding continued to increase with a X1.20 celeration until she met aim at 60 correct responses per min. Her correct responding was more variable with a bounce of X10 but became stable when she reached aim. The change in her celeration for correct responding between BL and PT was X1.42.

Incorrect responses. Her incorrect responding during baseline was high and was showing an increasing trend with a celeration of X1.20. Following DI, her incorrect responding had a turn down at a ÷1.57 celeration.

Retention. Two weeks following mastery of the skill retention checks were administered. During these retention checks her correct responding was still at aim and her incorrect responding remained below one response per min.

Table 2. JR results summary one day per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.0</td>
<td>X1.20</td>
<td>X1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.42</td>
<td>÷1.57</td>
<td>X10.0</td>
<td>X6</td>
<td>X1.42</td>
</tr>
</tbody>
</table>
Endurance. Endurance checks were conducted once a week and indicated that when the timing length was increased to four times the length of the practice timing, JR’s responding maintained the same rate when compared to the practice timings.

5 Day Per Week

Correct responses. JR’s correct responding during baseline was at low levels with a celeration of ÷1.62. During baseline her correct responding was on a decreasing trend with low variability with a bounce of X2.14. Following DI there was a jump up in level for correct responding with a frequency multiplier of X4. The frequency multiplier indicates that from the final data point in baseline to the first data point in the PT phase her responding increased by X4.
Her correct responding continued to increase at a \( X1.39 \) celeration until she met the aim at 60 correct responses per min. Her correct responding had more variability than baseline with a bounce of \( X3.19 \) but became stable when her frequencies reached the aim. The change in her celeration for correct responding (celeration multiplier) between BL and PT was \( X1.17 \) indicating an increase in the rate of learning in the PT phase.

**Table 3.** JR results summary five days per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 day/wk BL</td>
<td>( \div 1.62 )</td>
<td>( \div 1.11 )</td>
<td>( X2.14 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>( X1.39 )</td>
<td>( \div 1.17 )</td>
<td>( X3.19 )</td>
<td>( X4 )</td>
<td>( X1.17 )</td>
</tr>
</tbody>
</table>

**Incorrect responses.** Her incorrect responding during baseline was high and was showing a decreasing trend with a celeration of \( \div 1.11 \). Following DI, her incorrect responding continued decreasing at a \( \div 1.17 \) celeration.

**Retention.** Two weeks following mastery of the skill, retention checks were administered. During these retention checks, JR’s frequency level of correct responding was still at aim while her incorrect responding stayed below one response per min.

**Endurance.** Endurance checks were conducted once per week. The data from these probes indicate that when the timing length increased to four times the length of the practice timings, JR’s responding maintained the same rate as the practice timings.
Figure 2. JR five day per week SCC.

Table 4. JR results comparison

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.0</td>
<td>X1.20</td>
<td>X1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.42</td>
<td>+1.57</td>
<td>X10.0</td>
<td>X6</td>
<td>X1.42</td>
</tr>
<tr>
<td>5 day/wk BL</td>
<td>+1.62</td>
<td>+1.11</td>
<td>X2.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.39</td>
<td>+1.17</td>
<td>X3.19</td>
<td>X4</td>
<td>X1.17</td>
</tr>
</tbody>
</table>

Participant 2 (CK)

**Total Timings to Mastery.** To reach mastery criteria on material presented one day per week, CK required 20 timings across 3 weeks. To reach mastery criteria on material presented
five days per week, CK required 20 timings across three weeks. The same numbers of timings were conducted across both distributions of sessions for CK.

**Table 5.** CK Total Timings to Mastery

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Total Timings</th>
<th>Total Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/week</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>5 day/week</td>
<td>20</td>
<td>3</td>
</tr>
</tbody>
</table>

**1 Day Per Week**

**Correct responses.** CK’s correct responding during baseline was at low levels of frequency with a celeration of X1.18. During baseline, there was moderate variability in his responding with a bounce of X8.0. Following DI, there was a jump up in level for correct responding indicated by a frequency multiplier of X1.8. He continued to increase in his correct responding at a X1.61 celeration until he met the aim at 15 correct responses per min. His correct responding during the PT phase had less variability with a bounce of X3, which stabilized as he approached the aim. The celeration multiplier, or the change in his celeration for correct responding between BL and PT phase, was X1.32 indicating a greater acquisition rate of learning.

**Table 6.** CK results summary one day per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.18</td>
<td>+1.64</td>
<td>X8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.61</td>
<td>+2.08</td>
<td>X3</td>
<td>X1.8</td>
<td>X1.32</td>
</tr>
</tbody>
</table>
Figure 3. CK one day per week SCC.

Incorrect responses. His incorrect responding during baseline was high and was showing a decreasing trend with a celeration of \( \frac{1}{1.64} \). Following DI, his incorrect responding continued the downward trend but had steeper a celeration of \( \frac{1}{2.08} \).

Retention. Two weeks following mastery of the skill, retention checks were administered. During these retention checks, his correct responding maintained the frequency level at the aim while his incorrect responding stayed below one response per min.

Endurance. Endurance checks were administered once per week. Data from these probes indicated that when the timing length was increased to four times the length of the practice timings, CK’s responding maintained the same rate as during the practice timings.
5 Day Per Week

Correct responses. CK’s correct responding during baseline was at low frequency levels with a celeration of ÷1.16. During baseline, his correct responding was on a decreasing trend and there was low variability with a bounce of X3. Following DI, there was a jump up in level for correct responding with a frequency multiplier of X2.5. During the PT phase, CK continued to increase in his correct responding with a X1.24 celeration until he met the aim of 60 correct responses per min. His correct responding during the PT phase was more variabe with a bounce of X5.2 but became more stable as his frequencies neared the aim. The celeration multiplier, or the change in his celeration for correct responding between BL and PT phase, was X1.06 indicating a slight increase in the rate of learning during the PT phase.

Incorrect responses. CK’s incorrect responding during baseline was high and showed an increasing trend with a celeration of X1.97. Following DI, his incorrect responding had a turn down with a ÷1.28 celeration. These data indicate that accuracy significantly improved during the PT phase.

Retention. Two weeks following mastery of the skill, retention checks were administered. During these retention checks, CK’s correct responding maintained frequencies at the aim while his incorrect responding stayed below one response per min. Therefore, CK’s performance not only maintained its speed but its accuracy as well.

Table 7. CK results summary five days per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 day/wk BL</td>
<td>÷1.16</td>
<td>X1.97</td>
<td>X5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.24</td>
<td>÷1.28</td>
<td>X3.95</td>
<td>X2.5</td>
<td>X1.06</td>
</tr>
</tbody>
</table>
Figure 4. CK five day per week SCC.

**Endurance.** Endurance checks were administered once a week. The data from these probes indicated that when the timing length was increased to four times the length of the practice timings, CK’s responding maintained the same level of frequency when compared to the frequencies of the practice timings.

**Table 8.** CK results comparison

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.18</td>
<td>+1.64</td>
<td>X8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.61</td>
<td>+2.08</td>
<td>X3</td>
<td>X1.8</td>
<td>X1.32</td>
</tr>
<tr>
<td>5 day/wk BL</td>
<td>+1.16</td>
<td>X1.97</td>
<td>X5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.24</td>
<td>+1.28</td>
<td>X3.95</td>
<td>X2.5</td>
<td>X1.06</td>
</tr>
</tbody>
</table>
Participant 3 (JM)

**Total Timings to Mastery.** To reach mastery criteria on material presented one day per week, JM required 61 timings across five weeks. To reach mastery criteria on material presented five days per week, JM required 54 timings across six weeks. This is a difference of seven timings between the different session distributions.

Table 9. JM Total Timings to Mastery

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Total Timings</th>
<th>Total Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/week</td>
<td>61</td>
<td>5</td>
</tr>
<tr>
<td>5 day/week</td>
<td>54</td>
<td>6</td>
</tr>
</tbody>
</table>

1 Day Per Week

**Correct responses.** JM’s correct responding during baseline was at low frequency levels with a celeration of X1.08. During baseline, there was moderate variability in his responding with a bounce of X6. Following DI, there was a jump up in level for correct responding with a frequency multiplier of X2.66. His correct responding continued to increase at a X1.23 celeration until frequencies met the aim at 60 correct responses per min. His correct responding during the PT phase had less variability than baseline with a bounce of X2.43, which then became more stable as his frequencies approached the aim. The celeration multiplier, or change in his celeration for correct responding between BL and PT phase, was X1.13 indicating a slight increase in the rate of acquisition across time in the PT phase.

**Incorrect responses.** JM’s incorrect responding during baseline was at high frequency levels and showed an increasing trend at a celeration of X1.15. Following DI, the celeration of incorrect responding turn down with a celeration of ÷1.07 indicating a significant increase in accuracy during the PT phase.
Retention. Two weeks following mastery of the skill, retention checks were administered. During these retention checks, his correct responding maintained frequency levels at the aim while his incorrect responding stayed below one response per min. These data indicate that not only did his performance maintain the high speed of responding as in the PT phase, but that it also maintained its accuracy following a period of no practice.

Table 10. JM results summary one day per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.08</td>
<td>X1.15</td>
<td>X6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.23</td>
<td>+1.07</td>
<td>X2.43</td>
<td>X2.66</td>
<td>X1.13</td>
</tr>
</tbody>
</table>

Figure 5. JM one day per week SCC.
**Endurance.** Endurance checks were administered once a week. Data from these probes indicated that when the timing length was increased to four times the length of the practice timings, JM’s responding maintained the same frequency level as during the practice timings.

**5 Day Per Week**

**Correct responses.** JM’s correct responding during baseline was at low levels with a celeration of $\div 1.09$. During baseline, his correct responding was on a decreasing trend and there was low variability with a bounce of X1.55. Following DI, there was a jump up in level for correct responding with a frequency multiplier of X5. He continued to increase in his correct responding with a X1.15 celeration until his responses met the aim at 60 correct responses per min. His correct responding during the PT phase had more variability with a bounce of X2.6 but became stable as they approached the aim. The celeration multiplier, or change in his celeration for correct responding between BL and PT phase, was X1.05 indicating a very slight increase in the speed of acquisition during the PT phase.

**Table 11.** JM results summary five days per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 day/wk BL</td>
<td>$\div 1.09$</td>
<td>$\div 2.62$</td>
<td>X1.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.15</td>
<td>$\div 1.10$</td>
<td>X2.6</td>
<td>X5</td>
<td>X1.05</td>
</tr>
</tbody>
</table>

**Incorrect responses.** His incorrect responding during baseline was high and showed a decreasing trend with a celeration of $\div 2.62$. Following DI, his incorrect responding continued the downward trend at a $\div 1.10$ celeration.
Retention. Two weeks following mastery of the skill, retention checks were administered. During these retention checks, his correct responding maintained the high levels of responding as seen during the PT phase while his incorrect responding stayed below one response per min. Therefore, JM’s speed and accuracy from the PT phase retained after a period of no practice.

Endurance. Endurance checks were administered once a week. Data from these checks indicated that when the timing length increased to four times the length of the practice timings, JM’s responding stayed at same level of responding as during the practice timings.
Table 12. JM results comparison

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.08</td>
<td>X1.15</td>
<td>X6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.23</td>
<td>+1.07</td>
<td>X2.43</td>
<td>X2.66</td>
<td>X1.13</td>
</tr>
<tr>
<td>5 day/wk BL</td>
<td>+1.09</td>
<td>+2.62</td>
<td>X1.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.15</td>
<td>+1.10</td>
<td>X2.6</td>
<td>X5</td>
<td>X1.05</td>
</tr>
</tbody>
</table>

Participant 4 (CF)

**Total Timings to Mastery.** CF did not reach mastery criteria on material presented one day per week. In this condition, he completed 105 timings across seven weeks. To reach mastery criteria on material presented five days per week, CF required 60 timings across five weeks. This is a difference of 45 timings between the two distributions.

Table 13. CF Total Timings to Mastery

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Total Timings</th>
<th>Total Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/week</td>
<td>105</td>
<td>7</td>
</tr>
<tr>
<td>5 day/week</td>
<td>60</td>
<td>5</td>
</tr>
</tbody>
</table>

**1 Day Per Week**

**Correct responses.** CF’s correct responding during baseline was at low frequency levels with a celeration of X1.18. During baseline there was low variability in his responding with a bounce of X2.77. Following DI, there was not a jump up in level for correct responding, a frequency multiplier of X1.0. He continued to increase in his correct responding at a X1.17 celeration until his performance met the aim of 60 correct responses per min. His correct responding during the PT phase was more variable with a bounce of X8.83, which stabilized as the frequencies approached aim. The celeration multiplier, or the change in his celeration for
correct responding between BL and PT phase, was X1.0 indicating no change in the rate of acquisition of presented material.

**Incorrect responses.** CF’s incorrect responding during baseline was at high frequency levels and showed an increasing trend at a celeration of X1.25. Following DI, the celeration across incorrect responses turned down at a celeration of ±1.05 indicating an increase in accuracy during the PT phase.

**Retention.** CF did not master the letters targeted one day per week. Therefore, a retention check could not be performed.

---

**Figure 7. CF one day per week SCC.**
**Endurance.** Endurance checks were taken once a week during the course of the study. Data from these probes indicated that when the timing length increased to four times the length of the practice timings, CF’s responding maintained the same rate when compared to the practice timings.

**Table 14.** CF results summary one day per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.18</td>
<td>X1.25</td>
<td>X2.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.17</td>
<td>÷1.05</td>
<td>X8.83</td>
<td>X1.0</td>
<td>X1.0</td>
</tr>
</tbody>
</table>

**5 Day Per Week**

**Correct responses.** CF’s correct responding during baseline was at low frequency levels and maintained these low levels at a celeration of X1.0. During baseline, no correct responses were observed resulting in low variability with a bounce of X2.68. Following DI, the frequency of correct responses maintained its frequency level indicated by a frequency multiplier of X1.0. His responses continued to increase during the PT phase at a X1.62 celeration until these frequencies met the aim of 60 correct responses per min. His correct responding during the PT phase had moderate variability with a bounce of X8.46 but became more stable as his performance reached aim. The celeration multiplier, or the change in his celeration for correct responding between BL and PT phase, was X1.36 indicating a significant increase in the rate of acquisition during the PT phase.

**Incorrect responses.** His incorrect responding during baseline was at high frequency levels and showed an increasing trend with a celeration of X1.60. Following DI, the celeration across incorrect responses turned down at a ÷1.57 celeration.
Table 15. CF results summary five days per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 day/wk BL</td>
<td>X1.0</td>
<td>X1.62</td>
<td>X2.68</td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.36</td>
<td>+1.57</td>
<td>X8.46</td>
<td>X1.0</td>
</tr>
</tbody>
</table>

Retention. Two weeks following mastery of the skill, retention checks were administered. During these retention checks, his correct responding was still at the aim frequency levels and his incorrect responding stayed below one response per min. Therefore both the speed and accuracy from the PT phase were retained following a period of no practice.

Figure 8. CF five day per week SCC.
**Endurance.** Endurance checks were administered once a week throughout the course of the study. The data from these probes indicated that when the timing length increased to four times the length of the practice timings, CF’s responding maintained the frequency level as the 15 s practice timings.

**Table 16. CF results comparison**

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.18</td>
<td>X1.25</td>
<td>X2.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.17</td>
<td>+1.05</td>
<td>X8.83</td>
<td>X1.0</td>
<td>X1.0</td>
</tr>
<tr>
<td>5 day/wk BL</td>
<td>X1.0</td>
<td>X1.62</td>
<td>X2.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.36</td>
<td>+1.57</td>
<td>X8.46</td>
<td>X1.0</td>
<td>X1.36</td>
</tr>
</tbody>
</table>

**Participant 5 (WN)**

**Total Timings to Mastery.** To reach mastery criteria on material presented one day per week, WN required 143 timings across 12 weeks. To reach mastery criteria on material presented five days per week, WN required 147 timings across 12 weeks. This is a difference of four timings between the two session distributions.

**Table 17. WN Total Timings to Mastery**

<table>
<thead>
<tr>
<th></th>
<th>Total Timings</th>
<th>Total Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/week</td>
<td>143</td>
<td>12</td>
</tr>
<tr>
<td>5 day/week</td>
<td>147</td>
<td>12</td>
</tr>
</tbody>
</table>

**1 Day Per Week**

**Correct responses.** WN did not engage in any correct responding during baseline. As such, there was no variability in his responding yielding a bounce of X1.0. Following DI, the frequency level of correct responses did not change (frequency multiplier of X1.0). His responding continued to increase at a X1.14 celeration until the frequencies met the aim of 60
correct responses per min. These data during the PT phase were more variable yielding a bounce of X10.83, which stabilized as the frequencies approached the aim. The celeration multiplier, or the change in his celeration for correct responding between BL and PT phase, was X1.06 indicating a slight increase in the rate of learning in the PT phase.

**Incorrect responses.** His incorrect responding during baseline was high showed a slight increasing trend at a celeration of X1.02. Following DI, the celeration across incorrect responding turned down at a celeration of ÷1.10. These data indicate that accuracy improved during the PT phase when compared to baseline accuracy.

**Retention.** One week following mastery of the skill, retention checks were administered. WN received retention checks after one week due to the ending of school. During these retention checks, his correct responding was still at aim and his incorrect responding stayed below one response per min.

**Table 18.** WN results summary one day per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.0</td>
<td>X1.02</td>
<td>X1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.14</td>
<td>÷1.10</td>
<td>X10.83</td>
<td>X1.0</td>
<td>X1.14</td>
</tr>
</tbody>
</table>

**Endurance.** Endurance checks were taken once a week. The data from these probes indicated that when the timing length increased to four times the length of the practice timings, WN’s responding was near the same frequency level as the practice timings.

**5 Day Per Week**

**Correct responses.** The celeration across correct responses was flat at a X1.0 below the record floor indicating no observed correct responses. Further, there was low variability with a bounce of X2.36 during baseline. Following DI, correct responding maintained the frequency
levels observed during baseline yielding a frequency multiplier of X1.0. WN’s frequency of responding continued to increase at a X1.06 celeration until his responding met the aim of 60 correct responses per min. His correct responding during the PT phase had more variability with a bounce of X12.54 but became more stable as they reached levels of 60 per min. The celeration multiplier, or the change in his celeration for correct responding between BL and PT phase, was X1.06 indicating a very slight increase in the rate of learning in the PT phase.

Figure 9. WN one day per week SCC.
Incorrect responses. WN’s incorrect responding during baseline was at high frequency levels and increasing at a celeration of $X3.82$. Following DI, the celeration across incorrect responding turned down at a $\div1.08$ celeration.

Retention. One week following mastery of the skill, retention checks were administered. WN received retention checks after one week due to the ending of school. During these retention checks his correct responding maintained frequency levels at the aim while his incorrect responding stayed below one response per min. Therefore, WN’s speed and accuracy were retained following a period of no practice.

![Graph showing SCC and Successive, Calendar, Weeks]

Figure 10. WN five day per week SCC.
Table 19. WN results summary five days per week

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 day/wk BL</td>
<td>X1.0</td>
<td>X3.82</td>
<td>X2.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.06</td>
<td>+1.08</td>
<td>X12.54</td>
<td>X1.0</td>
<td>X1.06</td>
</tr>
</tbody>
</table>

**Endurance.** Endurance checks were taken once a week. Data from these probes indicated that when the timing length as increased to four times the length of the practice timings, WN’s responding maintained the same frequency levels as those during the practice timings.

Table 20. WN results comparison

<table>
<thead>
<tr>
<th></th>
<th>Correct Celeration</th>
<th>Incorrect Celeration</th>
<th>Bounce</th>
<th>Frequency Multiplier</th>
<th>Celeration Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day/wk BL</td>
<td>X1.0</td>
<td>X1.02</td>
<td>X1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day/wk PT</td>
<td>X1.14</td>
<td>+1.10</td>
<td>X10.83</td>
<td>X1.0</td>
<td>X1.14</td>
</tr>
<tr>
<td>5 day/wk BL</td>
<td>X1.0</td>
<td>X3.82</td>
<td>X2.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 day/wk PT</td>
<td>X1.06</td>
<td>+1.08</td>
<td>X12.54</td>
<td>X1.0</td>
<td>X1.06</td>
</tr>
</tbody>
</table>
CHAPTER FIVE:
DISCUSSION

The purpose of the present study was to identify the most effective session distribution of PT learning sessions. The results of this study indicate that there was not a clear effect of session distribution on the rate acquisition, endurance, or retention of the skill, but rather that it may be more important to evaluate the number of timings conducted per week. When 15 timings were distributed in either one or five days per week it is evident with these participants that there was not a substantial difference in the amount of time necessary to learn the skill (e.g., frequencies reach aim). Additionally, the retention seen in the data from all participants shows that once correct responding met the optimum frequency levels the participants were able to respond at similar speed and accuracy levels for extended periods of time without practice. Further, when evaluating endurance, data from all participants indicate that their frequency levels of responding during the endurance checks correlated to those in which they were responding during the practice timings; thus, there was no observed difference in endurance between the two different session/timing distributions. In sum, a letter set was not mastered more quickly in either condition and both conditions produced equivalent outcomes on endurance and retention checks.

Most participants showed low levels of correct responding during baseline with a jump up in level when they entered the PT phase. The participant whose level of correct responding did not instantly improve following DI was CF. Additionally there was a decrease in incorrect responding when all participants entered the PT phase. These observations were consistent
across all participants in both one day/week and five day/week letter sounds. High variability was seen for all participants in both correct and incorrect responding. Yet, this variability decreased as performance reached the aim for the correct letter sounds omission. Further, accuracy improved throughout the PT phase as correct responding increased there was a decrease in incorrect responding.

The results of this study suggest that it may not be necessary to engage in PT sessions five days a week; but, that when the number of timings is held constant, there appears to be no difference in celeration, retention and endurance when the skill is practiced on a single day.

The results from this study can help in clinical setting by protecting from potential loss of progress when a student is going to have a period of time without practice, such as a family vacation. The results of this study suggest that if the number of timings is held constant but all timings that he/she would miss from the absence are conducted before the vacation, there may be no apparent effect based simply on the distribution. This discovery may also be useful when designing programming for a student. It could allow for case managers to focus on a smaller number of programs more intensely on particular days as opposed to a brief practice on a number of programs across a number of days. This change in programming could then alter staff training so that certain staff members could develop expertise in a smaller number of programs and interventions instead of having to train all staff to proficient levels on all possible programs.

In an educational or school setting, the implications of this study are significant. With the current application of Response to Intervention (RtI), this study suggests that for a child who needs additional support, it may not be necessary to have a child participate in small group settings 5 days a week, but rather that it may only be necessary that a child practices a skill more often with these practice opportunities distributed at the leisure and convenience of the teacher.
This could be as simple as giving the child the opportunity to practice the deficit skill following the completion of an activity or when the child has extra time after an assignment.

Throughout the study certain limitations presented themselves. One limitation of this study was that it was a single case design. Single case design does not lend itself to be generalized to others without a sufficient number of data sets reflecting similar patterns. Further, embracing the SCC, as necessary when conducting PT, made it rather difficult to select a rigorous experimental design to compare the two session distributions. More research experimenting with the accompaniment of the SCC in traditional behavior analytic experimental designs seems to be warranted.

Another limitation is the order in which timings were presented; on the day when 1-day/week and 5-day/week timings were conducted, the 5-day/week always preceded the 1-day/week timing. It is possible that there was a warm up effect in the acquisition of the 1-day/week letters. Additionally, the endurance check was always conducted following the training timings. This too could have benefited from the practice the participants received from the practice timings during training prior to the endurance check. However even if a warm up effect were present there would be no impact on the accuracy.

**Future Directions**

This study sets the pathway for further analysis of the distribution of learning sessions. The current study focused on evaluating the maximum and minimum number of days PT sessions could be administered in a school setting: 5 days and 1 day a week. Further research could evaluate different session distributions and its subsequent effect on the acquisition of material learned. Since no difference could be observed between 5 days/week and 1 day/week, could these findings hold true when comparing 5 days/wk to 1 day every other week? It may also
be important to identify a minimum number of timings to engage in during a given time period. Therefore the number of timings run per day could also be evaluated to see if more or less timings per day result in more rapid acquisition. To mimic the “cramming” study method, could all timings to master a skill be performed on one day and still achieve proficient, fluent levels of endurance and retention? This further examination would give empirical data to support the number of timings run per session rather than an arbitrary number.

Finally, further research should be conducted using groups to allow for broader generalizations of the results. Group research would allow researchers to conduct statistical analyses, which would give a better analysis of learning.

This study has provided a pathway for much needed additional research in PT on the “best practices”. Further research on these best practices would help provide clinicians with the possibility of seeing and working with more clients therefore increasing productivity for PT clinics and schools. Additionally, not every child/family can devote the time to receive PT sessions 5 days a week. Identifying the characteristics of the most effective PT sessions would allow clinicians to make recommendations to families that may best fit the schedule of the family while still providing the best possible outcomes. Research should be conducted to identify the necessity of different session distributions based on the age of the child, younger versus older and the recommended number of sessions. Finally additional research could take into account the verbal behavior of the child to evaluate preference.

These are just some of the many lines of research in the area of PT that are necessary to provide clinicians with the empirical support for parents and teachers. We need to move from the word of mouth era to an era rich in supportive data. Data may help better communicate with the
rest of behavior analysis, education, and psychology as a whole the reliable and valid tool that we have with PT.
REFERENCES


Appendix A: Blank Dpm SCC
Appendix B: IRB Letter of Approval

January 7, 2013

Elizabeth Hasbrouck, B.S.
ABA-Applied Behavior Analysis
930 Bayview Place NE
St. Petersburg, FL 33704

RE: Expedited Approval for Initial Review
IRB#: Pro000010410
Title: An Evaluation of the Effects of Session Distribution on the Acquisition, Retention, and Endurance of Material Learned Using Precision Teaching

Dear Mrs. Hasbrouck:

On 1/6/2013 the Institutional Review Board (IRB) reviewed and APPROVED the above referenced protocol. Please note that your approval for this study will expire on 1/6/2014.

Approved Items:
Protocol Document:
Revised Final Thesis 12.2.12.doc

Consent Document:
Parental Permission Minimal Risk.docx Revised.pdf
Please use only the official, IRB-stamped consent document(s) found under the "Attachment Tab" in the recruitment of participants. Please note that these documents are only valid during the approval period indicated on the stamped document.

This study involves children; approved under 45CFR46.404: Research not involving greater than minimal risk. It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review categories:

(5) Collection of data from voice, video, digital, or image recordings made for research purposes.
(7) Research on individual or group characteristics or behavior (including, but not limited to,
research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[Signature]

John A. Schinka, Ph.D., Chairperson
USF Institutional Review Board
Appendix C: Letter Of Support

FAMILY OF CHRIST
LUTHERAN CHURCH
SCHOOL AND CHILD DEVELOPMENT CENTER
16190 Bruce B. Downs Blvd. • Tampa, FL 33647
(813) 558-9543

Jill Hammond, Director          David Haaza, Pastor

September 10, 2012
Family of Christ Lutheran Church
School and Child Development Center
16190 Bruce B Downs Blvd.
Tampa, FL 33647
(813) 558-9543

To Whom It May Concern:

The Family of Christ Child Development Center would be pleased to allow Elizabeth Hasbrouck
to recruit potential participants as well as complete data collection for her thesis entitled “An
Evaluation of the Effects of Session Distribution on the Acquisition, Retention, Endurance and
Application of Material Learned Using Precision Teaching” at our school.

If you have, any questions please feel free to call or email me at jillhale76@men.com

Sincerely,

Jill Hammond
Director of Child Development Center
Appendix D: Letter Of Support

To Whom It May Concern,

I give Elizabeth Hasbrouck permission to use the offices of Precision Teaching Learning Center to run participants for her thesis at her leisure. There is no expiration to this offer.

If you have any questions, please feel free to contact me at the above number.

Best,

Kerri Milyko, Ph.D., BCBA-D
kmilyko@gmail.com
A Research Study about Precision Teaching

Researchers at USF want to find ways to make learning material through Precision Teaching most effective. This research study is for children ages 3-5 years old.

Research is always voluntary!

Would the study be a good fit for my child?
This study might be a good fit if:
• Your child is age 3-5
• You want your child to learn their letter sounds
• Attends Family of Christ Child Development Center

What would happen if my child took part in the study?
If you decide to have your child take part in the study, your child would:
• Be pulled out from class for learning sessions 1 or 5 Days a week (about 15 mins)
• Learn letter sounds that they don’t already know
• Have fun while learning!

To take part in this research study or for more information, please contact Elizabeth Hasbrouck
Phone: (727)686-4104
Or
Email: ergarnett@gmail.com

The principal researcher for this study is Elizabeth Hasbrouck. This study is being done through the Applied Behavior Analysis program at USF under the advisement of Timothy Will.
Appendix F: Inclusion Assessment Stimuli

Name: ___________  Date: ___________

<table>
<thead>
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<th>z</th>
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<td>u</td>
<td>i</td>
<td>q</td>
</tr>
</tbody>
</table>
Appendix G: Sample PT Stimuli

aptntpnapantnnnapa

tpnantpatnppatna

natpantpatnpatn

patnppntnnapnapatp

atnptpantpnnatpnn
Appendix H: Sample Training Stimuli

a

n

t

p