EFFECTS OF TRAINING ACCURATE COMPONENT STROKES USING RESPONSE CONSTRAINT AND SELF-EVALUATION ON WHOLE LETTER WRITING

Tammy Lynn Cline, B.S.

Thesis Prepared for the Degree of

MASTER OF SCIENCE

UNIVERSITY OF NORTH TEXAS

December 2006

APPROVED:

Jesus Rosales-Ruiz, Major Professor
Sigrid Glenn, Committee Member
Richard Smith, Committee Member and Chair
of the Department of Behavior Analysis
Thomas L. Evenson, Interim Dean of the
College of Public Affairs and Community
Service
Sandra L. Terrell, Dean of the Robert B.
Toulouse School of Graduate Studies

This study analyzed the effects of a training package containing response constraint, self-evaluation, reinforcement, and a fading procedure on written letter components and whole letter writing in four elementary school participants. The effect on accuracy of written components was evaluated using a multiple-baseline-across components and a continuous probe design of components, as well as pre-test, baseline, and post-test measures. The results of this study show that response constraint and self-evaluation quickly improved students’ performance in writing components. Fading of the intervention was achieved quickly and performance maintained. Results also show that improvement in component writing improved whole letter and full name writing and letter reversals in the presence of a model were corrected.
ACKNOWLEDGEMENTS

I would like to thank the Behavior Analysis faculty for providing such an intensive, high quality education, results of which allow me to grow personally and professionally and to positively affect individuals that I serve. Dr. Glenn serves as a role model to me as a leader in the field who established this department and continues to disseminate behavior analysis throughout the world. Dr. Shahla Ala’i-Rosales is an amazing professor and practitioner who I admire for her dedication to the autism community and for the invaluable experience she provided to students and families in the North Texas Autism Project and now in Family Connections. Dr. Smith was instrumental in my undergraduate training and laid the foundation for my graduate career and for that I am grateful.

Dr. Jesus Rosales-Ruiz has been not only a professor, but a mentor, teaching me life lessons and a very unique approach to behavior analysis. I will always be inspired by your ways of looking at behavior, development, and life and am forever grateful for the opportunity to know you. Finally, I would like to thank my mother, the person I cherish most in this world. Her love, support, and dedication made this possible.
TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS ........................................................................................................ii

LIST OF ILLUSTRATIONS ............................................................................................iv

Chapter

1. INTRODUCTION ....................................................................................................... 1

2. METHODS ............................................................................................................... 9
   Participants and Settings ......................................................................................... 9
   Materials ............................................................................................................... 9
   Behavioral Measures and Recording Procedures ........................................... 11
   General Procedures ............................................................................................. 13
   Experimental Tasks and Conditions ................................................................. 14
   Design .................................................................................................................... 19

3. RESULTS .............................................................................................................. 20
   Measures of Component and Composite Quality .............................................. 20

4. DISCUSSION ....................................................................................................... 39

REFERENCES ............................................................................................................ 60
# LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
</tr>
<tr>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
</tr>
<tr>
<td>4.</td>
</tr>
<tr>
<td>5.</td>
</tr>
<tr>
<td>6.</td>
</tr>
<tr>
<td>7.</td>
</tr>
<tr>
<td>8.</td>
</tr>
<tr>
<td>9.</td>
</tr>
<tr>
<td>10.</td>
</tr>
<tr>
<td>11.</td>
</tr>
<tr>
<td>12.</td>
</tr>
<tr>
<td>13.</td>
</tr>
<tr>
<td>14.</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Recent estimates of handwriting difficulties among children attending schools in urban areas in the United States range from 12% to 21%, although estimates have been as high as 44% (Graham, 1996). For the large majority of children with handwriting problems it is usually impossible to identify with any certainty the underlying etiology. Handwriting problems are often diagnosed as dysgraphia, and it is thought that poorly arranged learning conditions may contribute to or be the sole cause of writing difficulties (Towle, 1978). Hamstra-Bletz and Blote (1993) describe dysgraphia as being a written-language disorder that concerns mechanical writing skill. It manifests itself in poor writing performance in children of at least average intelligence who do not have a distinct neurological disability and/or an overt perceptual-motor handicap.

Currently, it is estimated that 30-60% of a child’s school day is spent performing tasks consisting primarily of handwriting (Rosenblum, Weiss, and Parush, 2003). With no effective substitute for handwriting in place, participants are required and often struggle to produce written text. Difficulties with handwriting interfere with the execution of composing processes during the act of writing. These difficulties may lead young children to avoid writing and develop a mind-set that they cannot write, resulting in arrested writing development (Graham, Harris, and Fink, 2000). The mastery and automatization of handwriting skills are important prerequisites to a participant’s development as a competent writer. For beginning writers, both handwriting and spelling contribute directly to compositional fluency, with handwriting contributing more than spelling to the amount of text that is written (Graham, Berninger, Abbott, Abbott, and
Whitaker, 1997). The importance of handwriting skills actually increase over time and accounts for 25% and 42% of the variability in writing quality at the primary and intermediate grades, respectively (Baker, Gersten, and Steve, 2003). Children’s handwriting competence can further affect how long it takes to complete written assignments, their facility at taking notes during lectures, and how frequently they write (Graham and Weintraub, 1996).

Struggling writers are more likely to become good writers if they get help early on, in the primary grades, before their difficulties become more intractable (Troia and Graham, 2003). For example, Graham (2000) reports that handwriting instruction resulted in immediate as well as long-term improvements in participant’s compositional fluency skills. Therefore, if educators want to improve composition skills of participants, they need to focus not just on the content and process of writing, but on transcription skills such as handwriting. Many schools teach composition using systems that rely on indirect rather than direct methods of instruction and assume that mechanical skills (handwriting and spelling) will develop naturally if participants are provided plenty of opportunities to read and write for real purposes. Graham et al. (1996) reports that teachers typically spend 30 to 60 minutes per week teaching handwriting and only 36% of teachers indicated that they received formal training in handwriting instruction. Unfortunately, instruction for handwriting does not match its importance. The time frame allotted to handwriting instruction mentioned above is not problematic if the instruction is systematic and effective. However, given the lack of teacher training in effective handwriting instruction, the time allotted and the methods of instruction are not producing the desired outcome of neat handwriting.
Systematic and effective handwriting instruction is needed because handwriting legibility can affect students' educational placement, influence others' perceptions about one's competence, and effects communication and success in the workplace. Given the current state of handwriting in America, the College Board Online® announced in 2006 that the SAT (Standardized Achievement Test) used as a college entrance exam had added a writing section to the test (The College Board Online, New York, New York, www.collegeboard.com). The College Board believed that the addition of writing encouraged and supported the teaching of writing at every grade level and sent a strong message about its importance. "The addition of writing has made the SAT a better measure of the skills students need to succeed in college and later in life. We will continue to work with schools and colleges to encourage high standards and a greater focus on writing in the classroom," said Gaston Caperton, president of the College Board (The College Board, 2006). For the written portion of the exam, students are required to write an essay. As SAT scores are a major determinant of which colleges students can apply to and are likely to be accepted in, it is important that handwriting is adequate to write a legible essay. In addition, as handwriting is a prerequisite for composing, better handwriting can allow students to focus on the content of the essay as opposed to the mechanical motor skill, which may increase the quality. Previous research suggests that better handwriting receives better scores. When teachers evaluate two or more versions of a paper differing only in their legibility, neatly written papers are assigned higher marks for composing quality than papers of poorer penmanship (Graham and Berninger, 1998; Graham et al. 2000). Therefore, the neatness of the handwriting may affect the score awarded to the essay. In addition,
poor handwriting can affect communication and effectiveness in the workplace. In the case of doctors, who are notorious for poor handwriting, this deficit poses a threat to the health and welfare of their patients. In the event that a prescription, instructions for treatment, or medical records are illegible, the consequences can be life threatening.

Given the importance of legible handwriting in life, suggests that legible handwriting may be a cusp. What makes a behavior a cusp is that it exposes the individual’s repertoire to new environments, especially new reinforcers, new contingencies, new responses, new stimulus controls, and new communities of maintaining contingencies, which expands the individual’s repertoire. (Rosales and Baer, 1997). The ability to write legibly increases the amount and type of academic tasks that can be completed, other's evaluation of the quality of those tasks, placement and success in higher education and adult life, and overall independent functioning.

Unfortunately, handwriting is a behavior that receives little direct instruction in most schools, but can be attributed to many of the academic deficits that students face and may now affect their college and life placement. The current study was conducted in an attempt to find a simple, effective, cost-efficient, and quick solution to remediate handwriting.

Due to the lack of research on how to teach and remediate handwriting skills, many educators and parents encourage participants to use word processors in lieu of handwriting because the information can be more easily read. However, MacArthur and Graham (1987) conducted a comparative study of handwritten and word-processed stories. Although many of the participants reported a preference for composing on the word processor because the output was much neater and easily read by others, the
stories written did not differ in length, quality, story structure, mechanical or grammatical errors, or vocabulary. In addition, word processing was less than half as fast as handwriting. Therefore, word processing does not seem to be an effective or time-efficient replacement for handwriting.

The literature reviews different types of handwriting instruction which include: teacher modeling, behavioral techniques such as reinforcement, feedback, and self-evaluation, self-regulation procedures which include verbalizing the formational process while writing the letter, tracing, copying letters, computer-assisted handwriting instruction; cuing difficult letter parts; prewriting exercises, and evaluative overlays to name a few. Many techniques have been used and suggested but few systematic handwriting procedures have empirically proven to be effective.

The use of evaluative overlays is a promising technique that may be most useful during the initial acquisition stage of handwriting and as a tool for self-evaluation (Graham et al., 1996). Overlay training, also known as correct/incorrect scoring procedures typically assess topographic features such as shape and/or descriptive criteria to determine if specified standards of performance are met (Graham et al., 1996; Rosenblum et al., 2003). In past research, evaluative overlays were used as an evaluation or scoring tool by educators and experimenters (Trap et al., 1978; Graham, 1986; Helwig, Johns, Norman, & Cooper, 1976). These studies demonstrated that reliable measurement of letter strokes is possible with evaluative overlays. Interobserver agreement measures have ranged from .86 to .97, and raters agree that the procedure is accurate, reliable, and easy to learn. Novice evaluators can be trained in a short amount of time, as little as 30 minutes to use and score participant samples.
Evaluative overlays offer effective and reliable evaluation not just by educators and experimenters, but also for school-aged children who are in need of handwriting instruction. In several studies, participants have been taught to effectively evaluate their own handwriting using the evaluative overlays (Jones et al., 1977; Le Page, 2001; and Strickland, 2004). This is an important finding because the ability to respond differentially to poorly formed and well-formed manuscript letters is considered a prerequisite, which enables the child not only to correct and reinforce his own written responses but to work independently (Rayek et al., 1972). Similarly, Potts, Eshleman, and Cooper (1993) found that self-evaluation is cost effective, reliable, produces better learning than a teacher-evaluated system and gives the learner ownership of their performance. The cost for producing overlays and other materials should be within the reach of all school systems and classrooms, regardless of size or budget. (Helwig et al., 1976; Graham, 1986; Trap, Milner-Davis, Joseph, and Cooper, 1978). Children must develop the capacity for independently evaluating and improving their handwriting. Teachers can assist in this development by immediately reinforcing qualitatively superior handwriting attempts and asking participants to apply similar criteria while making their own judgments (Troia and Graham, 2003).

LePage (2001) and Strickland (2004) expanded on previous research and modified the evaluative overlays so they can be used as an instructional tool. These experimenters cut a small square out of the overlay next to the model letter and participants were asked to write their response within the borders of the square. This simple modification allowed the participant’s written response to be constrained and quickly self-evaluated. The response constraint and immediate visual feedback proved
to be an effective and economical intervention for improving letter quality and to
remediate letter and number reversals. Strickland (2004) found that the improvements
maintained after the evaluative overlay had been faded.

In previous studies using overlay training (LePage, 2001; Strickland, 2004), with
the exception of Jones, Trap, and Cooper (1977), letters were trained as a single unit.
The current study is interested in breaking down the letters into their components and
using the evaluative overlays to train accurate component writing. This modification was
made as an attempt to make the intervention more economical than LePage (2001) and
Strickland (2004) and to test if training component writing would produce as much
change in letter writing as training the whole letter. Graham et al. (1996) states that
single strokes and combinations of strokes are the basic unit of handwriting, the
components. Several popular handwriting systems also utilize procedures designed to
increase the fluency of component, not composite, performances. These handwriting
systems break down handwriting into component sequences and composite response
classes (Binder, 1996; Johnson and Layng, 1996; Rayek and Nesselroad, 1972;
Haughton, 1999; Becht, 2000; Olsen, 2001). Component sequences include writing
strokes such as vertical, horizontal, diagonal, and curved lines, which are the basic
strokes of letters. Alternatively, composite response classes include combining
component sequences to make a more complex response, namely letters of the
alphabet. By teaching component skills, it is believed that writing neat composites,
written letters, will be more easily achieved. Research has demonstrated that progress
in complex tasks depends on high prerequisite skill performance (Johnson and Layng,
1992). The higher the prerequisite skill rates, the faster a complex skill will be learned
(Johnson and Layng, 1992; Binder, 1996). For example, in order to build fluency in oral reading, one must be able to say sounds and words quickly. In order to build fluency in composition, one must be able to copy letters and words quickly (Johnson and Layng, 1992). It is reasonable to conclude then, that in order to build fluency in letter writing, one must be able to copy letter components (strokes) quickly and accurately. Becht (2000) suggests that how legibly a writer forms letters is dependent on how well the writer has learned to form basic lines. Focusing on those basic lines allows the new writer the opportunity to successfully learn writing skills in small, obtainable steps. All lines are introduced before being used in letters and only one type of line is introduced at a time.

The purpose of this study was to improve fine motor control by training the letter components (strokes) to a mastery criterion and to evaluate the effect of training on the performance of letter writing. The experimental question is: does a handwriting system which focuses on training component strokes to mastery by using response constraint, self-evaluation, fading, and reinforcement effect the composite response of writing letters more accurately?
CHAPTER 2

METHODS

Participants and Setting

After obtaining informed consent from the school principal, teacher, and children’s parents, three male and one female were selected as participants. The participants attended a suburban, private elementary school. Participants 1 and 2 were seven years old and attended first grade. Participants 3 and 4 were six years old and attended kindergarten. All participants were right handed and typically developing. They were selected based on teacher recommendation and experimenter’s confirmation that each participant could independently write the letters of their name but did so in a sloppy fashion with need for improvement.

An unused classroom next door to the children’s classroom was used for the experiment. The room contained desks, chairs, academic materials, a piano, and an overhead projector. A small table was placed against a wall and two chairs were arranged on the same side of the table so that the participant and I could sit side by side. I sat to the left of the child and presented worksheets and overlays during each session. The participant and I were the only people present when sessions took place.

Materials

Materials used in the current study included mechanical pencils (Ticonderoga Sensematic medium 0.7 mm), handwriting worksheets, full name and isolated letters worksheet, components worksheet, component overlays, full name tracing evaluation
worksheet, component and letter tracing evaluation worksheet, stickers, and a small treasure chest with tangible items.

**Handwriting worksheet.** The handwriting worksheet was printed using landscape orientation and resembled writing paper from standard elementary school writing tablets. Writing spaces consisted of two solid lines, the headline and baseline, which were separated by a dashed mid-line. Spacing between the headline and baseline was 0.5 in. with the mid-line located equidistant between them. Each worksheet contained 11 rows of writing spaces separated by a 0.2 in. descender space below each baseline (See Figure 1).

**Full name and isolated letters worksheet.** The full name and isolated letters worksheet was the same as the handwriting worksheet with the exception that it was divided into two equal halves using a white vertical line. The worksheet also contained a typed sample of the child’s first and last name in the first writing space. In addition, each letter of the child’s name was typed in isolation, left justified, in consecutive writing spaces. Letter samples were typed using Century Gothic font with size 48 for uppercase letters and size 32 for lowercase letters (See Figure 2).

**Components worksheet.** The components worksheet was the same as the handwriting worksheet with the exception that it was divided into two equal halves using a white vertical line. The 10 components were typed, one per writing space and left justified, on both halves of the worksheet. Components were extracted from Century Gothic letters (See Figure 3).

**Component overlays.** A set of 10 transparent overlays were produced by laminating a transparency that was the same as the handwriting worksheet with the
exception that each writing space contained 1 of the 10 components extracted from Century Gothic font imposed over the lines. Each overlay was 4.75 in. by 0.9 in. and included a 0.5 in. by 0.5 in. square hole to the right of the printed component (See Figure 4).

**Full name tracing evaluation worksheet.** The full name tracing evaluation worksheet was the same as the handwriting worksheet with the exception that it was divided into two equal halves using a white vertical line and was printed on tracing paper (See Figure 5).

**Component and letter tracing evaluation worksheet.** The component and letter tracing evaluation worksheet was the same as the full name tracing evaluation worksheet with the exception that it also contained 132 boxes (11 horizontal rows and 12 vertical columns) which were printed over the writing spaces (See Figure 6).

Behavioral Measures and Recording Procedures

**Measures of component and composite quality.** Two different systems were used to evaluate the quality of component formation: correct/incorrect scoring and tracing evaluation. One system was used to evaluate the quality of the composite (letter formation): tracing evaluation.

**Correct/Incorrect Scoring of Components.** Evaluative overlays were used to score the topography of participants’ written components as correct or incorrect. A correct was scored when the participant’s written component was not visible when the component printed on the overlay was aligned with it. For straight lines, the written response had to also be a minimum of 3/4 of the size of the written model to be scored as correct. On
curved lines, only the arch of the written response need not be visible to be scored as correct. An incorrect was scored when the written component fell outside the boundaries of the headline and/or baseline that defined the writing space. An incorrect was also scored if a written response was visible outside the boundaries of the model and white space was visible between the written response and the model. To score an item, the child (with help from experimenter if needed) first placed the overlay so that the writing space on the overlay was aligned with the writing space on the worksheet. Next, the child (with help from experimenter if needed) ensured that the component printed on the overlay was aligned with the participant’s written component. The component was scored as correct or incorrect. The correct/incorrect scoring allowed evaluation of each written response per session.

**Tracing Evaluation of Component and Composite Formation.** To preserve the data, the participants’ written responses were traced onto tracing paper. The tracing evaluation was used to track progress and changes in accuracy by comparing directional orientation, size, slant, straightness, roundness, and smoothness, across sessions and to determine when new targets would be introduced into fading conditions. When tracing the components or letters, the experimenter aligned the writing spaces of the participant’s component or letter worksheet with writing spaces on the tracing evaluation worksheet. I then traced the first written response for all 10 components or all the letters in the child’s name that were written in isolation into a column on the tracing evaluation worksheet. The tracing evaluation only evaluated the first written response for each component per session. Each column represented one session and tracing was
completed for each session for components and during pre and post-tests for the letters.

I also traced the written response of the child’s full name on the full name tracing evaluation worksheet. When tracing the child’s full name, I aligned the writing spaces of the participant’s full name and isolated letters worksheet with writing spaces on the full name tracing evaluation worksheet. I then traced the full name horizontally across the tracing evaluation worksheet. Tracing was completed during pre and post-tests for the full name.

**Interobserver agreement.** Interobserver agreement (IOA) was assessed by having a second observer independently score the accuracy of letter components using evaluative overlays in 25% of all baseline, overlay training, maintenance, fading, and probe sessions. Reliability of the scoring procedures was determined by dividing the number of agreements by the total number of agreements plus disagreements, multiplied by 100. Mean agreement ranged from 88 to 94 % across the 4 participants.

**General Procedures**

Sessions were conducted four mornings per week and lasted approximately ten minutes. Teachers identified a convenient time for participants to leave the classroom to participate in sessions. During all conditions, participants received verbal praise, stickers, and the opportunity to choose a small tangible from a treasure chest at the end of each session.
Experimental Tasks and Conditions

**Pre-test/post-test.** Pre-test measures were obtained during the first three sessions of the experiment. Participants wrote all 10 components with a model present, full name and letters in isolation from dictation, and letters and full name with a model present. In the first session, I first greeted the participant, thanked the participant for agreeing to participate in the study, and engaged in pleasant, casual conversation for several minutes. I then informed the participant of the upcoming tasks by stating, “For the first three sessions, you will be writing lines, letters, and your full name as neatly as you can so I can have samples of your handwriting. Are you ready to begin?” Upon confirmation, I handed the participant a mechanical pencil and presented worksheets sequentially. No feedback was given regarding the child’s performance on any worksheet. Upon completion of each worksheet, I said, “Thank you.”

**Components with Model.** The experimenter placed a component worksheet on the desk and explained, “Now we will begin by writing some straight, diagonal, curved, and circular lines.” During the first session, I demonstrated how to complete the component worksheet by writing each component next to the model on the worksheet, progressing through all 10 sequentially. After the participant asked questions and vocalized that they understood what to do, I put a component sheet in front of the participant and instructed them to, “Write one of each line as neatly as you can.”

**Full Name from Dictation.** The experimenter placed a handwriting worksheet on the desk and explained, “Now, we will continue by writing your full name.” During the first session, I demonstrated how to complete the worksheet by writing her own name on the
first writing space. Once the child confirmed that they understood what to do, I instructed, “Write your name as neatly as you can” and dictated the child’s name.

**Letters of Name from Dictation.** The experimenter placed a letters in isolation worksheet on the desk and explained, “Now we will write the letters of your name one by one.” During the first session, I demonstrated how to complete the worksheet by spelling aloud and writing the letters in her own name. Once the child confirmed that they understood what to do, I instructed, "As I tell you a letter of your name, write that letter once, as neatly as you can in the writing space, then move down to the next writing space and write the next letter that I tell you.” I then dictated the letters in the child’s name.

**Full Name with Model and Letters of Name in Isolation with Model.** The experimenter placed a Full name and Isolated Letters worksheet in front of the participant and instructed, “Let's write your full name and the letters of your name one by one next to a typed sample.” During the first session, I demonstrated how to complete the worksheet by writing her full name and letters of name in isolation next to a typed model. Once the child confirmed that they understood what to do, I instructed the participant, “Write your full name and each individual letter next to the model as neatly as possible.”

**Baseline.** Baseline was the same as the components with model task given during pre-test.

**Overlay Training.** The experimenter placed a components worksheet in front of the participant and explained, “Now we will use this overlay to write lines.” During the first session only, I explained and demonstrated the overlay training procedure. I explained to the participant, “Line up the overlay with the lines on the worksheet, then write the
line that you see in the hole like this” while simultaneously modeling the procedure. The target component was written five times per session using the overlay and two sessions were conducted daily. Overlay training was introduced one component at a time. The order that components were introduced was vertical line, horizontal line, forward slash, backslash, large backward arch, large forward arch, small backward arch, small forward arch, large circle, and small circle.

**Self-Evaluation.** The experimenter explained self-evaluation procedures by stating, “You are also going to evaluate the lines that you wrote. After you line up the overlay and write the line in the hole, you will slide the overlay over the line that you wrote so that the sample line rests over yours. If you cannot see what you wrote, then it matches the model. If you can see what you wrote it doesn’t match. If it doesn’t match, please tell me why it doesn’t.” I modeled the procedures several times and demonstrated self-evaluation while asking the participants to help answer questions such as, “Does it match? What is different about my component? What is the same? How can I make mine match?” In addition, I modeled statements such as, “It matches” or “Let’s make the next one bigger, straighter, more curved, etc.” I then instructed, “Write the component as neatly as possible and then use the overlay to see if it matches the model.” The participant wrote the component and self-evaluated five times. The experimenter delivered praise for all self-evaluations during the first two sessions. Incorrect self-evaluations were discussed to ensure participants could identify what was a correct and incorrect written response. By the 3rd and 4th session, all participants were correctly self-evaluating all five written responses and praise was only delivered after the 5th self-
evaluation. Participants received praise and a sticker for having four or more correct written components and self-evaluations.

Components in overlay training had to reach a mastery criterion to move to the next phase. Mastery criterion was defined as: the written component matched the overlay model at least four out of five times for two consecutive training sessions. When mastery was achieved for the component in overlay training, the component moved into the maintenance condition and the experimenter initiated overlay training on the next component.

Component Maintenance. Each component entered the maintenance phase after it reached mastery criterion in overlay training. Component maintenance procedures were the same as overlay training procedures with the exception that the participant was required to write the component only until it matched the model on the overlay. If the first written response matched the model on the overlay, the participant did not have to continue to write the component. On the other hand, if it did not match, the participant continued to write and evaluate the written response until they correctly wrote the component. Components remained in the maintenance phase until all components had reached mastery criterion in overlay training.

Post-training probes with/without a model present. Post-training probes were the same as baseline procedures with the exception that probes with a model present had a typed sample of the component on the worksheet. Post-training probes were administered each session after the participant had attained mastery on all 10 components in overlay training. Components most consistently scored incorrect during probes were targeted in fading conditions first.
**Overlay fading.** After the participant had attained mastery on all 10 components in overlay training as well as completed a post-training probe, overlay fading was initiated. The evaluative overlay was faded using two steps. Two components were introduced into Fading 1 simultaneously and were chosen based on their performance during probes. Subsequent targets entered Fading 1 when the previous targets had entered Fading 2. Feedback and reinforcement for child’s performance is consistent with that in overlay training.

**Fading 1.** Participants were given a component worksheet and instructed to “Write the component as neatly as possible without the overlay and then use the overlay to see if it matches and tell me why or why not.” The target component was written five times per session. The participant remained in this condition until the participant could accurately write the component at least four out of five times for two consecutive fading sessions. Upon reaching criterion, the component entered Fading 2.

**Fading 2.** The participants were given a handwriting worksheet with no model of the component and then instructed to, “Write this component (and a model was briefly shown) as neatly as possible and then use the overlay to see if it matches and tell me why or why not.” The target component was written five times per session. The participant remained in this condition until the participant could accurately write the component at least four out of five times for two consecutive fading sessions. Once each of the 10 components had successfully reached criterion for Fading 1 and 2, post-test procedures were initiated.

**Post-test.** Post-test procedures were identical to pre-test procedures with the exception that the I did not model the procedures.
Design

The independent variable in this study was a training package containing response constraint, self-evaluation, reinforcement and a fading procedure. The effect of the training package on writing letter components was evaluated using a multiple-baseline-across components and a continuous probe design of components. The effect of the training package on letter and name writing were evaluated using pre-test, baseline, and post-test measures.
Measures of Component and Composite Quality

Figure 7 shows the correct and incorrect performance of participants during pre-test, baseline, overlay training, maintenance, post-training probe, and post-test of written components. Grey boxes represent correct responses and white boxes represent incorrect responses. Each box represents the score of the first written response during each session. The x-axis represents consecutive sessions and the y-axis represents the 10 components. Bold black lines and a space separate phases. All boxes below and to the left of the bolded black outlined boxes represent baseline. The bolded black outlined boxes indicate that a component was in overlay training. The boxes above and to the right of the overlay training boxes represent maintenance.

Participant 1 responded correctly two times to 2 of the 10 components, one time to 4 of the 10 components, and never correctly to 4 of the 10 components during pre-test. During baseline, performance remained inconsistent with only occasional correct responses. During pre-test and baseline, two components were never correct, the backslash and the large circle. During overlay training, accuracy immediately increased and met criteria in the minimum time required, two sessions, for 7 of the 10 components. One additional training session was necessary for the large backward arch, and two for the vertical line and large forward arch. During maintenance, Participant 1 continued responding correctly with few, inconsistent errors. During the post-training probe, all components were correct with the exception of the horizontal
line. During post-test, Participant 1 consistently responded correctly to eight of the 10 components, and one time to the large backward arch and the large circle.

Participant 2 consistently responded correctly for 2 of the 10 components, two times to 3 of the 10 components, one time to 3 out of 10 components, and was never correct with 2 of the 10 components during pre-test. During baseline, performance remained inconsistent. The forward slash was consistently correct during pre-test yet during baseline was never correct. The large circle was never correct in both pre-test and baseline. During overlay training, accuracy immediately increased and was meeting criteria in the minimum time required, two sessions, for 7 of the 10 components. One additional training session was necessary for the backslash, and two for the forward slash and large forward arch. During maintenance, Participant 2 continued responding correctly with few errors. During the post-training probe, 7 of the 10 components were correct with the exception of the forward slash, small forward arch, and large circle. During post-test, Participant 2 consistently responded correctly to 3 out of 10 components, two times to 2 of the 10 components, one time to 4 out of 10 components and never correctly to one component, the large circle.

Participant 3 responded correctly one time to 3 out of 10 components, and never correctly to 7 of the 10 components during pre-test. During baseline, performance remained incorrect with few corrects. Five of the 10 components that were never correct during pre-test continued to be incorrect during baseline: the forward slash, large forward arch, small backward arch, and the large and small circles. During overlay training, accuracy immediately increased and was meeting criteria in the minimum time required, two sessions, for six of the 10 components. One additional training session
was necessary for the backslash and large backward arch, six for the forward slash, and seven for the large circle. During maintenance, Participant 3 continued responding correctly with some errors. During the post-training probe, 3 of the 10 components were correct, the horizontal line, large backward arch, and small backward arch. During post-test, Participant 3 consistently responded correctly to 4 of the 10 components, two times to 2 of the 10 components, and never correctly to 4 of the 10 components, the forward slash, the large forward arch, and the big and small circles.

Participant 4 responded correctly one time to 2 out of 10 components, and never correctly to 8 of the 10 components during pre-test. During baseline, performance remained incorrect with few corrects. Three of the 10 components were never correct in pre-test and baseline, the forward slash, large forward arch, and large circle. During overlay training, accuracy immediately increased and was meeting criteria in the minimum time required, two sessions, for three of the 10 components. One additional training session was necessary for the large backward arch and the small circle, two for the vertical line and large circle, 4 for the horizontal line and forward slash, and 13 for the large forward arch. During maintenance, Participant 4 continued responding correctly with frequent errors. During the post-training probe, 4 of the 10 components were correct, the horizontal and vertical lines, the forward slash, and large backward arch. During post-test, Participant 4 responded correctly two times to 4 of the 10 components, one time to 1 of the 10 components, and never correct to five of the 10 components, the large forward and backward arches, the small backward arch, and the big and small circles.
Figure 8 shows trial-by-trial cumulative records of the repetitions of written components during Fading 1 and Fading 2. The x-axis represents the components. The y-axis represents the cumulative number of correct responses. Fading 1 is designated by a grey circle and Fading 2 is designated by a black circle. A horizontal shift in data points shows incorrect performance and a vertical shift shows correct performance.

For Participant 1, 8 of the 10 components met criteria in the minimum time required, two sessions during Fading 1 and two sessions during Fading 2 and two components required additional training sessions. The backslash required one additional session during Fading 1 and the large circle required three additional sessions of Fading 1 and one additional session of Fading 2.

For Participant 2, eight of the 10 components met criteria in the minimum time required and two components required additional training sessions. The large circle required 11 additional sessions of Fading 1 and 3 additional sessions of Fading 2 and the small circle required one additional session of Fading 1.

For Participant 3, six components met criteria in the minimum time required and five components required additional fading sessions. The large backward arch required one additional session of Fading 1, the horizontal line required two additional sessions of Fading 1, the small circle required four additional sessions of Fading 1, and the backslash required five additional sessions of Fading 1 and two additional sessions of Fading 2.

For Participant 4, six components met criteria in the minimum time required and four components required additional fading sessions. The small circle required two additional sessions of Fading 2, the large forward arch required one additional session
of Fading 1 and two additional sessions of Fading 2, the large backward arch required
four additional sessions of Fading 1, and the large circle required seven additional
sessions of Fading 1 and one additional session of Fading 2.

Figure 9 shows tracings of components written by the participants during pre-test,
the post-training probe, and post-test when a model was present. Each column shows
the participant’s written responses on the component worksheet. All components were
evaluated for their directional orientation, size, and smoothness of the stroke. In
addition, the vertical and horizontal lines were evaluated for straightness, diagonal lines
for straightness and slant, large and small arches and large and small circles were
evaluated for their roundness.

For Participant 1, tracings show that directional orientation and size was correct
for all components during pre-test. All strokes in pre-test, especially the horizontal and
diagonal lines, small arches, and large and small circles were rough. The straightness
of the vertical and horizontal and forward and backward diagonal lines, the slant of the
forward and backward diagonals, and the roundness of the large and small arches and
large and small circles were inconsistent. During probe and post-test, the accuracy of
directional orientation and size were maintained and the smoothness of all strokes
showed improvement, especially the diagonals and large and small circles. The
straightness of the vertical and horizontal and forward and backwards diagonal lines,
the slant of the forward and backward diagonal lines, and the roundness of the large
arches improved during the probe and further improved during post-test. The
roundness of the small arches showed improvement during probe and maintained for
the small backward arch. The roundness of the large and small circles did not show improvement during probe but showed improvement during post-test.

For Participant 2, tracings demonstrate that directional orientation was correct for nine components during pre-test. The small backward arch was reversed two times during pre-test. The size of the components during pre-test was similar to the model. The smoothness of strokes was consistent during pre-test with the exception of the big and small circles. The straightness and slant of the forward and backward diagonal lines, the roundness of the large forward and backward arches and the small forward arches were consistent. Inconsistent performance occurred in the straightness of the vertical and horizontal lines and the roundness of the small backward arches and large and small circles. During probe and post-test, directional orientation and size was correct for all components. Smoothness of all strokes showed improvement during probe, especially the small arches and big and small circles. The straightness of the vertical and horizontal lines improved during probe but did not maintain in post-test. The straightness and slant of the forward and backward diagonals, the roundness of the large and small circles, and the roundness of the large arches improved during the probe and maintained during post-test. The roundness of the small arches maintained during probe and post-test with improvement shown in the small backward arch.

For Participant 3, tracings demonstrate that directional orientation was correct for all components during pre-test. The size of the components was correct for 7 of the 10 components, however, the forward and backslashes and the large circles were smaller than the model. Inconsistent performance during pre-test occurred in the smoothness of strokes, straightness of the vertical and horizontal and forward and backward diagonal
lines, the slant of the forward and backward diagonals, and the roundness of the large and small arches and large and small circles. During probe and post-test, directional orientation and size was correct for all 10 components. Smoothness of strokes showed improvement during probe and even greater improvement during post-test, especially the big and small circles. The straightness of the vertical, horizontal, and diagonal lines improved during probe but only maintained in the horizontal lines during post-test. The slant of the forward and backward diagonal lines improved during probe but did not maintain during post-test. The roundness in all curved components shows improvement during probe, and even greater improvement during post-test.

For Participant 4, tracings show that directional orientation was correct for all components during pre-test. The size of the components was inconsistent, as well as the smoothness of all strokes, the straightness of the vertical and horizontal lines, the straightness and slant of the forward and backward diagonal lines, the roundness of the large forward and backward arches and the small backward and forward arches, and the roundness of the large and small circles. During probe and post-test, directional orientation was correct for all components. The size of the components during probe and post-test became closer to the model but did not maintain in post-test. Smoothness of strokes improved most notably for the big and small circles. The straightness of the vertical and horizontal lines improved during probe but only maintained in the horizontal line during post-test. The straightness and slant of the forward and backward diagonals improved during probe and maintained during post-test. The roundness of the curved components shows some improvement during the probe but did not maintain during post-test.
Figure 10 shows tracings of the letters written in isolation with a model present during pre-test and post-test sessions. Each column represents one session.

For Participant 1, tracings show that directional orientation and size were correct for all letters during pre-test. The smoothness of all strokes and the straightness of the horizontal lines were inconsistent as well as the straightness of the vertical lines, most noticeably in the t and n. The straightness of the forward and backward diagonal lines was also inconsistent as shown in the W as well as the roundness of the letters as shown in the o and n. During post-test, the directional orientation and size maintained for all letters. The smoothness of all strokes improved most notably in e, g, h, t, o, and n. The straightness of the vertical lines improved most notably in h, t, and n. The straightness of the forward and backward diagonal lines improved and the slant became more similar to the model. The roundness of the g and o also showed improvement.

For Participant 2, tracings demonstrate that directional orientation and size were correct for all letters during pre-test. The smoothness of strokes was inconsistent and many letters contained extraneous marks as seen in the a, o, n, u, d, i, and l. The straightness of the vertical lines was inconsistent too especially for the n. The roundness of the letters was inconsistent for the letters a, o, n, and u. During post-test, the directional orientation maintained and the size of the letters decreased slightly from pre to post-test. The smoothness of strokes improved during post-test and the extraneous marks decreased for a, n, o, u, d, i, and l. The straightness of the vertical lines improved most notably in n, i, and l. The roundness of the letters maintained during post-test.
For Participant 3, tracings show that directional orientation and size was correct for all letters during pre-test. The smoothness of strokes was inconsistent and needed improvement. The straightness of the vertical lines was inconsistent most noticeably in the T, r, d, and i. The straightness of the horizontal lines was also inconsistent during pre-test in the T and e. The straightness of the backward diagonal lines was inconsistent as shown in the y. The roundness of the letters is inconsistent for the letters a, o, D, and c. During post-test, the directional orientation maintained for all letters. The size of the letters decreased for the r, D, and i. The smoothness of strokes improved most notably in the a and o and the straightness of the vertical lines maintained during post-test. The straightness of the backward diagonal lines improved and the slant became more similar to the model. The roundness of the a, o, D, and c show noticeable improvement and are more similar to the model during post-test.

For Participant 4, tracings show that directional orientation was correct for all letters during pre-test. The size of the letters was much larger than the model during pre-test. The smoothness of strokes was inconsistent and needed improvement especially the a, h, and r. The straightness of the vertical lines was inconsistent most noticeably in the h and r. The straightness of the horizontal lines and the straightness of the backward diagonal lines were inconsistent as shown in the letter Z. The roundness of the letters is inconsistent as shown in the a, c, and G. During post-test, the directional orientation maintained for all letters and the size of the letters decreased for a, c, h, r, y, and G. The smoothness of strokes improved during post-test most notably in the c and y. The straightness of the vertical lines showed some improvement for the r during post-
test. The straightness of the backward diagonal lines maintained and the roundness of the a was more similar to the model during post-test.

Figure 11 shows tracings of letters written by participants during pre-test and post-test sessions with no model present.

For Participant 1, tracings show that directional orientation and size were consistent during pre-test for all letters. The smoothness of all strokes was inconsistent, especially the g, o, and n. The straightness of the vertical lines was inconsistent most noticeably in the t and n. The straightness of the horizontal lines was inconsistent and the straightness of the forward and backward diagonal lines was also inconsistent as shown in the W. The roundness of the letters was inconsistent as shown in the h, o and n. During post-test, directional orientation and size was maintained for all letters. The smoothness of all strokes improved during post-test most notably in g, h, and n. The straightness of the vertical lines improved most notably in h, t, and n. The straightness of the forward and backward diagonal lines improved and the slant became more similar to the model. The roundness of the g, h, o, and n show improvement.

For Participant 2, tracings show that directional orientation was correct for all letters with the exception of one c and two d during pre-test. The size of the letters was similar to the model. The smoothness of strokes was inconsistent and many letters contained extraneous marks as can be seen in the a, o, n, u, d, i, and l. The straightness of the vertical lines was inconsistent especially for the J, d, i, and l. The roundness of the letters was inconsistent in the o, c, u, and d. During post-test, the directional orientation was correct for all letters and the size of the letters maintained during post-test. The smoothness of strokes improved during post-test for the o and l
and the extraneous marks decreased for a and i. The straightness of the vertical lines maintained during post-test. The roundness of the letters maintained during post-test.

For Participant 3, during pre-test tracings show correct directional orientation was correct for all letters. However, the size of the letters varied with some letters much smaller than the model. The smoothness of strokes was inconsistent, especially for the r, D, e, and t. The straightness of the vertical lines was also inconsistent most noticeably in the r, d, and i. The straightness of the horizontal lines was inconsistent for the e and t and the straightness of the backward diagonal lines was inconsistent as shown in the y. The roundness of the letters is inconsistent as shown in the a, o, and D. During post-test, the directional orientation and size maintained for all letters. The smoothness improved during post-test most notably in the r, y, l, e, and t. The straightness of the vertical lines maintained during post-test. The straightness of the backward diagonal lines improved and the slant became more similar to the model. The roundness of the a, o, and D, are more similar to the model during post-test.

For Participant 4, tracings show that directional orientation was correct for all letters during pre-test, with the exception of the h and the y. The size of the letters was larger than the model. The smoothness of strokes was inconsistent and needed improvement especially the a, h, and r, and y. The straightness of the vertical lines was inconsistent most noticeably in the h. The straightness of the horizontal lines was inconsistent for the letters Z and G. The straightness and slant of the backward diagonal lines was consistent. The roundness of the letters is inconsistent as shown in the a, c, y, and G. During post-test, directional orientation was correct for nine of the 10 letters, with the exception of the Z. The size of the letters decreased for a, c, y, and G. The
smoothness of strokes improved during post-test most notably in the a. The straightness of the vertical lines maintained during post-test. The straightness and slant of the backward diagonal lines maintained during post-test for the Z with the exception of the reversal. The roundness of the a and G was more similar to the model during post-test.

Figure 12 shows tracings of each participant’s full name written with a model present during pre-test and post-test sessions. Each row represents one session.

For Participant 1, tracings show that directional orientation and size was correct for all letters during pre-test. The smoothness of all strokes was inconsistent and needed improvement, especially the e, g, h, t, o, and n as well as the straightness of the vertical lines most noticeably in the letters I, h, t, and n. The straightness of the horizontal lines was inconsistent especially in the e and the straightness of the forward and backward diagonal lines was also inconsistent as shown in the W. The roundness of the letters was inconsistent as shown in the e, g, h, o and n. During post-test, the directional orientation and size maintained for all letters, although the spacing between letters significantly decreased. The smoothness of all strokes improved during post-test most notably in the o, n, W, h, i, and e. The straightness of the vertical lines improved most notably in t, n, and h. The straightness of the forward and backward diagonal lines improved significantly and the slant became more similar to the model as shown in the W. The roundness of the o showed improvement during post-test. Overall, pre and post-test measures show significant improvement in full name quality. Most noticeably, spacing of the letters decreased making for a more concise name sample.
For Participant 2, tracings demonstrate that directional orientation was correct for all letters, with the exception of the d which was reversed two times during pre-test. The size of the letters was consistent during pre-test. The smoothness of strokes was inconsistent and needed improvement, especially the d, i, and l as well as the straightness of the vertical lines most noticeably in the letters d, i, and l. The straightness of the horizontal lines was inconsistent as shown in the J and the roundness of the letters is inconsistent as shown in the a, C, and d. During post-test, the directional orientation was correct and the size of the letters of the last name decreased. The smoothness of strokes improved during post-test most notably in the d, i, and l. The straightness of the vertical lines improved most notably in the d, i, and l. The roundness of the a and c was more similar to the model during post-test. Overall, pre and post-test measures show improvement in full name quality.

Participant 3’s tracings demonstrate that directional orientation was correct for all letters although the size of the letters varied during pre-test. The smoothness of strokes was inconsistent in the letters o, r, and e as well as the straightness of the vertical lines most noticeably in the T, l, and i. The straightness of the horizontal lines was inconsistent in the e and the straightness and slant of the backward diagonal lines was inconsistent as shown in the y. The roundness of the letters is inconsistent as shown in the a, o, e, c, and h. During post-test, the directional orientation maintained for all letters, although size and placement of the letters was much more consistent resulting in a more uniform full name during post-test. The smoothness of all strokes improved during post-test most notably in the a, r, and h. The straightness of the vertical lines improved most notably in t, n, and h. The horizontal lines improved in the e. The
straightness of backward diagonal lines improved significantly and the slant became more similar to the model as shown in the y. The roundness of the a, o, e, and c showed improvement during post-test. Overall, pre and post-test measures show improvement in full name quality.

Participant 4’s Tracings demonstrate that directional orientation was correct for all letters with the exception of one a during pre-test. The size of the letters was consistently larger than the model and the smoothness of strokes was inconsistent for the a, c, h, r, and y. The straightness of the vertical lines was inconsistent most noticeably in the a, h, r, and y and the straightness of the horizontal lines was inconsistent during pre-test in the Z and G. The straightness and slant of the backward diagonal line was consistent as shown in the Z and the roundness of the letters is inconsistent as shown in the a, c, h, r, y, and G. During post-test, the directional orientation for all letters was correct and the size of the letters and spacing between the letters significantly decreased resulting in a more uniform full name. The smoothness of all strokes improved during post-test most notably in the a, h, and r. The straightness of the vertical lines improved most notably in the h, and r. The horizontal lines showed improvement in the G. The straightness and slant of backward diagonal lines maintained during post-test. The roundness of the a, and G were more similar to the model during post-test. Overall, pre and post-test measures show significant improvement in full name quality.

Figure 13 shows tracings of the participants’ full name written with no model present during pre-test and post-test sessions.
For Participant 1, tracings demonstrate that directional orientation and size was correct for all letters during pre-test. The smoothness of all strokes was inconsistent especially in the e, g, h, t, o, and n. The straightness of the vertical lines was inconsistent most noticeably in the L, h, t, and n. The straightness of the horizontal lines was inconsistent especially in the e and the t. The straightness of the forward and backward diagonal lines was inconsistent as shown in the W. The roundness of the letters is inconsistent as shown in the e, g, h, o and n. During post-test, the directional orientation and size maintained for all letters, although the spacing between letters significantly decreased. The smoothness of strokes improved during post-test most notably in the o, n, W, h, i, and e. The straightness of the vertical lines improved most notably in t, and n. The straightness of the forward and backward diagonal lines improved significantly and the slant became more similar to the model as shown in the W. The roundness of the o and h showed improvement during post-test. Overall, pre and post-test measures show significant improvement in full name quality. Most noticeably, spacing of the letters decreased making for a more concise name sample.

For Participant 2, tracings demonstrate that directional orientation was correct for all letters, with the exception of the d which was reversed three times during pre-test. The size of the letters was consistent during pre-test. The smoothness of strokes was inconsistent, especially in the a, u, i, and l. The straightness of the vertical lines was inconsistent most noticeably in the j, n, i, and l. The straightness of the horizontal lines was inconsistent as shown in the J. The roundness of the letters was inconsistent as shown in the a, o, and C. During post-test, directional orientation was correct for all components with the exception of one d and one i. The size of letters maintained during
post-test. The smoothness of strokes improved slightly during post-test, most notably in the u. The straightness of the vertical lines maintained during post-test. The roundness of the o and u was more similar to the model during post-test. Overall, pre and post-test measures show improvement in full name quality.

For Participant 3, tracings demonstrate that directional orientation was correct for all letters during pre-test. The size of the letters varied and the smoothness of strokes was inconsistent for the a, o, r, and h. The straightness of the vertical and horizontal lines was inconsistent most noticeably in the D and I. The straightness and slant of the backward diagonal lines was inconsistent as shown in the y. The roundness of the letters is inconsistent as shown in the a, D, e, c, and h. During post-test, the directional orientation maintained for all letters. Size and placement of the letters was more consistent resulting in a more uniform full name during post-test, with the exception of the third written response, which is smaller than the other two. The smoothness of all strokes improved during post-test most notably in the a, o, r, t, and h. The straightness of the vertical lines maintained during post-test. The horizontal lines improved in the e. The straightness of backward diagonal lines improved significantly and the slant became more similar to the model as shown in the y. The roundness of the a, o, D, and c showed improvement during post-test. Overall, pre and post-test measures show improvement in full name quality.

For Participant 4, tracings demonstrate that directional orientation was correct for all letters during pre-test. The size of the letters was consistently larger than the model and the smoothness of strokes was inconsistent for the a, h, and r. The straightness of the vertical lines, most noticeably in the a, y, and r and the straightness of the horizontal
lines in the letters Z and G were inconsistent. The straightness and slant of the backward diagonal line was consistent as shown in the Z. The roundness of the letters is inconsistent as shown in the a, c, h, r, y, and G. During post-test, the directional orientation for all letters was correct. The size of the letters significantly decreased as well as spacing between the letters resulting in a more uniform full name. The smoothness of all strokes most notably in the a, h, r, and y and the straightness of the vertical lines most notably in the h, r, and y improved during post-test. The horizontal lines showed minor improvement in the G. The straightness and slant of backward diagonal lines maintained and the roundness of the a, c, and G were more similar to the model during post-test. Overall, pre and post-test measures show significant improvement in full name quality.

Figure 14 shows the total number of repetitions of components written by participants throughout the study. The x-axis represents the 10 components. The y-axis represents the total number of responses. The stacked bar graph is divided into 5 sections with different patterns. The black data series represents the number of trials completed during baseline. The grey data series represents the number of trials completed during overlay training. The white data series represents the number of trials completed during the maintenance condition. The black and white horizontal line data series represents the number of trials completed during the fading condition. Finally, the white with black dot data series represents the number of trials completed during probe conditions.

Due to the multiple baseline design, the baseline and maintenance trials completed vary for each component. Components that were introduced to overlay
training first had shorter baselines than components introduced to overlay training later. Components that were introduced into overlay training first had more repetitions during the maintenance condition than components introduced into overlay training later.

For Participant 1, the total number of repetitions per component ranges from 110 to 126 with the large circle requiring the most repetitions. Baseline repetitions range from 3 to 26 and overlay training repetitions vary from 10 to 20 trials with the vertical line and large forward arch requiring the most repetitions. Maintenance repetitions range from 0 to 21, fading repetitions range from 20 to 40 with the large circle requiring the most repetitions, and probe repetitions range from 49 to 54.

For Participant 2, the total number of repetitions per component ranges from 118 to 174 with the large forward arch and the forward slash requiring the most repetitions. Baseline repetitions range from 3 to 26 and overlay training repetitions vary from 10 to 20 trials with the forward slash and large forward arch requiring the most repetitions. Maintenance repetitions range from 0 to 23, fading repetitions range from 20 to 90 with the large circle requiring the most repetitions, and probe repetitions range from 48 to 62.

For Participant 3, the total number of repetitions per component ranges from 121 to 157 with the forward slash requiring the most repetitions. Baseline repetitions range from 3 to 36 and overlay training repetitions vary from 10 to 45 trials, with the forward slash and the large circle requiring the most repetitions. Maintenance repetitions range from 0 to 33, fading repetitions range from 20 to 55 with the backslash and small circle requiring the most repetitions, and probe repetitions range from 48 to 55.

For participant 4, the total number of repetitions per component ranges from 136 to 200 with the large forward arch requiring the most repetitions. Baseline repetitions
range from 3 to 47 and overlay training repetitions vary from 10 to 75 trials with the horizontal lines, the forward slash, and the large forward arch requiring the most repetitions. Maintenance repetitions range from 0 to 43, fading repetitions range from 20 to 65 with the large backward and forward arches and the large circle requiring the most repetitions, and probe repetitions range from 49 to 58.
The results of this study show that response constraint and self-evaluation quickly improved students’ performance in writing components. Fading of the intervention was achieved quickly and performance maintained. Results also show that improvement in component writing improved whole letter and full name writing and letter reversals in the presence of a model were corrected. The intervention is economical in terms of materials needed, time required, and repetitions of written responses. The total number of repetitions of written responses varied from 110 to 200 per component, which is very few compared to the number of written responses students complete during a school day.

This study replicates and expands previous studies by LePage (2001) and Strickland (2004). These studies showed that response constraint and self-evaluation greatly improved the accuracy of letter writing. In addition, letter reversals were corrected when the model was present in LePage (2001). Strickland (2004)’s program corrected reversals in the presence of the model and in its absence, as well as, in application tasks. The present study showed similar results.

A difference between this study and LePage (2001) and Strickland (2004) is that their improvements in accuracy of letter writing were slightly better. This may be attributed to several reasons. First, previous studies trained the whole letter, not the components of the letters. Their training was aimed at matching the shape of particular letters. As seen in LePage (2001), written responses became very similar-looking to the typed models used during training, even containing font specific strokes. In the current
study, letters were not trained directly to a particular letter model and that may account for the differences in letter accuracy. This suggests that it may be beneficial to directly train the composite. However, since the components also significantly improved the accuracy of letter writing, it may be more economical and more effective to begin the training with the components. If greater accuracy is required, it is recommended to combine the training of the components and the whole letters into one training package. Letter family training can be a nice compliment to component training. Letters containing common components and formational characteristics can be grouped into “letter families” and taught together (Rayek et al., 1972; Graham et al., 2000).

Another reason why the accuracy was slightly better in LePage (2001) and Strickland (2004) may be because the size of the model on the overlay allowed for response deviation and may have affected the accuracy of the composite. A 3 mm criterion was used to score the components as correct or incorrect during overlay training and fading. As shown in LePage (2001) a 3 mm criterion for evaluating accuracy increases the number of written responses that are correct, as compared to a 1 mm criterion, but results in less “perfect” written responses. For example, when scoring a horizontal component, often the component was slanting downward and was more diagonal than horizontal. However, when the evaluative overlay was placed on top of the written response, there was no sight of the written response and it was therefore counted correct. As a less stringent scoring system was used and allowed for response deviation in components, it is reasonable to conclude that this deviation would result in a less accurate written composite. To effectively train components to be very precise and to perfectly match the model, it would be important to integrate thinner models (2
mm and then 1 mm) on overlays during fading as an extra step to refine written components. However, with too stringent of a criteria students may require more time to advance through the treatment package resulting in a less economical intervention and one that may produce slightly more accurate responses but at the expense of the students’ success and enjoyment.

Another variable that may have affected the quality of handwriting especially in the probes and post-test was the motivational system. In this study, participants were able to discriminate when a contingency for advancement and reinforcement was in effect and performed differently which may have affected letter accuracy. The evaluative overlay and feedback were used during overlay training, maintenance, and Fading 1. During these conditions, accurate performance was required to progress through the training sequence. Participants learned to discriminate that no contingency was in place unless the overlay was being used and feedback was being delivered. Therefore, even though the experimenter asked participants to write as neatly as possible, when the overlay was not being used, students often hurried to finish and did not attend to the accuracy of the written response. As no overlay was used during post-test, the students may have detected that a contingency was not in place and therefore may not have attended to the accuracy of written letters and full-name in the same way as if a contingency was in place.

Interestingly, an improvement in letter reversals was seen from pre to post-test measures without ever training the letters or targeting directional orientation. Results show that all reversals shown during pretest of letters in isolation and full-name with and without a model present, with the exception of one, were corrected during post-test.
During pre-test reversals occurred for Participant 2 who reversed three letters during letters with no model present, two letters during full name with model present, and three letters during full name with no model present. During post-test for Participant 2, all reversals were corrected with the exception of one during full name with no model present. During pre-test, Participant 4 reversed two letters during letters with no model present and one letter during full name with model present. During post-test for Participant 4 all reversals observed during pre-test were corrected (although a new reversal, not seen during pre-test, was made by Participant 4). Results show that participants benefited from having a model present. These results are similar to LePage (2001) in which reversals occurred with and without a model present during pre-test but were corrected when a model was present during post-test. Strickland (2004), corrected letter reversals by training directional orientation of the whole letter to accuracy. The current study shows that training directional orientation of components to accuracy was also effective in correcting all but one letter reversal. These findings are significant and warrant further research.

Transparent overlays have consistently shown to be effective in the remediation of handwriting and as a self-evaluation tool. However, as an evaluative tool, overlays have been used with an “all or none” criterion. To ensure that students are successful and enjoy the training process, the stringency of the accuracy criterion should be based on the skills of the child’s ability to write components upon entry and how sensitive the child is to evaluative feedback. For example, a child who is making progress but is still receiving incorrect scores in the “all or none” scoring system may begin to respond emotionally. In the current study, each child had at least one component that was more
difficult and required more time and repetitions to write accurately. If a student is making progress and improving component writing over time, yet the performance is scored as incorrect, the child can start to respond emotionally. If the student is unsuccessful during self-evaluations with a 3 mm model, the experimenter can start with a thicker model and fade to a thinner model over time. This option may prevent emotional responding from occurring by increasing the success of the student and reinforcement provided. Previous research on evaluative overlays has found that they are not especially sensitive in detecting subtle changes in performance and may be overly sensitive to differences in handwriting style. (Graham, 1996; Rosenblum et al., 2003). By utilizing a shaping procedure of using thicker models and fading to thinner models, overlays can be more sensitive to the child’s entry-level handwriting style and reinforcement can be provided for improved performance.

To further increase the economy of the training and to ensure that this intervention is user friendly for teachers, a modification was made in the overlay of this study from previous studies. The current study used overlays without vertical slit cuts and full-page worksheets for the students to write on. LePage (2001) and Strickland (2004) used evaluative overlays that had 25 mm vertical slit cuts within 25 mm of each of the horizontal ends of the overlay. These slits held a paper strip in place that the student wrote responses on. The current study did not include the vertical slit cuts or the use of paper strips. I had conducted a previous study using the vertical slit cuts and paper strips and found it to be cumbersome. Paper strips needed to be cut to an exact size or the overlay would not line up correctly with the lines on the paper strips and would also be difficult to feed through the vertical slit cuts. Although the current process
seemed to save time and was easier to implement, the children still had difficulty aligning the lines on the overlay with the lines on the worksheets at times. The experimenter would adjust the overlay in this event to ensure alignment. Therefore, eliminating the slits seems to be an improvement but further modification is needed to ensure that the student can quickly and independently align the lines on the overlay with the lines on the worksheets.

Although accuracy should be the first goal for handwriting, being able to write quickly while maintaining accuracy should be a second goal. Graham (1996) reviewed handwriting research and found that competence in handwriting is usually described in terms of legibility and speed. Accuracy is not a sufficient criterion for mastery. For some children, training handwriting to accuracy followed by practice alone may produce faster rates of handwriting. Once the mechanics of writing are mastered, the rate usually improves accordingly (Towle, 1978). However, some students may need speed to be targeted for increase formally. Future research should focus on incorporating fluency-based procedures to help students learn to write more quickly. Binder (1996) defines fluency as the fluid combination of accuracy plus speed that characterizes competent performance. Fluent behavior is flowing, effortless, well practiced and accurate (Johnson and Layng, 1996). Future research should include training participants to write the letters of the alphabet to fluency, or a predetermined rate per minute. Haughton (1999) identifies letter fluency as writing uppercase letters 50 or more repetitions per minute and writing lowercase letters 100 or more repetitions per minute. Although Haughton’s recommendations can be used as a guide, it is recommended to set the fluency rate by collecting a rate per minute sample of writing by students of the same
age who are in the same class, and whose handwriting is accurate and of adequate speed to take notes during class.

The current study demonstrates that evaluative overlays offer an effective, cost-efficient and reliable intervention to improve motor control with a writing instrument and writing skills by constraining participants’ handwritten responses and allowing for self-evaluation. As individuals, we all have a unique writing style. It is important that children be trained to write accurately and quickly and then be allowed to develop their personal flare. As Blote and Hamstra-Bletz (1991) states, children have to first learn the skill of writing, and after that, when formal instruction in handwriting has stopped, the script continues to change as they adopt a more efficient movement strategy and develop their personal writing styles. Handwriting is an important skill that will affect people in their schooling, careers, and in people’s perceptions of one’s competence. It is important that an economical, systematic, and effective intervention be provided in early childhood to ensure that the child’s handwriting will afford them success in their endeavors.
Figure 1. Handwriting worksheet.
Leighton White

L

e

i

g

h

i

t

o

n

W

Figure 2- Full name and isolated letters worksheet
Figure 3. Components worksheet.
Figure 4. Evaluative Overlay.
Figure 5. Full name tracing evaluation worksheet.
Figure 6. Component and letter tracing evaluation worksheet.
Figure 7. Correct and incorrect performance of written components during pre-test, baseline, overlay training, maintenance, post-training probe, and post-test for Participants 1-4.
Figure 8. Trial by trial cumulative records of the repetitions of components written during Fading 1 and Fading 2 for Participants 1-4.
Figure 9. Tracings of components written with a model present during pre-test, the post-training probe, and post-test sessions with a model present by Participants 1-4.
Figure 10. Tracings of letters written with a model present during pre-test and post-test sessions by Participants 1-4.
Figure 11. Tracings of letters written with no model present during pre-test, the post-training probe, and post-test sessions by Participants 1-4.
<table>
<thead>
<tr>
<th>Model</th>
<th>Participant 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Pre-Test</strong></td>
</tr>
<tr>
<td></td>
<td>Leighton White</td>
</tr>
<tr>
<td></td>
<td>Leighton White</td>
</tr>
<tr>
<td></td>
<td>Leighton White</td>
</tr>
<tr>
<td></td>
<td><strong>Post-Test</strong></td>
</tr>
<tr>
<td></td>
<td>Leighton White</td>
</tr>
</tbody>
</table>

|                | **Pre-Test**                                                                  |
|                | Jason Caudill                                                                |
|                | Jason Caudill                                                                |
|                | Jason Caudill                                                                |
|                | **Post-Test**                                                                 |
|                | Jason Caudill                                                                |
|                | Jason Caudill                                                                |

|                | **Pre-Test**                                                                  |
|                | Taylor Duetrich                                                              |
|                | Taylor Duetrich                                                              |
|                | Taylor Duetrich                                                              |
|                | **Post-Test**                                                                 |
|                | Taylor Duetrich                                                              |
|                | Taylor Duetrich                                                              |

|                | **Pre-Test**                                                                  |
|                | Zachary Grey                                                                 |
|                | Zachary Grey                                                                 |
|                | Zachary Grey                                                                 |
|                | **Post-Test**                                                                 |
|                | Zachary Grey                                                                 |
|                | Zachary Grey                                                                 |

**Figure 12.** Tracings of the participants’ full name written with a model present during pre-test and post-test by Participants 1-4.
No Model

Participant 1

<table>
<thead>
<tr>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leighton White</td>
<td>Leighton White</td>
</tr>
<tr>
<td>Leighton White</td>
<td>Leighton White</td>
</tr>
<tr>
<td>Leighton White</td>
<td>Leighton White</td>
</tr>
</tbody>
</table>

Participant 2

<table>
<thead>
<tr>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jason Caudill</td>
<td>Jason Caudill</td>
</tr>
<tr>
<td>Jason Caudill</td>
<td>Jason Caudill</td>
</tr>
<tr>
<td>Jason Caudill</td>
<td>Jason Caudill</td>
</tr>
</tbody>
</table>

Participant 3

<table>
<thead>
<tr>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taylor Dietrich</td>
<td>Taylor Dietrich</td>
</tr>
<tr>
<td>Taylor Dietrich</td>
<td>Taylor Dietrich</td>
</tr>
<tr>
<td>Taylor Dietrich</td>
<td>Taylor Dietrich</td>
</tr>
</tbody>
</table>

Participant 4

<table>
<thead>
<tr>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zachary Gray</td>
<td>Zachary Gray</td>
</tr>
<tr>
<td>Zachary Gray</td>
<td>Zachary Gray</td>
</tr>
<tr>
<td>Zachary Gray</td>
<td>Zachary Gray</td>
</tr>
</tbody>
</table>

Figure 13. Tracings of full name written with no model present during pre-test and post-test by Participants 1-4.
Figure 14. The total number of repetitions of written components throughout the study by Participants 1-4.
REFERENCES


