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An Investigatory Study of Relationships Among Selected Theoretical components of Letter-Writing fluency

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AN INVESTIGATORY STUDY OF RELATIONSHIPS AMONG SELECTED THEORETICAL COMPONENTS OF LETTER-WRITING FLUENCY

by

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ABSTRACT

An Investigatory Study of Relationships Among Selected Theoretical

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Research that shows the need for letter-writing fluency as a foundation for being able to attend to higher-level thinking skills in writing calls for more research as to what the components of letter-writing fluency actually are and how they are related to writing efficiency. This hierarchical multiple regression study entailed two parts.

First, results of assessments of three selected subskills of letter-writing fluency were analyzed to determine how much variance they contribute to the task of letter-writing fluency in 49 kindergarten students in December of their kindergarten year. The first assessed subskill was letter-naming fluency (LNF), which has previously been shown to be predictive of reading ability. The other two subskills that were assessed focus on critical features of letters: (a) letter construction of lowercase letters using physical manipulation and placement of critical features, and (b) critical feature production (CFP) in the form of writing pseudo-letters made up of the same critical

features as Roman alphabet letters. As LNF was suspected to be a strong indicator of letter-writing fluency, the other two subskills of critical feature identification and CFP were also analyzed to see how much variance they accounted for in LNF. LNF, CFP, and letter construction were shown to account for a total of 49% of the variance in the skill of letter-writing fluency.

LNF accounted for 39% and thus most strongly correlated with writing fluency. Letter construction using critical features and writing of pseudo-letters together added 10% more to the variance of letter-writing fluency. Critical feature identification and CFP were shown to account for 20% of the variance in LNF.

This study has implications for letter-writing instruction in early childhood education classrooms, including a strong emphasis on letter-naming activities in the early stages of letter writing. Exploratory, developmentally sensitive instruction may be beneficial involving early writers in activities that require identification, manipulation, and writing of basic critical features of letters. These instructional options are worthy of further research.

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PUBLIC ABSTRACT

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Research that shows the need for letter-writing fluency as a foundation for being able to attend to higher-level thinking skills in writing calls for more research as to what the components of letter-writing fluency actually are and how they are related to writing efficiency. To study the components of letter-writing fluency, four assessments were used to evaluate 49 kindergarten students' letter writing abilities. These assessments were made in December of their kindergarten year. The first assessed subskill was letter-naming fluency (LNF), which has previously been shown to be predictive of reading ability. The other two subskills that were assessed focus on critical features of letters: (a) letter construction of lowercase letters using physical manipulation and placement of critical features, and (b) critical feature production (CFP) in the form of writing pseudo-letters made up of the same critical features as Roman alphabet letters. As LNF was suspected to be a strong indicator of letter-writing fluency, the other two subskills of critical feature identification and CFP were also analyzed to see how much variance they accounted for in LNF. LNF, CFP, and letter construction were shown to have various

amounts of effect on the task of letter-writing fluency. The task of LNF was most strongly correlated with letter-writing fluency. The two tasks of lowercase alphabet letter construction using critical features and the writing of pseudo-letters containing critical features of alphabet letters together were only somewhat related to letter-writing fluency. These two tasks were more strongly related to the task of LNF than letter-writing fluency. This study has implications for letter-writing instruction in early childhood education classrooms, including a strong emphasis on letter-naming activities in the early stages of letter writing. Exploratory, developmentally sensitive instruction may be beneficial involving early writers in activities that require identification, manipulation, and writing of basic critical features of letters. These instructional options are worthy of further research.

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CHAPTER I

INTRODUCTION

In elementary schools across the nation there is an increased focus on writing in elementary curriculums, both quantitatively and qualitatively. Reflecting this change of instructional focus, the English language arts (K-12) *Common Core State Standards* (CCSS) have placed renewed emphasis on improving students'awriting to meet the goal of preparing college and career-ready students upon high school graduation (National Governor's Association & Council of Chief State School Officers, 2010). Students are being asked to write not only personal narratives, but expository texts across all subject areas. Even young students are expected to not just invent stories or use prior knowledge to retell experiences, but to use critical thinking skills and to cite evidence in making arguments. The purpose of this emphasis on improving writing achievement is to better prepare students for the kind of writing that will be required in the workforce and in college (Carr, 2014).

While the end goal is increased writing competency, the beginning of this process is learning to scribe—to write letters by hand. The Utah State Board of Education approved the inclusion of handwriting to the Utah Core standards in June 2013. The focus of this handwriting standard is to help students to develop fluent, automatic and legible handwriting as a foundational subskill of writing (Jones & Hall, 2013; Utah Core Language Standards, 2013).

There is research that warrants this addition of handwriting to the core standards. Peverly and colleagues (2007) studied the relationship of test performance to

transcription fluency among undergraduate college students. They then studied the relationship of note taking to test performance. From the results of their study, they suggest that transcription fluency is a very high predictor of school success. Yet Jones and Christensen (1999) noted how complex the writing task is for younger students. Given this complexity, it is crucial that writers be able to write letters and words automatically so as to free up attention and processing capacity to attend to the other cognitive demands of writing (Berninger et al., 1997). Graham and Weintraub (1996) described three important reasons why a focus on letter writing automaticity, often referred to as transcription fluency, is necessary. First, when a child's handwriting is very slow and laborious, attention is focused almost exclusively on letter transcription. When attention is primarily focused on letter transcription, the child may forget writing ideas before he/she can write them down as concentration is so heavily focused on forming letters correctly. Second, it is difficult to switch attention back and forth between the parallel writing processes of handwriting and composition planning. Third, laborious letter transcription can depress motivation as a child becomes frustrated with the writing process. Children's beliefs about their own writing capabilities will directly influence how often and how well they write (Graham & Weintraub, 1996).

Failing to gain writing skills early in elementary school can have very negative, long-term, academic consequences for students (Graham & Weintraub, 1996). This continues as students face the higher demands of writing necessary for college and career (Connelly, Dockrell, & Barnett, 2005). On the other hand, early identification of deficits in low-level writing skills can lead to early interventions that can prevent later frustration

and lower achievement in writing and general academic success (Berninger, Mizokawa, & Bragg, 1991). These authors recommended specific instructional interventions based on individual differences in specific writing disabilities.

Research has established a causal connection between letter-writing fluency and writing production (quantity and quality of compositions; Edwards, 2003; Graham, Harris, & Fink, 2000). Because letter-writing fluency is important, handwriting instruction is extremely beneficial for preventing writing difficulties early on. Early interventions in letter-writing fluency are needed to reverse "ineffective or inefficient letter formation habits learned at home, kindergarten, or preschool [that] may be difficult to change" (Graham & Weintraub, 1996, p. 21). Graham and colleagues conducted a study on first-grade children who were having handwriting and writing difficulties. Children who participated in intensive instruction in handwriting made greater gains in handwriting, as well as compositional fluency, than those who received only instruction in phonological awareness without instruction in handwriting. This instruction included learning to name and identify letters of the alphabet as well as learning to form the letters correctly.

Via a structural equation modeling study Kim and colleagues (2011) investigated hypothesized components of writing production. The latent variables of spelling, letter-writing fluency, reading, and word- and syntax-level oral language skills were all assessed in relation to the predicted variable of writing skills of end-of-year kindergarteners. Each of these latent variables was indicated by several measured variables, with the exception of letter-writing fluency. There were no measured variables

that contributed to the construct of letter-writing fluency except for a single measure of letter-writing fluency. Yet, letter-writing fluency (as measured by a one-minute task of writing lower-case letters in alphabetical order,) was one of the three latent variables found to positively and uniquely predict students'oend-of-year writing production in their exploratory study. Kim and colleagues recommended that multiple indicators of handwriting fluency be the focus of study in future research.

One of these indicators may be letter-naming fluency (LNF). Ritchey (2004) found that letter-naming skills are predictive of sublexical skills as they require integration of visual stimuli and recall of phonological labels, namely, letters and sounds. As LNF has been shown to be a predictor of reading ability (Ritchey, 2004), it may well also be a high predictor of letter-writing fluency.

Another potential component of both letter recognition and letter-writing fluency is the ability to distinguish critical features of letters. Even though letters are often seen as the basic unit of writing, individual, single strokes or critical features may be observed as the lowest basic unit of a letter (Graham & Weintraub, 1996). This aspect of letters may precede letter identification and letter-forming speed. Gibson, Gibson, Pick, and Osser (1962) studied critical features of letters to "trace the development of letter differentiation as related to those dimensions or features of letters which are critical for the task and which may present more or less difficulty" (Gibson et al., 1962, p. 897). They found that the difficulty of discrimination among features varied for different transformations of letters (letters that were changed by orientation or addition of features). Subsequently, Townsend and Ashby (1982) did research with mixed results on whether or not

participants were able to perceive critical features of letters as a factor in letter identification.

In another study of the critical features of letters, Pelli, Burns, Farell, and Moore-Page (2006) found that complex letter forms were more difficult to identify than less complex letters forms. According to these authors, feature detection was significant in identifying letters, even more important than age of reader, experience of reader, overall contrast of letter to background on which it was represented, duration of being exposed to the letter, eccentricity (how much it varied from other letters), and size. They identified seven distinctive features. These features existing in letters were not named, specifically, but were found to be unique in that they all differ in regard to complexity, overlap, height, width, area, and efficiency. What is significant about the features is that they were found to be detected independently by participants. In another study of letter features, Fiset, Blais, Arguin, Tadros, and Ethier-Majcher (2009) also identified distinct letter features.

Because letter-writing fluency is an important part of becoming a proficient writer, especially for young children, it is important for teachers of young students to understand the underlying component abilities that lead to or predict letter writing or transcription fluency. Understanding these components could improve how teachers might diagnose and intervene to help increase students’dletter-transcription fluency in service to writing compositional quality and quantity. The purpose of this study is to theoretically deconstruct the construct of letter-writing fluency into suspected sub- or contributing components to examine their ability to predict kindergarten students’rletter-

writing fluency scores and, thus, inform effective letter-writing instruction accordingly.

This leads to the question of how a measure of letter-writing fluency can be obtained. Writing letters is "speeded access of verbal codes", which requires both orthographic coding and a motor task (Peverly, Garner, & Vekaria, 2014, p. 7). Both accuracy and automaticity are required. In letter writing, accuracy can be thought of as legibility, the accuracy of reproducing recognizable written symbols or writing letters. Automaticity refers to how quickly letters can be reproduced, or how fast students can write letters (Kim, Al Otaiba, Puranik, Folsom, & Gruelich, 2014). The measure of letter-writing fluency used by Kim and colleagues (2011) contain elements of both accuracy and automaticity and the current study utilized these constructs. As LNF has been shown to be a predictor of reading ability (Ritchey, 2004), it was measured as one predictor of letter-writing fluency. The ability to identify and to write critical features of alphabet letters was also measured as predictors of letter-writing fluency.

The purpose of the present study is twofold. This first part is to explore how much variance the three following selected theoretical components predict variance in letter-writing fluency: letter-naming fluency, critical feature identification, and critical feature production (CFP). As letter-naming fluency is known to be highly predictive of literacy skills (Ritchey, 2004), in this study it is purposed to explore how much the ability to identify and produce critical features of letters predicts variance in letter-naming fluency as well.

Thus, the research questions for this study were as follows.

1. To what degree does the ability to name upper and lower-case letters of the

alphabet (LNF) predict variance in letter-writing fluency as measured by the letter-writing fluency assessment used by Kim and colleagues (2011)? A hypothesis of this study is that the ability to name alphabet letters fluently does predict variance in letter-writing fluency.

2. To what degree does the ability to identify critical features of letters (as measured by an assessment of ability to identify critical features of lowercase alphabet letters) predict variance in both letter-writing fluency (as measured by the letter-writing fluency assessment used by Kim et al., 2011) and in letter-naming fluency? A hypothesis of this study is that the ability to identify critical features of letters does predict variance in both letter-writing fluency and letter-naming fluency.

3. To what degree does the ability to produce critical features of letters as measured by an assessment of ability to produce critical features of letters predict variance in both letter-writing fluency (as measured by the letter-writing fluency assessment used by Kim et al., 2011) and in letter-naming fluency? A hypothesis of this study is that the ability to produce critical features of letters does predict variance in both letter-writing fluency and letter-naming fluency. To better understand how these research questions are informed by the assessments, see Appendix A.

CHAPTER II

LITERATURE REVIEW

The following review of literature will first discuss the role of writing skill as being crucial to later academic and career success. It will then seek to establish through the literature that alphabet letter writing is a foundational component of writing. Selected theoretical components of letter-writing fluency are then presented.

Importance of Learning to Write Early in School

Early writing development is complex. It involves both the handwriting aspect (pencil grip, muscle development, hand-eye coordination, awareness of space and line, combined with memory for upper and lower-case letters and punctuation marks,) as well as the capacity to generate and organize ideas and information. It is important that students gain effective writing skills in their early elementary years (Coker, 2006). Students who struggle with writing skills can be predicted to continue having difficulty communicating effectively as writers through school and beyond. Juel (1988) demonstrated this in a study of first through fourth graders who were assessed on reading and writing abilities. The writing assessment used in that study required students to write a story about a colorful picture of animals in a schoolroom setting. Scores were determined based on sentence structure, relation of sentences to each other, ideation about characters or objects, and bringing in background knowledge. Early writing skill in this study was found to predict later writing skills, including spelling. Students with poor writing skills in first grade continued to score poorly on writing assessments administered

when they were in fourth grade.

Not only do proficient writing skills in the early elementary years predict writing success in later school years, the acquiring of writing skills supports reading. In one study, Spanish-speaking kindergarteners were observed as they developed phonological awareness and as they developed as writers. One important implication of this experimental study reported by Vernon and Ferreiro (1999) is that children's ability to understand and use phonics is correlated with their level of writing development. A second implication of this study according to these authors is that teaching students to write in kindergarten and first grade stimulates their analysis of spoken sounds, syllables, and words.

Reading and writing have often been separated as academic subjects for various reasons but research suggests that the skills of reading and writing are, indeed, partially correlated. Both learning to read and learning to write require knowledge of the phonological and orthographic systems of English (Ritchey, 2008). In fact, the development of both reading and writing skills is important in promoting the acquisition of the other (Fitzgerald & Shanahan, 2000) suggesting that educators focus on the "critical shared thinking that underlies both reading and writing" (p. 47) as literacy skills are developed. Such findings warrant a focus on writing for beginning students and writing expectations warrant a need for handwriting instruction and practice.

Role of Letter-Writing Fluency

Related research supports the primacy of handwriting and its relationship to

various kinds of scholastic achievement. But, the question is often asked: In this digital age, is handwriting fluency still important? A popular press article by Ramirez (2014) said it was, even for students with laptops. According to this article, students who take notes on laptops do not perform as well as students who take notes longhand on tasks that require synthesis of ideas, reframing, and understanding of information. Taking notes by longhand, according to Ramirez, requires the student to process the information and represent it in a way that makes sense to them. In order to take notes well, automaticity of handwriting is required.

Letter-writing fluency is a low-level component skill of writing (Kim et al, 2011). The term "letter-writing fluency" is often synonymous with the terms of handwriting fluency, transcription fluency, and letter writing. In the literature, these terms may be interchangeable, although letter-writing fluency is more focused on writing letters (Ritchey, 2008); whereas, handwriting fluency and transcription fluency include writing letters, words, sentences, and even paragraphs. Whichever term is used, "the ability to write individual letters [is a skill that is] potentially important in better understanding early writing development" (Ritchey, 2008, p. 29)

Predictor of Other Literacy Skills

The results of a study conducted by Kim and colleagues (2014) "suggest that letter-writing fluency merits attention as a predictor of spelling skill" (p. 249). In their structural equation modeling study of 242 English-speaking kindergarteners, they examined the relationship among letter-writing automaticity and word reading and spelling. It was observed that letter-writing fluency was related to word reading and

spelling after accounting for phonological awareness, alphabet knowledge fluency, and vocabulary.

Another study by Abbott, Berninger, and Fayol (2010) focused on the normal writing process of students. In their longitudinal study of students from Grade 1 to Grade 7, the researchers observed that when the skill of handwriting was in the structural equation model, a path was observed from spelling to word reading. In fact, an even stronger correlation was observed between handwriting and text composing than between handwriting and spelling in the first two grades.

Foundation for Higher-Level Writing Skills

Research indicates that having to concentrate intensely on orthographic-motor integration leaves fewer cognitive resources for generation and organization of text, even among students in Grades 8 and 9 (Christensen, 2005). A study done with second-year undergraduate students in the United Kingdom (Connelly et al., 2005), found that students who had performed poorly with handwriting fluency were constrained in performing the higher-order writing processes. Writing, being a form of language production, is very complex. Like other language production models, it contains three main processing components—a conceptual component that includes generating and selecting ideas, a linguistic planning component that includes mapping ideas to an appropriate linguistic structure, and an articulation component (Connelly et al., 2005). In the case of writing, the articulation component involves executing the plan graphemically (rather than phonetically as in the case of oral production). All three of these components draw on cognitive resources in a student's brain. If one is intensely attending to one

aspect of writing (for example, handwriting fluency,) it is less likely he/she will also be able to attend intensely to other aspects.

Relating to the need to free up cognitive space for higher-level thinking, Bereiter and Scardamalia (1987) have produced data indicating that children aged 11 and up, including adults, are better able to produce written texts when writing rather than dictating them. This is the reverse of younger children, who can produce written texts better when dictating them. Bereiter and Scardamalia suggested that the reason for this is that handwriting fluency is no longer an issue constraining writing performance in the older students; hence, the need for handwriting fluency to be in place as soon as possible as writers are developing their skills.

In spite of this need, handwriting fluency may not be stressed in early childhood education as it once was. According to Graham and Weintraub (1996), beginning students often come to school with very little or, perhaps even more challenging, incorrect knowledge of basic handwriting skills. If a child has learned to make a letter inefficiently, it is often difficult to change. Berninger and colleagues (1997) reported that many students entering first grade do not have the level of handwriting typical of first graders in the past. They speculate that this may be due to the fact that handwriting is not given as much priority in kindergarten and first-grade classrooms as it once was. However, these authors found that direct instruction to improve transcription with beginning writers does lead to students' improvement in producing written text. Their study was done with 144 first graders. The control group received only phonological awareness training. Five other groups received different kinds of handwriting instruction.

It was found that frequent, brief, explicit handwriting instruction helped young children learn to automatize letter production and led to the increased probability of their becoming skillful writers. Although the handwriting instruction varied from group to group, the use of numbered arrows to guide letter formation and memory retrieval techniques were found to be the most beneficial in this study.

Christensen (2005) performed a similar study with students in Grades 8 and 9. After participating in a systematic handwriting program, students at posttest had made significant improvement in orthographic-motor integration as well as length and quality of written text. This improvement was measured by performance on a pretest and a posttest in which students were asked to independently complete a hand-written piece of text on a specified topic.

Preventative for Negative Mindset about Writing

Difficulty in transcribing letters can lead to negative feelings about writing. During tutorials, third graders said that they avoid writing because other people cannot read their writing (Berninger et al., 1997). Early on, such students can develop a mindset that writing is difficult and unpleasant based on their lack of handwriting fluency. This suggests that early intervention directed toward improving handwriting fluency may enhance confidence and writing skills in later grades. According to Berninger and colleagues, the goal is to “automatize low-level processes so that working memory resources are freed for the higher level constructive aspects of composing” (p. 652), thus, providing a positive foundation for writing.

Aid in Memorizing Letter Forms

In this day when much writing is done on a computer, the debate continues about whether children need to learn to write letters manually or just learn how to type them on a computer. Longcamp, Zerbato-Poudou, and Velay (2005) tested their hypothesis that motor conditions affect whether or not children are able to learn to recognize alphabet letters. They trained two different groups of children to write letters. One group was trained to copy by typing the letters; the other group was trained to copy letters of the alphabet by hand. The group that was trained to copy letters of the alphabet by hand performed better on a letter recognition assessment than did the group that was trained to copy by typing the letters. From these results, the authors suggest that handwriting is important in helping children learn to memorize the form of a letter and letter recognition.

In a related experiment involving forty-eight, 8- to 9-year-old children, Hulme (1979) found that children memorize graphic items better when they not only looked at the forms, but traced them with their index fingers. This positive effect was noted only during free writing recall, not in simple visual recognition tests. The results support the supposition that tracing letters produces a distinct motor memory trace that aids in visual recognition of letters.

Naka (1998) also observed a positive effect of writing training on the free recall of graphic designs. Writing, looking, and tracing were each used to teach letter recognition. First, third, and fifth graders were found to recall characters and letters better when they learned them by writing rather than by looking at the letters only or by tracing.

From this study, it appears that holding an image of the item in the brain, as well as using motor movements during writing, are important in facilitating memory recall. This replicates the results obtained in an earlier study by Naka and Naoi (1995) that children learn to recall graphic items better after writing them repeatedly, rather than just looking at them.

From the above studies, it appears that handwriting is more than just penmanship. It is an opportunity to develop spelling, the "orthographic understanding of the writing system" (Edwards, 2003, p. 141). Additionally, handwriting requires the integration of orthographic and memory processes, as well as motor skills (Christensen, 2005). Letter-writing fluency appears to be critical in developing literacy skills.

Recognizing the importance of letter-writing fluency, Kim and colleagues (2011) studied letter-writing fluency as a potential component of writing. Letter-writing fluency was assessed as the number of alphabet letters students wrote from memory within a specified period. Their study also measured three other potential components of writing: reading, oral language, and spelling. Of these four components, letter-writing fluency was found to be a critical component. However, it was the only component of the four measured using a unitary assessment in their study. The skill of letter-writing fluency was not broken down, while oral language, spelling, and reading were broken down into two or three subskills. To better understand the complexity of letter-writing fluency, the authors of that study recommended using multiple indicators of handwriting fluency as broken down into subskills in future studies.

Another study that recommends a more in-depth study of the subskills of letter-

writing fluency was conducted by Peverly and colleagues (2014). In an investigation of note-taking skill among undergraduates, these researchers measured handwriting speed, fine motor fluency, speed of verbal access, language comprehension, working memory, and attention to note taking. In measuring handwriting speed, participants were instructed to write the letters of the alphabet as many times as they could in 45 seconds, lowercase or uppercase as they preferred. Only 29% of the variance of students'ohandwriting was accounted for by fine motor speed and the speeded access of verbal codes. Unaccounted for was the other 71% of variance. These authors suggested that further research would do well to focus on determining what other skills contribute to the variance of handwriting speed.

Selected Theoretical Subconstructs of Letter-Writing Fluency

The constructs of interest in this study as they relate to letter-writing fluency are letter-naming fluency, critical feature identification, and CFP.

Letter-Naming Fluency

Accuracy of letter writing requires both letter knowledge (Abbott & Berninger, 1993) and motor skills (Graham & Weintraub, 1996). Letter knowledge involves three things: having a verbal label to attach to a letter form, having an accurate representation of the letter form in the memory, and being able to access that letter form in the memory and retrieve it. Abbott and Berninger suggested that weak letter knowledge may be as much a factor in poor transcription skills as motor difficulties.

Kim and colleagues (2014) stated that the relation between letter-writing

automaticity and alphabet knowledge has not been adequately studied. These same authors note that it is the motoric aspect of writing letters that is unique to the letter-writing automaticity task. The alphabet-knowledge fluency task requires students to recognize letters and retrieve their names and sounds. The letter-writing automaticity task additionally requires students to retrieve shapes and produce letters, not just identify and name letters. These authors raise the question in their discussion as to whether letter naming is a separate construct from letter-writing automaticity (Kim et al., 2014).

Critical Feature Identification

Many researchers have studied critical features of letters as a component of letter recognition and letter writing. One study on the subject of how critical features of letters contribute to letter recognition was reported by Fiset and colleagues (2009). These authors identified 10 distinct letter features that aid in letter recognition: intersections, horizontals, verticals, slants tilted right, slants tilted left, curves opened at the top, curves opened at the bottom, curves opened on the left, curves opened on the right, and terminations. Each of the four participants, university students, in this study were asked to identify 26,000 letters (100 blocks of 260 trials each). Their response accuracy was computed using a classification image technique, which revealed the letter areas responsible for the accurate identification of uppercase Arial letters. Of the 10 feature classes, line terminations and horizontals appeared to be the two most important for letter identification.

The purpose of another study of critical features of letters was to show how children develop from age 4 through age 8 in their ability to discriminate visually certain

critical features of letters (Gibson et al., 1962). In this study, actual letters were analyzed according to number of strokes, straight vs. curved lines, angles, open vs. closed forms, symmetry, etc. From this analysis of letters, standard rules were made that summarized how letters are constructed. These standard rules were used to create new letter-like forms. The letter-like forms were composed of two to four strokes. Half were symmetrical and half asymmetrical, half open and half closed. Some combined straight and curved lines, while others were either composed of only curves or only straight lines. All the letter-like forms were printed on cards. The task of the student was to match a letter-like form to its replicate in a row of letter-like forms. It was found that as participants increased in age from 4 to 8, so did their ability to discriminate the features of letters. For example, a high rate of errors for rotations and reversals at age 4 declined to almost 0 by age 8. The authors suggest that the reason for this increased ability to discriminate features of letters may be that children between ages of 4 and 8 learn something about letter-like forms. In fact, it is suggested that what they do learn is features or dimensions of difference, which are crucial for differentiating among letters.

In another study, Pelli and colleagues (2006) used a series of experiments to examine how people identify letters. These authors defined feature as an image. They said that the signal (or letter) to be identified is a combination of independently detectable features. They hypothesized in their study that the "probability of failing to detect a signal made up of many features is equal to the product of the probabilities of failing to detect each feature" (p. 4647). Participants in this study, ranging in age from 3 to 68 years, were shown a faint letter surrounded by visual noise. Their task was to select that

same letter from a display of all the letters in the alphabet. Results showed that the ability to detect a letter accurately drops with increasing complexity of the letter. Complexity was computed according to the ratio of inside-and-outside perimeter squared and divided by “ink” area. It appeared that letters can only be seen/identified by means of independent detection of multiple simple features. Even as the Gibson and colleagues (1962) study showed that children make a gain from age 4 to age 8 in ability to discriminate features of letters, this study showed that this gain is very rapid. After only a few hours of experience with a new alphabet, there was little or no reported difference in ability between novice participants and experienced readers. It would seem that children in preschool and early elementary are at a great age developmentally to process instruction regarding critical features of letters.

A study that challenges the assumption that observers identify letters by looking at individual critical features was reported by Townsend and Ashby (1982). The participants/observers in this study were required to report perceived features of letters, as well as to identify the respective letters. The letters were constructed from line segments of equal length. Observers were not shown to identify letters by sampling independent features except in extremely simplified experimental circumstances. In addition, observers often reported ghost features, features which were not contained in the stimulus letter. However, more research about whether or not line and curve features are used to identify letters and numbers is recommended by the authors of this study.

More recently, Madec, Rey, Dufau, Klein, and Grainger (2012) studied visual identification processes as related to letter perception. Participants were individually

seated before a computer screen where a white letter appeared. Each participant was asked to say the letter name aloud as quickly as possible. “Immediate naming time” was calculated as the time between when the letter was presented until the beginning of the vocal response, at which time the letter disappeared from the screen. On some trials another letter would appear, at which time the participant was asked to compare the new letter with the previous one. EEG activity was recorded throughout the session. Results of this study suggest the following sequence of events in a participant’s brain while identifying letters: (a) low-level visual feature processing, followed by (b) letter identification processes that enable activation of letter names, and finally (c) conscious identification of the letter.

Critical Feature Production

The study of critical features of letters has been applied not only to recognizing but producing letters. Williams (1968), in a study of the effectiveness of two different training methods of kindergarten pupils learning to recognize and reproduce letters, hypothesized that reproducing a complex letter form causes more awareness of its critical features than does just discriminating it from unlike forms. Writing a letter requires more active participation than does simply identifying a letter. However, the study also recommended that kindergarteners be taught to compare critical features of letters as they are learning to write them (Williams, 1968).

Other authors (Gibson & Levin, 1975) also identified and studied basic units of letters. They called these basic units graphic distinctive features. They identified vertical, horizontal, diagonal, curved, and open-closed lines as the most basic units from which to

construct letters.

From the above studies, it appears that identification and production of critical features of letters may be a subskill of letter-writing fluency.

Use of Critical Points of Letters as a Cognitive Tool for Identification and Production

Patina (1957) studied and experimented with the idea of using a pattern to teach children to write letters. Pantina (reviewed in Arievitch & Stetsenko, 2000) compared three instructional methods of teaching a child to write the letters of the alphabet. One was the traditional method of having teachers teach one letter at a time. The teacher would show the letter and then demonstrate how to write it, explaining the process aloud. The student was asked to memorize each letter and how to write it. This method lacked any inherent logic or pattern.

Patina then used his own system to teach children to write letters of the Russian alphabet. Instead of using critical features as identified by others (Fiset et al., 2009; Gibson et al., 1962; Gibson & Levin, 1975), Patina identified what he called critical points of letters. This system consisted of using one model letter to show the learner how to identify critical points of that letter (the beginnings, the ends, the vertices, and the curves). That same pattern was then used to identify critical points of another and then another letter. Soon students were able to identify critical points of all letters and write them easily without putting critical points on the paper first. This knowledge was found to transfer with dramatic improvement to students being able to reproduce a variety of abstract symbols, ability to solve problems involving coordination in the plane, and

counting ability. The advantage of this method, according to Kirsch (2013), was that children did not become bored with the tedium of rote memorization that takes place in the traditional method of teaching children to write letters of the alphabet. Automaticity to write letters quickly increases when children learn the critical points and the pattern for using them. This gives them more time for deeper-level thinking about the meaning and use of the symbols themselves (Patina's work reviewed by Kirch, 2013).

Arievitch and Stetsenko (2000) stressed the importance of providing students with adequate cognitive tools (criteria, orientation schemas, algorithms of action, etc.) for the learning task at hand. One such cognitive tool is a pattern. If a pattern is taught, the student is able to maneuver the task much more quickly, not always having to go from graphic and concrete examples, nor bit by bit, but going directly to the whole task as the pattern guides the way. In the case of alphabet letter writing, as reported by Arievitch and Stetsenko, Patina gave a pattern of a letter with an orientation tool to guide how to accomplish the task of reproducing the letter correctly. This same pattern of identifying critical points could be used with all letters in different languages and even abstract symbols.

Given the research related to handwriting fluency and how children develop this skill, an investigation of selected possible components of letter writing it seems warranted to more fully understand the relationship between letter-writing fluency and its subskills. In light of the above research studies, the three theoretical components selected for this study are letter-naming fluency, critical feature identification, and CFP.

CHAPTER III

METHODS

Research Design

The purpose of this exploratory, multiple regression, study was to determine how much variance three selected theoretical components predict in letter-writing fluency (LWF) as measured by the following tasks: (a) letter-naming fluency, (b) letter construction of lowercase alphabet letters (LCS) using manipulation of physical critical features of alphabet letters, and (c) CFP by writing pseudo-letters made up of critical features of lowercase alphabet letters. It was also the purpose of this study to determine how much variance the latter two variables (LCS and CFP) predict in letter-naming fluency as previous research indicates it may be a high predictor of letter-naming fluency.

Sampling

Participants for this study were selected from a convenience sample of volunteer, local, kindergarten teachers and their students in three teachers' classrooms within the same school in Logan City School District. This sampling yielded a sample size of 49 participating students out of approximately 150 possible students distributed between the three teachers' morning or afternoon classrooms. All students in those classrooms for whom a parental consent form could be obtained participated in the study. Of those students, 23 (47%) were female and 26 (53%) were male. Nine of the 49 students were currently receiving ESL (English as a second language) services. Birthdates of all 49

students fell within a 13-month period of 1 August 2008 to 31 August 2009.

Gall, Gall, and Borg (2007) recommend at least 15 individuals for each variable that will be included in a multiple regression analysis to provide sufficient statistical power. Therefore, at least 45 individuals were needed for the three predictor variables to be investigated in this study. There was no grouping.

To establish the context of current letter-writing instruction in this school, a survey was sent to the three participating teachers and collected with their answers to questions relating to what handwriting program was being used, terms used in describing letters, and how often and how long letter-writing instruction takes place in the kindergarten classrooms from which participants were drawn. This survey is found in Appendix B.

Assessments for this study took place in early December of kindergarten. This timing provided a very basic understanding of young children's letter awareness and writing skills and allowed discernment of the role of letter-naming fluency and critical feature identification and production in that awareness and skill.

Variables

The first criterion variable in this study was letter-writing fluency, which includes both accuracy and rate. Letter-writing fluency can be assessed in many different ways. Copying letters from a model, writing all the letters in alphabetic order, or writing letters as they are dictated are examples of assessing letter-writing fluency (Ritchey, 2008). In this study students were asked to write all the lowercase alphabet letters as quickly as

they could in one minute, following the model of the letter-writing fluency assessment used by Kim and colleagues (2011). Uppercase letters were not included as a part of this letter-writing fluency test. Uppercase letters are found to be easier to write and identify, but have a narrower range of difficulty (Bowles, Pentimonti, Gerde, & Montroy, 2014). As lowercase letters make up a higher percentage of reading and writing in kindergarten, they were used in this assessment.

The predictor variables were as follows.

1. Letter-naming fluency (a subtest of Dynamic Indicators of Basic Early Literacy Skills [DIBELS], 2014) in which students were asked to name random alphabet letters quickly for one minute,

2. Ability to identify and use eight critical features of lowercase alphabet letters as measured by a researcher-designed assessment in which students were asked to select from the following groups of critical features to construct lowercase alphabet letters on a mat: tall lines, short lines, closed curves, open curves, long hooks, short hooks, u-turns (also called humps) and dots.

3. Ability to produce critical features as assessed by a researcher-designed test in which pseudo-letters employing seven critical features of the Roman alphabet were visually displayed for the students to copy with a pencil.

In the second part of the analysis of this study, letter-naming fluency was used as a criterion variable with the critical feature identification and CFP being the two predictor variables.

Data Collection

Permission was obtained from the Utah State University IRB, from Logan City School District, from the teachers of three kindergarten classes from an elementary school in that school district, and from parents of children in these classes (via Informed Letters of Consent; see Appendix C). The researcher visited each class to be introduced to the students. An explanation was made by the researcher to the students, communicating that she was interested in seeing how they write letters and would be calling each one of them to come with her to do some letter writing activities. After receiving oral assent from each student, she escorted one child at a time to a designated quiet location in the school for administration of the planned assessments. Each child was assessed individually and then escorted back to the classroom. This process was repeated until all students had been tested. Each kindergarten participant was assessed on two different occasions within a 2-week period so that all four assessments (LWF, LNF, LCS, and CFP), were completed. In order to ensure that the two critical feature assessments did not affect performance on the letter-writing fluency assessment, the letter-writing fluency assessment was administered first to each student, followed by the letter-naming fluency assessment. Both critical feature assessments, one regarding construction of letters using critical features and the other involving copying pseudo-letters containing critical features, were administered during the second session. These individual sessions took approximately 10 minutes. This limited time period was distributed among four different tasks at two different settings so as not to be too tiresome for children ages 5 or 6. The students were asked to complete tasks very similar to those currently taught in

kindergarten. Teachers of the kindergarten participants were interviewed about writing instruction in their classrooms to verify this assumption that the assessments were developmentally appropriate and related to the curriculum.

A Description of the Four Assessments

1. A DIBELS (Dynamic Indicators of Basic Early Literacy Skills) letter-naming-fluency subtest (LNF) was administered to each participating kindergartener. Directions for administration and scoring of DIBELS letter-naming fluency are found in Appendix D. letter-naming fluency was used as a predictor variable of LWF. letter-naming fluency was also later used as a criterion variable with LCS and CFP being the predictor variables.

2. A researcher-designed assessment of letter construction (LCS) using eight critical features of lowercase alphabet letters was administered to all participating kindergarten students to determine how accurately they could identify and use critical features to construct lowercase alphabet letters (LCS). Figure 1 shows the eight features or strokes that were used in this study of critical features of letters.

A list of lowercase alphabet letters used in this assessment with an analysis of the critical features of each is shown in Appendix E. In identifying this set of critical features

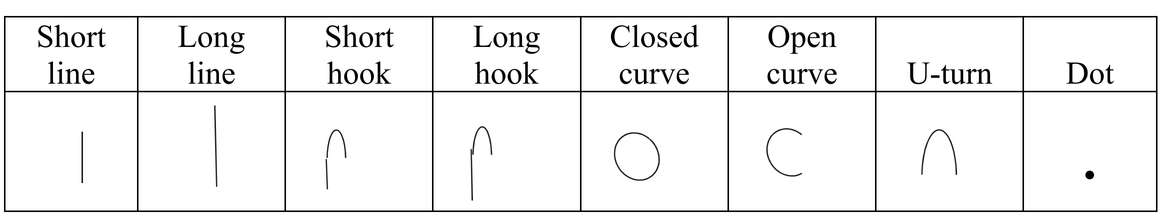

Figure 1. The features or strokes used for this study.

the goal was to reduce the range of potential features from the work of other researchers (Fiset et al., 2009; Gibson et al., 1962; Gibson & Levin, 1975) to the fewest number of critical features necessary to produce all lowercase manuscript letters. In administering this assessment, an attempt was made to use language familiar to kindergarteners in discussing letters and their features. Instructions for administration of this assessment are found in Appendix D. One additional critical feature was added to the list of features used in making pseudo-letters (CFP), the U-turn. The U-turn, sometimes referred to as a hump in handwriting programs, is simply a combination of a hook with a short line added to one side.

In scoring this assessment (see Appendix D), it was deemed necessary to score each letter individually, giving points for number of correct features used, correct orientation of features, correct size of features, and correct overlap or fit of features. These subscores yielded a total score for each letter and an overall total score for 22 letters. Directions for administration and scoring of this letter construction using critical features assessment are found in Appendix D.

Of the 49 completed assessments, 11 (23%) were scored by both the researcher and another professional educator who had been trained in regard to the study to determine interrater agreement. Because a subset of assessments were rated by two coders, an intraclass correlation (ICC) was computed to determine interrater agreement. The ICC was .958, with .75 to 1.0 being considered excellent interrater reliability. With sufficient scoring reliability, the researcher then scored the remaining assessments.

3. A researcher-designed assessment of written production of critical features

(CFP), in the form of pseudo letters, was also administered to each student. This assessment used seven typically occurring critical features (strokes) found in the Roman alphabet, namely, short lines, tall lines, open curves, closed curves, short hooks, long hooks, and dots. Twenty-two cards were made, each one showing a pseudo-letter made up of one, two, or three critical features put together in a way that could be a letter in that it contains critical features of letters, but is not a "real" letter. It was thought that 22 cards would be ample to provide an adequate variety of pseudo-letters showing all critical features in a variety of ways yet not overly tire the kindergarten participants. A chart showing pseudo-letters used in this assessment followed by an explanation of the rationale of their creation are shown in Appendix F.

During the assessment of the written production of pseudo-letters, the student was shown each pseudo-letter one-by-one on flash cards. He/she was instructed to look at and then write the pseudo-letter after being shown the pseudo–letter on a flash card. The student was allowed to look at the flash card while making the letter. After the student completed writing one pseudo-letter, the card was moved away, and the next card was shown. In scoring this assessment, 1 or 2 points were given for each pseudo-letter formed correctly—1 if it contained the correct critical features and an additional point if the features were correctly placed and oriented (correctly positioned left, right, up, and down). More detailed instructions for administering this assessment are found in Appendix D.

As with the LCS assessment 11 (23%) were scored by both the researcher and another professional educator who had been trained in regard to the study to determine

interrater agreement. Because the subset of assessments were rated by two coders, an intraclass correlation, ICC, was computed to determine interrater agreement. The ICC for this assessment was found to be .861, with .75 to 1.0 being considered to be excellent interrater reliability. The remaining assessments were then scored by the researcher.

4. The letter-writing fluency assessment (LWF) used by Kim and colleagues (2011, p. 520) was the final assessment and criterion variable in this study. This assessment was used by Kim and colleagues (2011) and Kim and colleagues (2014) to predict writing production. Accuracy or legibility, defined in this study as “the letter being recognizable to readers in isolation from other letters in a word” (Utah Core Language Standards, 2013) is a part of the assessment. Rate or automaticity, defined as “the rate at which children can access, retrieve from memory, and write alphabet letters accurately” (Kim et al., 2014, p. 238), is also a part of this assessment. Directions for administration and scoring of the letter fluency assessment are found in Appendix C. The 11 samples scored by the researcher and another professional educator yielded an ICC of .99. The researcher then completed the remaining assessments.

Letter-writing fluency as a construct was analyzed in this study as to how the three selected theoretical subconstructs, namely, letter-naming fluency, written CFP, and lowercase alphabet letter construction using critical features were able to predict its variance. letter-naming fluency was also analyzed in this study as to how lowercase alphabet letter construction (LCS) and CFP were able to predict its variance.

Data Analysis Procedure

Hierarchical multiple regression was used to analyze the results to determine the amount of variance accounted for in the criterion variable of letter-writing fluency by the three predictor variables entered in the following order—(a) letter name fluency (LNF), (b) critical feature production of pseudo letters (CFP), and (c) letter construction of lowercase alphabet letters using critical features (LCS). Hierarchical multiple regression was also used to analyze the results to determine the amount of variance accounted for in the criterion variable of letter-naming fluency by the other two predictor variables—(a) LCS using critical features (LCS) and (b) CFP of pseudo letters (CFP).

CHAPTER IV

RESULTS

The research questions of this study were: (a) To what degree does the ability to name upper and lower-case letters of the alphabet (LNF) predict variance in letter-writing fluency? (b) To what degree does the ability to identify critical features of letters predict variance in both letter-writing fluency and in LNF? (c) To what degree does the ability to produce critical features of letters as measured by an assessment of ability to produce critical features of letters predict variance in both letter-writing fluency and in LNF?

In addition to a statistical analyses of students'operformances on letter-related tasks, a teacher survey (Appendix B) provided some basic information about the instructional context of the current study. Of the three teachers surveyed, all said no set handwriting program was recommended nor used by them. They were encouraged to teach D'Nealian font as preparation for manuscript penmanship. One teacher reported teaching a ball and stick method combined with D'Nealian. Concerns reported by these teachers were that there was little consistency among teachers or grade levels within their school. For example, some taught D'Nealian font in kindergarten, but first-grade teachers in the same school did not necessarily use that font. Terms used to teach strokes of letters included such words as lines, hooks, and circles, but also included rhymes and action phrases, such as "climb up the ladder," monkey tails, bumps, and so forth. All three teachers surveyed used explicit instruction in introducing one letter at a time, usually in alphabetic order, and then practicing it repeatedly until students could write it correctly. One concern reported was that some students had trouble holding and maneuvering a

pencil, creating frustration with handwriting. Essentially, the teacher-reported data indicated a varied instructional program for the participants in this study.

In addition to the instructional context under which the assessments were administered, it is important to understand the scoring of the assessments. Letter-writing fluency was scored as recognizable letters per minute (LWF), which includes both accuracy and time. Letter-name fluency was scored as correct letters per minute (LNF), which also includes both accuracy and time.

So that both accuracy and time could be accounted for, the critical feature identification task, using physical critical features to construct lowercase alphabet letters task (LCS) was scored as a raw score (LCSR) and also as a timed score in seconds, (LCST). The raw score (LCSR) was divided by the number of seconds (LCST) to give a score signifying a number of points earned per second. This number was multiplied by 60 to give a number-of-points-earned-per-minute score (LCSM). The CFP task via writing pseudo-letters containing critical features of letters (CFP) was also first given a raw score (CFPR) and a timed score (CFPT). The raw score (CFPR) was divided by the number of seconds (CFPT) to give a points-earned-per-second score, which was multiplied by 60 to give a number-of-points-earned-per-minute score (CFPM). Thus, there were a total of eight individual scores available for analyses. All statistics reported below were calculated on the SPSS Version 22 for Mac.

Descriptive Statistics

The mean and the standard deviation for each of the eight measures are found in

Table 1. These descriptive statistics show a wide range of scores and variation. A large range of scores (1.5 to 20 letters written correctly per minute) were reported for letter-writing fluency (LWF) and positively skewed with more scores at the low end and only a few at the high end. Letter-naming fluency (LNF) also had a wide range of scores (from 2-72 letters correctly named in a minute), but was more evenly distributed. Critical feature production (CFP)—writing pseudo-letters (CFPR)—was more negatively skewed, with a narrower range of scores ranging from 29 to 43 (2 points allowed per each of 22 pseudo-letters). Letter construction of 17 lowercase alphabet letters using critical features (LCSR) had scores ranging from 36 to 67 out of 74 points possible, with a small amount of negative skewing. When time was factored in, CFPT had a range of 61 seconds to 174 seconds with less variance of scores and quite evenly distributed. LSCT had scores ranging from 209 to 494 (3 minutes 29 seconds to 6 minutes 14 seconds) to complete the task of constructing 17 lowercase alphabet letters positively skewed with fewer students having longer times than shorter times. CFPM scores (ranging from 13.10 to 38.71),

Table 1

Descriptive Statistics for LWF, LNF, CFPR, LCSR, CFPT, LCST, CFPM, and LCPM

Variables	Mean	*SD*	Range of scores
Letter-writing fluency (LWF)	8.16	4.79	1.5 – 20
Letter-naming fluency (LNF)	37.86	19.75	2 – 72
Critical feature production raw score (CFPR)	38.43	3.34	29 – 43
Letter construction raw score (LCSR)	58.33	8.03	36 – 67
Critical feature production time score (CFPT)	114.90	26.92	61 – 174
Letter construction timed score (LCST)	330.22	70.27	209 – 494
Critical feature production points earned per minute (CFPM)	21.31	6.03	13.1 – 38.71
Letter construction score points earned per minute (LCPM)	11.17	3.16	5.83 – 18.67

which include both time and accuracy were widely varied. LCPM scores were less varied with more scores on the high end (ranging from 5.83 to 18.67).

Correlation Matrix

A Pearson correlation matrix showing how each of the eight measures correlate is found in Table 2. LWF is the criterion variable and the other seven measures are predictor variables. LWF and LNF were 1-minute timed tests, so they included both accuracy and time in the score. The raw scores of CFP and LCS included only accuracy. The timed scores of CFP and LCS included only time. The per-minute scores of CFP and LCP included both accuracy and time. The correlation matrix in Table 2 shows how strongly each of the variables is correlated with the others.

Note that correlation is significant between LWF and LNF (.626) at the p <.05 level. Correlation is significant at the $p < .05$ level between LWF and the tasks of CFP (CFP) and of letter production (LCS) only when per-minute scores are used (.392 and -.462, respectively). Efficiency seems to be important as those tasks are less significantly correlated with LWF when a raw or time-only score is used. The two tasks using critical features are significantly correlated at the p <.05 level with each other (CFPR and LCSR, .541; CFPT and LCST, .322; CFPM and LCSPM, .473). LNF is significantly correlated with LCSR at the p <.05 level (.452) and LCSPM (.390), but not with CFP scores. This could possibly be explained by the fact that neither LNF nor LCS includes writing, but both include identification of critical features.

Table 2

Correlation Matrix for LWF, LNF, CFPR, LCSR, CFPT, LCST, CFPM, LCPM

Variables	LWF	LNF	CFPR	LCSR	CEPT	LCST	CFPM	LCPM
LNF	.626**	1						
CFPR	.348*	.252	1					
LCSR	.359*	.452**	.541**	1				
CFPT	-.310*	-.050	-.120	-.214	1			
LCST	-.345*	-.205	-.143	-.301*	.322*	1		
CFPM	.392**	.176	.428**	.353*	-.900**	-.359*	1	
LCSPM	.462**	.390**	.393**	.686**	-.356*	-.867**	.473**	1

LNF = Letter naming fluency.
CFPR = Critical feature production (raw score; copying pseudo-letters with pencil).
LCSR = Letter construction score (raw score; using critical features to physically construct lowercase alphabet letters).
CFPT = Critical feature production (timed score; letter construction).
LCST = Letter construction score (timed score; using critical features to physically construct lowercase alphabet letters).
CFPM = Critical feature production (pointed earned per minute; copying pseudo-letters with pencil).
LCSPM = Letter construction score (points earned per minute; using critical features to physically construct lowercase alphabet letters).

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Regression Fixed Entry Models

A multiple regression table uses one variable as the dependent variable. The other variables are entered in to see if they affect variance in the dependent variable. In a hierarchical multiple regression, the other variables are entered in the order that it is suspected that they affect the dependent variable, as opposed to just allowing the software program to order them. A hierarchical multiple regression was used in this study. Table 3 shows LWF as a dependent variable with LNF, CFPR, and LCSR force entered in that order. LNF is known to be a high predictor of LWF and was thus entered first. CFPR was entered next as it is a letter (pseudo-letter) writing task as is LWF. LCSR measures ability

Table 3

Hierarchical Regression Model of LNF, CFPR, and LCSR on LWF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
LNF	.626	.392	.392	30.355	(1, 47)	.000
LNF, CFPR	.656	.431	.039	3.113	(1, 46)	.084
LNF, CFPR, LCSR	.657	.431	.000	.015	(1, 45)	.904

LNF = Letter naming fluency.
CFPR = Critical feature production (raw score; copying pseudo-letters with pencil).
LCSR = Letter construction score (raw score; using critical features to physically construct lowercase alphabet letters).

to identify and arrange features to create lowercase letters, but not ability to write them. Therefore, it was entered last. The data in Table 3 adds to the understanding of how much variance in LWF is due to LNF, CFP, and LCS.

Tables 4 shows CFP and LCS as timed scores with LWF as the dependent variable and CFPT and LCST force entered in that order. Table 5 shows the results of CFP and LCS computed as per-minute scores (CFPM and LCPM) showing both accuracy and time with CFPM and LCPM force entered in that order.

In Tables 6, 7, and 8, LNF was withdrawn as a predictor variable in order to see how CFP and LCS accounted for variance in LWF without LNF possibly masking their effects. CFP and LCS were compared to LWF first as raw scores in Table 6, then as timed scores in Table 7, and finally as per minute scores in Table 8.

As LNF is strongly correlated with LWF and as indicated in the initial research question of this study, it was decided to determine if CFP and LCS were as strongly predictable of LNF as they are of LWF. Tables 9 through 11 are hierarchical regressions with LNF as the criterion variable, instead of LWF, with CFP and LCS as the predictor

Table 4

Hierarchical Regression Model of LNF, CFPT, and LCST on LWF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
LNF	.626	.392	.392	30.355	(1, 47)	.000
LNF, CFPT	.686	.470	.078	6.775	(1, 46)	.012
LNF, CFPT, LCST	.700	.490	.019	1.710	(1, 45)	.198

LNF = Letter naming fluency.
CFPT = Critical feature production (timed score; copying pseudo-letters with pencil).
LCST = Letter construction score (timed score; using critical features to physically construct lowercase alphabet letters).

Table 5

Hierarchical Regression Model of LNF, CFPM, and LCPM on LWF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
LNF	.626	.392	.392	30.355	(1, 47)	.000
LNF, CFPM	.689	.475	.082	7.206	(1, 46)	.010
LNF, CFPM, LCPM	.700	.489	.015	1.288	(1, 45)	.262

LNF = Letter naming fluency.
CFPM = Critical feature production (points earned per minute; copying pseudo-letters with pencil).
LCPM = Letter construction score (points earned per minute; using critical features to physically construct lowercase alphabet letters).

Table 6

Hierarchical Regression Model of CFPR and LCSR on LWF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
CFPR	.348	.121	.121	6.474	(1, 47)	.014
CFPR, LCSR	.403	.162	.041	2.269	(1, 46)	.139

CFPR = Critical feature production (raw score; copying pseudo-letters with pencil).
LCSR = Letter construction score (raw score; using critical features to physically construct lowercase alphabet letters).

Table 7

Hierarchical Regression Model of CFPT and LCST on LWF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
CFPT	.310	.096	.096	5.013	(1, 47)	.030
CFPT, LCST	.404	.163	.067	3.683	(1, 46)	.061

CFPT = Critical feature production (timed score; copying pseudo-letters with pencil).
LCST = Letter construction score (timed score; using critical features to physically construct lowercase alphabet letters).

Table 8

Hierarchical Regression Model of CFPM and LCPM on LWF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
CFPM	.392	.154	.154	8.555	(1, 47)	.005
CFPM, LCPM	.502	.252	.098	6.046	(1, 46)	.018

CFPM = Critical feature production (points earned per minute; copying pseudo-letters with pencil).
LCPM = Letter construction score (points earned per minute; using critical features to physically construct lowercase alphabet letters).

Table 9

Hierarchical Regression Model of CFPR and LCSR on LNF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
CFPR	.252	.064	.064	3.195	(1, 47)	.080
CFPR, LCSR	.452	.204	.141	8.139	(1, 46)	.006

CFPR = Critical feature production (raw score; copying pseudo-letters with pencil).
LCSR = Letter construction score (raw score; using critical features to physically construct lowercase alphabet letters).

Table 10

Hierarchical Regression Model of CFPT and LCST on LNF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
CFPT	.050	.003	.003	.119	(1, 47)	.731
CFPT, LCST	.206	.042	.040	1.919	(1, 46)	.173

CFPT = Critical feature production (timed score; copying pseudo-letters with pencil).
LCST = Letter construction score (timed score; using critical features to physically construct lowercase alphabet letters).

Table 11

Hierarchical Regression Model of CFPM and LCPM on LNF

Variables	*R*	R^2	*R* to change	*F* change	*df*	Sig *F* change
CFPM	.176	.031	.031	1.496	(1, 47)	.227
CFPM, LCPM	.390	.152	.121	6.585	(1, 46)	.014

CFPM =Critical feature production (points earned per minute; copying pseudo-letters with pencil).
LCPM =Letter construction score (points earned per minute; using critical features to physically construct lowercase alphabet letters).

variables. In Table 9, CFP and LCS are shown as raw scores (CFPR and LCSR). In Table 10, they are timed scores (CFPT and LCST). In Table 11, the scores are converted to per-minute scores (CFPM and LCPM), which show both time and accuracy.

ANOVA Models

Group differences were observed in administration of these assessments which indicated the value of using one-way ANOVA tables to examine classroom and gender differences. As this study involved three classrooms each taught by a different teacher, a one-way ANOVA table of classroom effects on LWF, LNF, CFPR, LCSR, CFPT, LCST, CFPM, and LCPM is presented in Table 12.

Table 12

One-Way ANOVA of LWF, LNF, CFPR, LCSR, CFPT, LCST, CFPM, LCS, PM by Classroom

Variables	Classroom #	*n*	Mean	*SD*	*df*	*F*	Sig.
LWF	1	18	10.97	5.19	(2, 46)	5.900	.005
	2	19	6.53	3.71			
	3	12	6.54	3.91			
	Total	49	8.61	4.79			
LNF	1	18	52.06	3.89	(2, 46)	10.230	.000
	2	19	28.89	3.55			
	3	12	30.75	5.51			
	Total	49	37.86	2.82			
CFPR	1	18	38.72	2.76	(2, 46)	.971	.386
	2	19	37.63	3.90			
	3	12	39.25	3.17			
	Total	49	38.43	3.34			
LCSR	1	18	59.67	7.80	(2, 46)	1.260	.293
	2	19	56.05	8.83			
	3	12	59.92	6.75			
	Total	49	58.33	8.03			
CFPT	1	18	113.56	28.05	(2, 46)	.111	.895
	2	19	117.21	28.75			
	3	12	113.25	24.03			
	Total	49	114.90	26.92			
LCST	1	18	327.39	71.55	(2, 46)	.057	.944
	2	19	329.16	68.32			
	3	12	336.17	77.11			
	Total	49	330.22	70.27			
CFPM	1	18	21.83	6.39	(2, 46)	.189	.829
	2	19	20.64	6.68			
	3	12	21.60	4.62			
	Total	49	21.31	6.03			
LCSPM	1	18	11.66	3.65	(2, 46)	.419	.660
	2	19	10.67	2.87			
	3	12	11.29	2.95			
	Total	49	11.17	3.16			

LWF = Letter-writing fluency.
LNF = Letter-naming fluency.
CFPR = Critical feature production (raw score).
LCSR = Letter construction score (raw score).
CFPT = Critical feature production (timed score).
LCST = Letter construction score (timed score).
CFPM = Critical feature production (pointed earned per minute).
LCSPM = Letter construction score (points earned per minute).

Only LNF scores and LWF scores were markedly different among the classrooms. These are the two skills which were given instructional time in the kindergarten classrooms. As gender has been shown in early elementary education research to have effects on achievement, it was decided to see if it had any effect in this study. A one-way ANOVA table of gender effects on LWF, LNF, CFPR, LCSR, CFPT, LCST, CFPM, and LCPM is presented in Table 13. This table also shows a gender effect appearing for scores only from CFPT. This assessment involves using a pencil to write pseudo-letters that are unfamiliar to kindergarteners.

Table 13

One-Way ANOVA of LWF, LNF, CFPR, LCSR, CFPT, LCST, CFPM, LCSPM by Gender

Variables	Classroom #	*n*	Mean	*SD*	*df*	*F*	Sig.
LWF	Female	23	9.11	4.73	(1, 47)	1.717	.196
	Male	26	7.33	4.77			
	Total	49	8.16	4.79			
LNF	Female	23	38.78	20.75	(1, 47)	.093	.761
	Male	26	37.04	19.19			
	Total	49	37.86	19.75			
CFPR	Female	23	38.78	2.97	(1, 47)		
	Male	26	38.11	3.67			
	Total	49	38.43	3.34			
LCSR	Female	23	60.17	6.91	(1, 47)	2.356	.131
	Male	26	56.69	8.72			
	Total	49	58.32	8.03			
CFPT	Female	23	105.39	24.11	(1, 47)	5.965	.018
	Male	26	123.37	26.88			
	Total	49	114.90	26.92			
LCST	Female	23	326.78	63.01	(1, 47)	.102	.751
	Male	26	333.27	77.25			
	Total	49	330.22	70.27			
CFPM	Female	23	23.16	5.57	(1, 47)	4.336	.043
	Male	26	19.68	6.05			
	Total	49	21.31	6.03			
LCSPM	Female	23	11.51	2.83	(1, 47)	.514	.477
	Male	26	10.86	3.45			
	Total	49	11.17	3.16			

LWF = Letter-writing fluency.
LNF = Letter-naming fluency.
CFPR = Critical feature production (raw score).
LCSR = Letter construction score (raw score).
CFPT = Critical feature production (timed score).
LCST = Letter construction score (timed score).
CFPM = Critical feature production (pointed earned per minute).
LCSPM = Letter construction score (points earned per minute).

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

As this study targeted the relationships among letter-writing fluency and selected theoretical components, a discussion of each separately as they relate to each other follows.

Discussion

Letter-Writing Fluency

Letter-writing fluency (LWF) has been shown to be a prerequisite skill for writing (Edwards, 2003; Graham et al., 2000). Because it involves the integration of orthographic and memory processes, as well as motor skills (Christensen, 2005), it serves as one door for accessing academic achievement. Accordingly, two notable studies have requested further research into the components of handwriting fluency, or specifically, letter-writing fluency. Peverly and colleagues (2014) reported that only 29% of the variance of students' handwriting was accounted for by fine-motor speed and the speeded access of verbal codes, leaving the other 71% of variance unaccounted for. They suggested further research to focus on determining what other skills contribute to the variance of handwriting speed. In another research study, Kim and colleagues (2011) also specifically called for further research to deconstruct the construct of letter-writing fluency.

The present study suggests that the following subskills are all at least somewhat predictive of letter-writing fluency.

Letter-Naming Fluency

In their study, Kim and colleagues (2014) raised the question of whether-letter naming is a separate construct from letter-writing fluency. The alphabet knowledge fluency task requires students to recognize letters and retrieve their names and sounds (Kim et al., 2014). Letter writing goes one step further in requiring students to retrieve shapes and produce letters (Kim et al., 2014). In the present study, letter-naming fluency (LNF) was found to be strongly correlated (.626) with letter-writing fluency (see Table 2). In the hierarchical regression analysis, LNF was force-entered first because research shows LNF to be highly predictive of both reading and letter-writing skills (Abbott & Berninger, 1993; Graham & Weintraub, 1996; Kim et al., 2011, 2014). LNF typically emerges as much higher than the other variables in accounting for variance in LWF (39.2% of variance, $F = 30.355$, $p = .000$; see Tables 3-5). It is important to note that there was a wide range of scores recorded for both LWF and for LNF, which means that these students were quite disparate in their awareness of letters after four months of their kindergarten year. This is likely due to differences in instructional experiences in their respective classrooms, and may indicate a need for more explicit or systematic instruction to address those who are struggling with letter-writing and letter-naming skills.

Critical Feature Production

The critical feature production (CFP) task required copying of pseudo-letters made of the same critical features as those found in lowercase alphabet letters. Students were asked to copy 22 pseudo-letters, which resulted in a raw score of accuracy only, the timed score, and a per-minute score that included both accuracy and time. This task

required students to distinguish critical features and also be able to write them quickly.

CFP scores were shown in three dimensions, the raw score (CFPR), the timed score (CFPT), and the per-minute score (CFPM). In the correlation matrix, CFPR was shown to be significantly correlated with LWF (.348). It was even more highly correlated with LCSR (.541). This is not surprising as they both involve using critical features to make letters. CFPR involves writing of critical features. LCSR involves physically constructing letters with individual critical features.

In the hierarchical regression analysis, CFPR (the accuracy only part) was shown to add only .04 of the variance to what LNF had already added ($F = 3.113$, $p = .084$), which is not significant (see Table 3). When time was added to the score, CFPT accounted for a larger amount of variance (.078, $F = 6.775$, $p = .012$, see Table 4). CFPM, which included time and accuracy, accounted for slightly even more variance (.082, $F = 7.206$, $p = .010$; see Table 5). It seems that when efficiency is accounted for in the task, the scores account for more variance in LWF than just the raw scores.

Letter Construction

The letter construction (LCS) task raw score (LCSR) required students to select individual critical features from sorted groups of lines, short lines, open curves, closed curves, short hooks, long hooks, U-turns, and dots to construct individual lowercase alphabet letters on a mat. As letters constructed by the students were extremely varied as to choice of features, orientation, size, and overlap, a score for each letter was computed showing points for number of correct features, correct orientation of features, correct size of features, and correct overlap or fit of features (see Appendix D). These elements were

included to strengthen the validity and reliability of the scoring process. Additionally, the task was timed to give a timed score (LCST). The raw score and timed score were computed to make a per-minute score (LCPM). This task did not require writing as did LWF and CFP. Observations noted that students were highly engaged and motivated in performing this task. The hierarchical regression shows that LCSR added no variance after LNF and CFPR. The timed score (LCST) added only a little (.019, $F = 1.710$, $p = .198$). LCPM added slightly less than LCST (.015; see Tables 3-5). Possibly, the variance of critical features was apparent in CFP enough that LCS added no more.

Hierarchical Regression Without LNF

As it accounted for so much more variance than either CFP or LCS, it was decided to take LNF out of the hierarchical regression to see if it might be masking the amount of variance of CFP and LCS accounted for in LWF. Results show that the variance added by CFP and LCS was slightly greater for raw (.121, .041), timed (.096, .067) and per-minute (.154, .098) scores than when LWF had been included. This re-affirms that CFP and LCS do account for some limited variance in LNF and, thus, are contributing components to letter-writing awareness and fluency.

Hierarchical Regression with LNF as Dependent Variable

Because LNF requires knowledge of critical features of letters (Gibson et al., 1962; Pelli et al., 2006), it seems likely that CFP and LCS would account for variance in the task of LNF. Tables 9-11 show results of a hierarchical regression analyses with LNF as the dependent variable with both CFPR and LCSR. Results show that CFP and LCS

(raw, timed, and per-minute scores) account for variance in LNF, as well as LWF, although not quite as much. It is interesting to note that LCS (.141) accounts for more variance in LNF than does CFP (.064). Both LCS and LNF require identification of critical features of lowercase alphabet letters, which are familiar at this point of writing development to kindergarteners. CFP requires writing of critical features in pseudo-letters, which are not familiar to kindergarten students.

Post-Hoc Analyses

The sample of 49 kindergarten students participating in this study included students taught by three different teachers. Of the 49 kindergarten students, 26 were boys and 23 were girls. Those kindergarten students enrolled in ESL services were 9 out of the 49. Birthdate of participating students ranged from August 2008 to August 2009. To better understand how these factors related to the tasks of LWF, CFP and LCS, post hoc analyses were computed for classroom effects and gender effects.

Classroom effects were found with the results for LWF and LNF. A classroom effect was found for letter-writing fluency ($F = 5.90$, $p < .005$) and for LNF ($F = 10.23$, $p < .001$). Kindergarten students in this study's participating classrooms received daily instruction on the skills of letter-writing fluency and LNF. Critical features of letters were taught minimally or not at all in these kindergarten classrooms, according to the teacher surveys completed before the assessments were administered. However, it seems very likely that teachers allot different amounts of time for instruction in writing alphabet letters at this time of year and the wide range of scores indicates that writing instruction was not yet a systematic focus across these classrooms

A gender effect was found for CFPT ($F = 5.97$, $p <.05$) and for CFPM ($F = 4.37$, $p < .05$). Males used more time to complete the task of copying pseudo-letters. This is interesting as the tasks of copying pseudo-letters (CFP) and letter construction (LCS) both require awareness of critical features. Yet one requires the maneuvering of a pencil and the other requires fitting physical pieces together.

Limitations

This study was conducted during December of the kindergarten year with 49 participating students, giving a one-time observation of the skills of letter-writing fluency, LNF, CFP through writing of pseudo-letters and construction of lowercase alphabet letters with critical feature parts. Therefore, the study is limited in its ability to capture a developmental profile of letter awareness and writing skills. The time of year when the tasks were administered was thought to allow for some acclimation to school and limited exposure to writing alphabetic letters, but may also constrain the study. Marked classroom differences were noted as assessments were administered; some of the students were much more accurate and efficient in the four assessment tasks. Thus, this sampling included marked variability and may not represent students in other kindergarten programs, especially those that include an explicit, systematic handwriting curriculum. Other limitations include it being a relatively small study conducted in one school in the northwest U.S. and the use of some researcher-designed assessments that restricted the ways that students represented their letter knowledge. Still, the use of multiple factors, some previously used measures and attending to accuracy and time strengthened the design and provided a better understanding of letter-writing subskills.

Conclusions

In answer to the research questions posed by this study, the results suggest that variance in letter-writing fluency is predicted significantly by LNF. The ability to write pseudo-letters that contain critical feature letter parts of lowercase alphabet letters and the ability to construct lowercase alphabet letters using individual critical feature parts predict a much smaller portion of variance in letter-writing fluency. This study also suggests that variance in LNF is predicted to a small degree by ability to write pseudo-letters that contain critical feature letter parts of lowercase alphabet letters and by ability to construct lowercase alphabet letters using individual critical feature parts. However, much of the variance of achievement on these tasks remains unexplained.

Writing is both an orthographic (representing sounds with written or printed symbols) and a motor task (Peverly et al., 2014). This is affirmed in the way the different variables of this study were shown to be linked to each other. For example, letter-writing fluency required students to access memory of the name and form of alphabet letters and then to produce critical features of letters to form that letter correctly with a pencil. LNF required only the oral naming of letters with no motor task involved. CFP required using a pencil (a motor task) with no memory of letters involved. LCS required the motor task of assembling features correctly after distinguishing critical features of familiar alphabet letters. This may explain why CFP in this study may be more correlated with letter-writing fluency; yet letter construction, a less-refined motor task not requiring not requiring manipulation of a pencil, may be more correlated with LNF.

From previous research, LNF is known to be a strong predictor of reading ability

(Ritchey, 2004). In this study LNF, a piece of the orthographic part of writing, is also shown to have a high correlation with letter-writing fluency (.63) and to account for 40% of the variance of letter-writing fluency.

LNF was shown to be related in a smaller degree to both CFP and LCS, both of which involved using critical features. Pelli and colleagues (2006) stated that feature detection is more significant in identifying letters than age, experience or contrast of the letter to its background. Gibson and colleagues (1962) suggested that this ability to discriminate between features of letters increases significantly between the ages of 4 and 8. It seems from the correlation between LNF and CFP and LCS that feature detection may be beneficial to being able to identify and name letters. CFP and LCS are also predictive and show variance in each other. Both involve the use of critical features of letters. Both are motoric—one in manipulating a pencil and the other manipulating physical critical features. Knowing that using motor skills helps entrench letters in the memory may be important in planning letter-writing instruction.

Finally, LNF was shown to account for 40% of the variance in letter-writing fluency. Critical feature writing production, and LCS using critical features were all shown to account for only a small degree of variance in the skill of letter-writing fluency. This study helps to delineate the relationships and significance of letter-writing elements.

Recommendations

As LNF has been shown in this study to be strongly predictive of letter-writing fluency, activities involving letter naming are highly recommended for early letter-

writing instruction. Teacher surveys conducted prior to this study indicate that letter-naming is currently an important part of early kindergarten literacy instruction.

If copying critical features in the form of pseudo-letters and constructing letters using physical manipulation of critical feature parts are components of letter-writing fluency, it seems that instruction of these elements could precede or at least be in conjunction with formal letter-writing instruction. Hulme (1979) suggested that looking at a letter is not as effective as tracing it with a finger. A progression to be further explored suggested by results from this study may be to (a) identify and name critical features, (b) trace carefully selected separate, critical features with a finger, (c) physically manipulate critical features as to orientation and placement, (d) write critical features separately, and then (e) write critical features as part of a letter. Further research could be done on this process of introducing critical features as a developmentally appropriate cognitive tool for letter-writing instruction.

Presenting critical features as a basic pattern for letters (Patina, 1957) provided a cognitive tool as recommended by Arievitch and Stetsenko (2000). This could be an improvement to the tedious copying of letters required by the traditional method of introducing one letter per week or per day in isolation from each other. This supports feature processing that has been identified as the first step in LNF (Madec et al., 2012) and in letter-writing fluency.

One of the teacher concerns expressed in the teacher survey (Appendix B) was that for some children, manipulating a pencil is difficult. Manipulating critical feature parts to construct letters could be one way to prepare young students for writing letters

with a pencil. A classroom center could be set up with physical critical features to manipulate and place on templates of alphabet letters to see how they fit together in the form of a puzzle. These activities could precede pencil letter-writing activities. This could possibly build a young student's confidence and interest in how letters are formed, laying the foundation for writing them with a pencil. Such activities could be the focus of subsequent research.

In analyzing difficulty of construction for different letters, it was observed that "m," "e," and "s" were among the most difficult for students in this study to construct from the targeted features. Letters with fewer features and fewer types of features seemed to be easier for students to construct, which corroborates findings by Pelli and colleagues (2006). Future studies could analyze and compare different letters by number of features and difficulty of placement of features. Errors in constructing letters could be analyzed and compared in terms of placement, orientation, and fit of critical features. This could guide instructional decisions regarding time allotment for more difficult letters.

It was noted earlier, classroom effects were found for letter-writing fluency and letter-name fluency but not for the assessments involving critical features of letters. As observed in the teacher surveys, instruction in kindergarten when this study was conducted included how to write and how to name alphabet letters. This instruction had focused very little or not at all on identifying or writing critical features of alphabet letters. Future research could focus on assessing ability to identify, write and construct letters from critical features of letters in preschool before teacher instruction regarding letter-writing fluency and LNF has taken place. This could answer the question of

whether critical feature study is more effective early on, before formal letter-writing instruction takes place and whether awareness of letter features via manipulative parts could be fostered before motor skills are well developed.

As the assessments were administered in this case, it was observed that the task of letter construction was very engaging to the kindergarten students in comparison to the writing and letter-naming tasks. It took the longest time to administer but students stayed on task. In fact, as the letters were presented for them to construct, they became seemingly more and more engaged in the task as observed by their facial expressions, leaning forward, and even self-talk about the task. Future research might involve a survey of kindergarten students about how their engagement using critical features relates to learning letters forms. Boys, especially, were observed to have very positive feelings about the task of constructing letters from individual critical feature parts. Gender differences related to motivation about learning to write also merit future study

In summary, it was shown in this study that LNF accounted for nearly 40% of the variance in letter-writing fluency. The tasks of writing, or copying, of pseudo-letters and the letter construction task added up to 10% more variance to letter-writing fluency and 20% to LNF. It would seem, in light of findings of this study, that classroom instruction in LNF is very important in the early stages of letter-writing. Instruction regarding patterns of critical features of letters with opportunities to identify, physically manipulate, and write individual critical feature parts could be explored as to their advantage in the very earliest stages of formal letter writing instruction and possibly less frustration for students and/or less instructional time than traditional letter-writing instruction. Further

research into the instructional process of teaching critical letter features, the stage at which it is most beneficial, and motivational aspects of this instruction are recommended.

Results of this study in determining how much variance in letter-writing fluency are due to ability to identify and produce critical features of letters are inconclusive. Because of previously stated limitations involving the timing of this study and the use of researcher-developed assessments, further research into the identification and production of critical features of letters as components of letter-writing fluency is recommended. Even with the variances accounted for by LNF (nearly 40%) and tasks involving critical feature identification and production (together adding 10% more), Figure 2 shows that the major portion of the variance in letter-writing fluency is still unaccounted for by this study (50%). Further research into identification of other components of letter-writing fluency is also recommended.

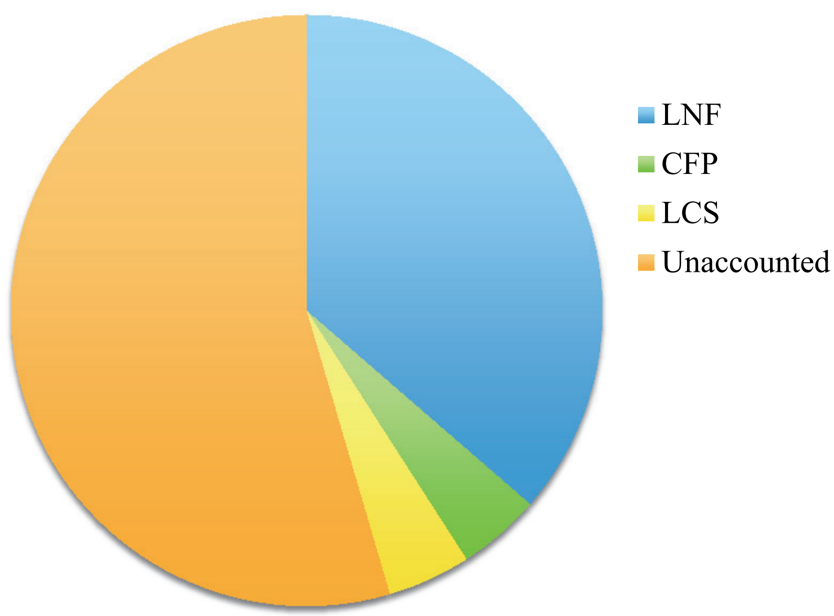

Figure 2. Explained and unaccounted for variance in LWF.

REFERENCES

Abbott, R., & Berninger, V. (1993). Structural equation modeling of relationships among developmental skills and writing skills in primary and intermediate grade writers. *Journal of Educational Psychology, 85,* 478-508.

Abbott, R., Berninger, V., & Fayol, M. (2010). Longitudinal relationships of levels of language in writing and between writing and reading in grades 1 to 7. *Journal of Educational Psychology, 102*, 281-298.

Arievitch, I., & Stetsenko, A. (2000). The quality of cultural tools and cognitive development: Gal'perin's perspective and its implications. *Human Development*, *43*(2), 69-92.

Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition. The psychology of education and instruction series.* Hillsdale, NJ: Erlbaum.

Berninger, V., Mizokawa, D. , & Bragg, R. (1991). Scientific practitioner: Theory-based diagnosis and remediation of writing disabilities. *Journal of School Psychology, 29*, 57-79.

Berninger, V., Vaughn, K., Abbott, R., Abbott, S., Rogan, L., Brooks, A., & Graham, S. (1997). Treatment of handwriting problems in beginning writers: Transfer from handwriting to composition. *Journal of Educational Psychology, 89*, 652-666.

Bowles, R., Pentimonti, J., Gerde, H., & Montroy, J. (2014). Item response analysis of uppercase and lowercase letter name knowledge. *Journal of Psychoeducational Assessment, 32*, 146-156.

Carr, S. (2014). *Common core has students writing—on just about every subject*. Retrieved from http://hechingerreport.org/just-facts-please-common-core-transforms-schools-teach-writing/

Christensen, C. A. (2005). The role of orthographic-motor integration in the production of creative and well-structured written text for students in secondary school. *Educational Psychology, 25,* 441-453. doi: 10.1080/01443410500042076

Coker, D. (2006). The impact of first-grade factors on the growth and outcomes of urban schoolchildren's primary-grade writing. *Journal of Educational Psychology, 98,* 471-488.

Connelly, V., Dockrell, J., & Barnett, J. (2005). The slow handwriting of undergraduate students constrains overall performance in exam essays. *Educational Psychology, 25*(1), 99-107. doi: 10.1080/0144341042000294912

Dynamic Indicators of Basic Early Literacy Skills. (2014). *Letter-naming fluency.* Retrieved from http://www.dibels.uoregon.edu/market/assessment/measures/lnf.php

Edwards, L. (2003). Writing instruction in kindergarten: Examining an emerging area of research for children with writing and reading difficulties. *Journal of Learning Disabilities, 36*(2), 136-148.

Fiset, D., Blais, C., Arguin, M., Tadros, K., & Ethier-Majcher, C. (2009). The spatio-temporal dynamics of visual letter recognition. *Cognitive Neuropsychology, 26*(1), 23-35.

Fitzgerald, J., & Shanahan, T. (2000). Reading and writing relations and their development. *Educational Psychologist, 35*(1), 39-50.

Gall, M. D., Gall, J., & Borg, W. R. (2007). *Educational research: An introduction.* Boston, MA: Pearson Education.

Gibson, E., Gibson, J., Pick, A., & Osser, H. (1962). A developmental study of the discrimination of letter-like forms. *Journal of Comparative & Physiological Psychology, 55*, 897-906.

Gibson, E., & Levin, H. (1975). *The psychology of reading*. Cambridge, MA: MIT Press.

Graham, S., Harris, K., & Fink, B. (2000). Is handwriting causally related to learning to write? Treatment of handwriting problems in beginning writers. *Journal of Educational Psychology, 92*, 620-633.

Graham, S., & Weintraub, N. (1996). A review of handwriting research: Progress and prospects from 1980 to 1994. *Educational Psychology Review, 8*(1), 7-87.

Hulme, C. (1979). The interaction of visual and motor memory for graphic forms following tracing. *The Quarterly Journal of Experimental Psychology,* 31, 249-261.

Jones, C., & Hall, T. (2013). The importance of handwriting: Why it was added to the Utah Core Standards for English Language Arts. *The Utah Journal of Literacy, 16*(2), 28-36. Retrieved from http://utahreading.org/index.php?page=the-importance-of-handwriting

Jones, D., & Christensen, C. (1999). Relationship between automaticity in handwriting and students' ability to generate written text. *Journal of Educational Psychology, 91*, 44-49.

Juel, C. (1988). Learning to read and write: A longitudinal study of 54 children from first through fourth grades. *Journal of Educational Psychology, 80*, 437-447.

Kim, Y., Al Otaiba, S., Puranik, C., Folsom, J., & Gruelich, L. (2014). The contributions of vocabulary and letter writing automaticity to word reading and spelling for kindergartners. *Reading & Writing, 27*, 237-253. foi: 10.1007/s11145-013-9440-9

Kim, Y., Al Otaiba, S., Puranik, C., Folsom, J., Gruelich, L., & Wagner, R. (2011). Componential skills of beginning writing: An exploratory study. *Learning &Individual Differences, 21,* 517-525.

Kirch, S. (2013). Instructional design that leads to the development of young scientists. In D. R. Reutzel (Ed.), *Handbook of research-based practice in early education* (pp. 326-347). New York, NY: Guilford.

Longcamp, M., Zerbato-Poudou, M., & Velay, J. (2005). The influence of writing practice on letter recognition in preschool children: A comparison between handwriting and typing. *Acta Psychologica, 119,* 67-79.

Madec, S., Rey, A., Dufau, S., Klein, M., & Grainger, J. (2012). The time course of visual letter perception. *Journal of Cognitive Neuroscience, 24*, 1645-1655.

Naka, M. (1998). Repeated writing facilitates children's memory for pseudocharacters and foreign letters. *Memory & Cognition, 26*, 804-809.

Naka, M., & Naoi, H. (1995). The effect of repeated writing on memory. *Memory & Cognition, 23,* 201-212.

National Governor's Association Center for Best Practices and Council of Chief State School Officers (NGA & CCSO). (2010). *Common core state standards.* Retrieved from http://www.ccsso.org/News_and_Events/Press_Releases/national_governors_association_and_state_education_chiefs_launch_common_state_academic_standards_.html

Patina, N. (1957). Formirovanie dvigatelnogo navika pisma v zavisimosti ot tipa orientirovki v zadanii (Formation of writing skills in relation to the type of orientation in the task). *Voprosy Psikologii, 4,* 117-132.

Pelli, D., Burns, C., Farell, B., & Moore-Page, D. (2006). Feature detection and letter identification. *Vision Research, 46*, 4646-4674.

Peverly, S., Garner, J., & Vekaria, P. (2014). Both handwriting speed and selective attention are important to lecture note-taking. *Reading and Writing, 27*(1), 1-30. doi:10.1007/s11145-013-9431-x

Peverly, S., Ramasway, V., Brown, C., Sumowski, J., Alidoost, M., & Garner, J. (2007). What predicts skill in lecture note taking? *Journal of Educational Psychology, 99*, 167-180.

Ramirez, A. (2014). *The lowdown on longhand: How writing by hand benefits the brain*. Retrieved from http://www.edutopia.org/blog/ writing-by-hand-benefits-brain-ainissa-ramirez?utm_source=facebook&utm_medium=post&utm_campaign=blog-writing-by-hand-benefits-image

Ritchey, K. (2004). IRA outstanding dissertation award for 2004: From letter names to word reading: The development of reading in kindergarten. *Reading Research Quarterly, 39*, 374-376

Ritchey, K. (2008). The building blocks of writing: Learning to write letters and spell words. *Reading &Writing: An Interdisciplinary Journal, 21*(1-2)*,* 27-47. doi 10.1007/s11145.007-9063-0

Townsend, J., & Ashby, F. (1982). Experimental test of contemporary mathematical models of visual letter recognition. *Journal of Experimental Psychology: Human Perception & Performance, 8*, 834-864.

Utah Core Language Standards. (2013). Retrieved from http://www.uen.org/core/core.do?courseNum=4700

Vernon, S., & Ferreiro, E. (1999). Writing development: A neglected variable in the consideration of phonological awareness. *Harvard Educational Review, 69*, 395-415.

Williams, J. (1968, February). *Effects of discrimination and reproduction training on ability to discriminate letter-like forms*. Paper presented at American Educational Research Association Conference, Chicago, IL.

APPENDICES

Appendix A

How Research Questions Are Aligned With Assessments

HOW RESEARCH QUESTIONS ARE ALIGNED WITH ASSESSMENTS

Assessment	What Measured?	Research Question
Letter-Naming Fluency (LNF) (Used as a predictor variable and later as a criterion variable)	Ability to name lowercase alphabet letters fluently	Does letter-naming fluency predict variance in letter-writing fluency?
Identification of Critical Features of Letters via alphabet letter construction (LCS) (Used as a predictor variable)	Ability to identify and use critical features of letters to construct lowercase alphabet letters	Does identification of critical features predict variance in letter-writing fluency? Does identification of critical features predict variance in letter-naming fluency?
Production of Critical Features via copying of pseudo-letters (CFP) (Used as a predictor variable)	Ability to produce critical features of letters	Does production of critical features predict variance in letter-writing fluency? Does production of critical features predict variance in letter-naming fluency?
Letter-Writing Fluency (LWF) (Used as a criterion variable)	Ability to write alphabet letters fluently	Do letter-naming fluency, critical feature identification, and critical feature production predict variance in letter-writing fluency?

Appendix B

Kindergarten Teacher Survey

Kindergarten Teacher Survey On Letter Writing Instruction

Note: Information taken from this survey will not be identified by teacher or classroom, but only used to indicate the general instructional context for this study.

Please provide a short answer to each of the following questions:

2. Do you use a letter writing or handwriting program? If so, please name and describe it.
3. How effective do you think your current handwriting program is for your students? Please, explain any concerns.
4. Please describe a typical lesson for letter writing instruction in your classroom.
5. What are the goals of a typical letter writing lesson?
6. How long and how often does a letter writing lesson take place?
7. What terms do you use to identify parts of letters—lines, circles, hooks, etc.?
8. How often do your students participate in writing activities beyond targeted handwriting lessons each week?
9. What kind of paper are you currently using for letter writing? Lined or unlined?

Would you be willing to e-mail me a sample?

Thank you!
Pam Reutzel
pamelareutzel@msn.com

Appendix C

Letter of Information

Letter of Information about Letter-Writing Fluency Study

I am a Utah State University master's degree student and a former kindergarten teacher. As a part of my graduate study, I am very interested in how children learn to write letters of the alphabet. Research shows that writing letters quickly and correctly at an early age is a predictor of later success in school. As a requirement for my master's thesis, I am conducting a simple study to collect information about how children learn to write. This study includes a series of brief letter-writing activities to show how kindergarteners write alphabet letters. Students who participate will be asked to complete four letter writing tasks in a location away from the other students. The activities will measure LNF, letter-writing fluency, how students identify critical features of letters, and how sessions of 10-15 minutes on separate occasions. The students' scores will be used anonymously and as a group to show what is typical among kindergarteners in general. No individual scores will be shared with others.

Attached is an Informed Letter of Consent that explains this study in more detail. Would you please read the letter and sign the back page to allow your child to participate in this study? Then please return the signed letter to your teacher as soon as possible. This would help me very much. If you have any questions, you can contact me or call Dr. Kathleen Mohr, my Utah State University advisor at Kathleen.mohr@usu.edu or 435-797-3946.

Thank you,

Pamela Reutzel pamelareutzel@msn.co

Carta Informativa sobre el Estudio Fluidez en la Escritura de Letras

Soy una estudiante de maestría en la Universidad del Estado de Utah (USU por sus siglas en inglés) y previamente fui maestra de kínder. Como parte de mis estudios graduados, estoy muy interesada en como los niños y niñas aprenden a escribir las letras del alfabeto. Estudios muestran que el escribir letras de manera rápida y correcta a una temprana edad es un indicador del futuro éxito escolar. Como requisito para mi tesis de maestría, estoy organizando un simple estudio para colectar información sobre como los niños y niñas aprenden a escribir. Estoy haciendo esto precisamente con la intención de determinar el valor predictivo de la capacidad de los niños actualmente en identificar y escribir letras en la fluidez que eventualmente desarrollan al escribir palabras. Para alcanzar esto, el estudio incluye una serie de breves actividades que consisten en escribir letras para mostrar como estudiantes del kínder escriben las letras del alfabeto. A los estudiantes que participen se les pedirá que completen cuatro tareas en un lugar separado de los otros estudiantes. Las actividades medirán la fluidez en nombrar las letras, la fluidez en escribir las letras, como los estudiantes identifican características fundamentales de las letras, y como los estudiantes copian los símbolos que se les muestran. Estas actividades se llevaran a cabo en 2 sesiones de 10 a 15 minutos cada una, en ocasiones separadas. Las calificaciones de los estudiantes se usaran de manera anónima, y la calificación grupal se usará para mostrar lo que es típico en los estudiantes de kínder en general. Ninguna de las calificaciones individuales será divulgada.

Anejada está la Carta de Consentimiento Informado que explica este estudio en más detalle. ¿Sería usted tan amable de leer la carta y firmarla permitiéndole a su hijo o hija participar en este estudio? Por favor, devuelva la carta firmada al maestro o a la maestra lo antes posible. Esto me ayudaría muchísimo. Si tiene cualquier pregunta, usted me puede contactar a mí o a la Dra. Kathleen Mohr, mi mentora en la Universidad del Estado de Utah, al 435-797-3946.

Gracias,

Pamela Reutzel
pamelareutzel@msn.com

Informed Consent Letter
Investigating Relationships Among Components of Letter-writing fluency

Introduction/ Purpose Dr. Kathleen Mohr, Associate Professor of Language and Literacy, in the School of Teacher Education and Leadership at Utah State University is supervising a research study to explore the role of five possible components of letter writing among young children. Your child has the opportunity to take part because he/she is a kindergarten student in Logan City School District at Bridger Elementary School. There will be approximately 48 participants in this research study at this site. Pamela Reutzel, a graduate student in the School of Teacher Education and Leadership will be collecting these data as part of the requirements to fulfill her master's thesis. She is a former kindergarten teacher and has completed a background check for Logan City School District.

Funding none

Procedures If you agree to allow your child to participate in this research project, your child will be asked to complete four letter-writing activities that will measure identification of important letter features, copying letter-like symbols, DIBELS letter-naming fluency, and letter-writing fluency. Scores from the first three tasks will be correlated with the letter-writing fluency score. These activities will be administered by the researcher at school in the next few weeks. This is expected to take no more than 15 minutes per student at each of two sessions. Students will be taken individually from the classroom to a quiet area of the school for the writing activities. All scores will be collected by task and reported as a group, so your child's name will not be associated with any of the results.

Risks Participation in this research study may involve minimal risks but none that are unusual to normal school attendance, instruction, or assessment activities. Students' identities will be protected in that the researchers will not use individual student information to analyze or report the data.

Benefits At present, there are no research findings on the relationships among individual components of letter-writing fluency. This research has the potential to determine the predictive value of letter name fluency, letter feature identification, and pseudo-letter production on letter-writing fluency. If these individual components are found to be predictive of letter-writing fluency, then teachers may want to provide instruction and practice via developmentally appropriate activities to incorporate these components into classroom instruction.

Explanation and offer to answer questions This letter has explained this research study to you. If you have other questions or research-related problems, you may reach Dr. Kathleen Mohr at (435) 797-3946 or Kathleen.mohr@usu.edu.

Extra Cost(s) There is no cost to students or parents of students who participate.

Voluntary nature of participation and right to withdraw without consequence Participation in research is entirely voluntary. You may refuse to allow your child to participate or withdraw him or her at any time without consequence. Your child may be withdrawn from this study without your consent by the investigator for test anxiety, unwillingness, or inability to participate in the tasks required. Your student may also refuse to participate when asked to complete the

activities.

If you wish to have your child participate, please complete the section "Agree to Participation" at the end of this document and return it to your child's teacher before the study begins.
If you do not wish to have your child participate, please complete the section "Decline to Participation" at the end of this document and return it to your child's teacher before the study begins.

Confidentiality Research records will be kept confidential, consistent with federal and state regulations. Only the investigator and the student researcher will have access to the data, which will be kept in a locked file cabinet or on a password protected computer in a locked room to maintain confidentiality. To protect your child's privacy, names will initially be used to match student data cross testing settings and then later replace with a code number. Once students complete the handwriting tasks, data will be collected using student code numbers rather than names. Data will be in summary form as a group; no individual scores will be identifiable nor will names be associated with any of the data. No personal, identifiable information will be obtained from study documents. Data will be stored electronically in a password protected computer file and all de-identified data will be kept indefinitely.

IRB Approval Statement The Institutional Review Board for the protection of human participants at Utah State University has approved this research study. If you have any questions or concerns about your rights or a research-related injury and would like to contact someone other than the research team, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

Signature of Researchers

______________________________	______________________________
Kathleen A. J. Mohr	Pamela Reutzel
Principal Investigator	Co-Investigator
435-797-3946	435-753-5106
Kathleen.mohr@usu.edu	pamelareutzel@msn.com

Agree to Participation

I agree to have my child, ___________________________________, participate in this research study.

Name of Student

_________________________________ _____________________________

Signature of Parent or Guardian Relationship to Student

_________________________________ _____________________________

Name of Parent or Guardian (PLEASE PRINT) Date

Decline to Participation

I decline to have my child, ___________________________________, participate in this research study.

Name of Student

______________________________ _____________________________

Signature of Parent or Guardian Relationship to Student

_______________________________________ _________________________

Name of Parent or Guardian (PLEASE PRINT) Date

Consentimiento Informado
Estudio Fluidez en la Escritura de Letras

Introducción/ Propósito La Dra. Kathleen Mohr, Profesora Asociada de Lenguas y Literatura, de la Escuela de Educación de Maestros y Liderato de la Universidad del Estado de Utah (USU por sus siglas en inglés) está supervisando un estudio investigativo para explorar el papel que tienen cinco posibles componentes de la escritura de letras entre niños pequeños. Su hijo o hija tiene la oportunidad de tomar parte de este estudio porque él o ella es estudiante de kínder en el Distrito Escolar de la Ciudad de Logan, en la Escuela Primaria Bridger. En este lugar serán aproximadamente 48 los participantes de este estudio investigativo. Pamela Reutzel, una estudiante graduada de la Escuela de Educación de Maestros y Liderato estará recopilando los datos como parte de los requerimientos para completar su tesis de maestría. Ella fue maestra de kínder y ha completado todas las verificaciones de antecedentes y la constatación de referencias requeridas por del Distrito Escolar de la Ciudad de Logan.

Fondos ninguno

Procedimiento Si usted acepta permitir que su hijo o hija participe de este proyecto de investigación, se le pedirá a su hijo o hija que complete cuatro actividades o tareas. Estas actividades medirán la identificación de características importantes de las letras, el copiar símbolos que parecen letras, la fluidez con que nombra las letras (DIBELS), y la fluidez con que escribe las letras. Las calificaciones de las primeras 3 tareas serán correlacionadas con la calificación de la fluidez al escribir letras. Estas actividades serán llevadas a cabo en la escuela por una investigadora durante las próximas semanas. Se espera que esto no tome más de 15 minutos por estudiante en cada una de las 2 sesiones. Los estudiantes serán llevados del salón de clases individualmente a un área tranquila de la escuela para que realicen las actividades de escritura. Todas las calificaciones se recopilarán por tarea y se reportarán de manera grupal, de esta manera el nombre de su hijo o hija no podrá ser asociado con ninguno de los resultados.

Riesgos La participación en este estudio de investigación puede que implique riesgos mínimos, pero ninguno que sea inusual a la habitual asistencia a clases, enseñanza, o evaluación de actividades. La identidad de los estudiantes será protegida de manera que los investigadores no utilizarán la información individual de los estudiantes al analizar o reportar la data.

Beneficios Al presente, no hay resultados investigativos que demuestren la relación que tienen los componentes individuales de la fluidez en el acto de escribir letras. Esta investigación tiene el potencial de determinar el valor predictivo que tienen la fluidez al nombrar las letras, identificar los componentes de las letras, y la producción de pseudo-letras en la fluidez de escribir letras. Si se encuentra que estos componentes individuales son útiles para predecir la fluidez en la escritura de letras, entonces los maestros podrían proveer adiestramiento y practica atreves de actividades apropiadas que incorporen estos componentes en la enseñanza del salón de clases.

Explicación y oferta para responder a las preguntas Esta carta le ha explicado este estudio. Si usted tiene preguntas adicionales o problemas relacionados con la investigación, usted puede contactar a la Dra. Kathleen Mohr al (435) 797-3946 o Kathleen.mohr@usu.edu.

Costo adicional No hay costo para los estudiantes o los padres de los estudiantes que participen.

Carácter voluntario de la participación y el derecho a retirarse sin consecuencias La participación en esta investigación es completamente voluntaria. Usted puede reusarse a permitir que su hijo o hija participe y puede retirarlo a él o ella en cualquier momento sin que haya ninguna consecuencia. La investigadora podría retirar a su hijo o hija de este estudio sin su consentimiento por razones de ansiedad, rechazo o la inhabilidad de participar en las tareas requeridas. Su hijo o hija también puede reusarse a participar cuando se le pida que complete las actividades.

Si usted desea que su hijo o hija participe, por favor complete la sección "Acepto Participar" al final de este documento y devuélvelo a la maestra o maestro de su hijo o hija antes de que el estudio comience. Si usted no desea que su hijo o hija participe, por favor complete la sección "Rechazo Participar" al final de este documento y devuélvelo a la maestra o maestro de su hijo o hija antes de que el estudio comience.

Confidencialidad Los resultados de la investigación se mantendrán confidenciales, en consistencia con las leyes federales y estatales. Solo la investigadora y la estudiante de investigación tendrán acceso a los datos, los cuales se mantendrán bajo llave en un archivo, o protegido por una contraseña en una computadora localizada en un cuarto con llave para mantener confidencialidad. Para proteger la privacidad de su hijo o hija, ni información personal, ni identificable será obtenida de los documentos del estudio. Los datos serán almacenados electrónicamente en un archivo de computadora protegidos por una contraseña por no menos de tres años y no más de siete años.

Declaración de Aprobación del IRB El Panel de Revisiones Institucionales (IRB por sus siglas en ingles) para la protección de los seres humanos participantes en la Universidad del Estado de Utah ha aprobado este estudio investigativo. Si usted tiene cualquier pregunta o preocupación sobre sus derechos o lesiones relacionadas a la investigación y quisiera contactar a alguien fuera del equipo de investigación, usted puede contactar la Administradora del IRB, quien habla español, al (435) 797-0567 o a través de email a irb@usu.edu para obtener información u ofrecer sugerencias.

Declaración del Investigador "Yo doy fe que el estudio investigativo se le ha explicado al individuo, por mi o por mi equipo de investigación, y que el individuo entiende la naturaleza y propósito, los posibles riesgos y beneficios asociados con tomar parte de este estudio investigativo. Cualquier pregunta echa fue contestada"

Firma de las Investigadoras

__________________________	__________________________
Kathleen A. J. Mohr	Pamela Reutzel
Investigador Principal	Asistente de investigación
435-797-3946	435-753-5106
Kathleen.mohr@usu.edu	pamelareutzel@msn.com

Acepto Participar

Acepto que mi hijo/hija, ________________________________, participe de este estudio investigativo.

Nombre del/de la Estudiante

____________________________________ ____________________________
Firma del Padre, Madre o Encargado Relación con el o la Estudiante

____________________________________ ____________________________
Nombre del Padre, Madre o Encargado Fecha
(en letras mayúsculas)

Rechazo Participar

Rechazo que mi hijo/hija, _______________________________, participe de este estudio investigativo.

Nombre del/de la Estudiante

____________________________________ ____________________________
Firma del Padre, Madre o Encargado Relación con el o la Estudiante

____________________________________ ____________________________
Nombre del Padre, Madre o Encargado Fecha
(en letras mayúsculas)

Appendix D

Administration and Scoring of Assessments

<u>1. DIBELS Letter-naming Fluency Subtest (LNF)</u>

Directions for administration and scoring of DIBELS Letter Name Fluency Subtest: (retrieved from dibels.uoregon.edu/market/assessment/measures/lnf.php)

"Students are presented with a page of upper- and lower-case letters arranged in a random order and are asked to name as many letters as they can. If they do not know a letter, the examiner provides the name of the letter. The student is allowed 1 minute to produce as many letter names as he/she can, and the score is the number of letters named correctly in 1 minute."

Materials Needed:

DIBELS LNF scoresheets

Pencils

Timer

Scoring (LNF): Number of letters named per minute**.**

<u>2. Written Production of Critical Features Assessment in the form of Pseudo-letters (CFP</u>)

Script:

Write student's name at top**.**

On these cards are written some "nonsense letters". These nonsense letters have the same parts as real letters, but they are arranged differently. Please copy these nonsense letters into the boxes on this paper so they have the same parts and look exactly like they do on the card.

First, let's practice:

(Assessor shows Practice Card #1).

Please write this nonsense letter on this paper so it has the same parts and looks exactly like the nonsense letter on this card.

Point to 1st box. Student writes pseudo-letter in the first box.

If incorrect, Assessor models and student practices until the nonsense letter is correct.

If correct, continue with other pseudo-letters until all are written, 1 in each box going left to right through the 1st row and then down through the 2nd and 3rd rows.

Begin the timer after the practice card and time until all cards have been completed.

Record time under student's name.

Materials Needed:

22 cards each displaying a pseudo-letter (Pseudo-letters shown in Appendix B.)

Paper and pencil on which the student may write the pseudo-letters

Timer

Scoring (CFP): Each pseudo-letter written will be assigned from 1-2 points as follows:

1 point if letter has all correct features, 1 point if all features are correctly placed in relation to each other and oriented correctly

Raw Score (CFPR): Total points earned for all pseudo-letters per student

Time-per-minute Score (CFPM): Raw score, divided by number of seconds it took student to complete the whole task, multiplied by 60, to yield number of points

earned per minute.

<u>3. Assessment of Letter Construction of Lowercase Alphabet Letters using Eight Critical Features (LCS)</u>

Before beginning, student teacher helper will take picture of student name and number to be attached to photos of letters constructed by that student.

Script:

Here are some parts that we can use to write letters. Pointing to each: *We have short lines, tall lines, closed circles, open circles, short hooks, long hooks, and horseshoes or u-turns. All letters can be made from these parts. Let's practice to see how they work. Will you look at this letter and then choose which of these parts you need to make the letter "v" as it looks on this card.*

(Student picks 2 short lines from parts and places them on the mat to make a "v." Researcher offers guidance, if needed.)

Please also notice how when I am finished making the letter, my helper will quickly take a picture of the letter, and then will you please slide the parts over to this side so you are ready for another letter?

Sometimes we have to move the part around to make a letter. Will you look at this letter and then choose which of these parts you need to make the letter "n" as it looks on this card?

Student picks 1 short line and 1 short hook (or 1 u-turn) from parts and places them on the mat to make an "n." Researcher offers assistance only as needed.)

I will show a letter to you. Please, pick up the parts you would need to make this

letter and put them on this mat. When you have finished making the letter, my assistant will quickly take a picture of the letter you have made, and then please slide the part over to this side, so you are ready for the next letter. Please move quickly but carefully.

Materials needed:

A stack of each of the following critical features of letters made of black cardboard:

Short lines, tall lines, open curves, closed curves, short hooks, long hooks, u-turns, and dots.

A rectangular 8 x 11 inch mat on which the student can place the letter parts

Alphabet cards for each of the following letters: a, c, e, f, h, j, k, m, o, p, q, r, s, t, w, x, z

In the interests of time and because their features were already included in the letters that were used, b, d, g, i, l, n, u, v, and y were not used. The size of the letters on the alphabet cards was the size that matched the critical feature parts made of black cardboard.

Timer

Scoring (LCS): This assessment was timed to prevent a ceiling effect in the case that many students performed perfectly. Criteria for assigning points for letters was as follows:

<u># Correct Features</u>: Number of features selected according to correct class (lines, circles, part circles, hooks, dots, or u-turns) without regard to size, orientation, or overlap/fit—not to exceed maximum of most effective features that can be used

according to Points Possible Table below. Note that in some cases, either a line and an open curve could correctly be used in place of a hook, but would still only get one point for that feature. In other cases more than one combination would yield the same correct score. For example, an m could be made from a short line and two short hooks, or from a short line and two u-turns.

Correct Orientation: Correct orientation of each feature within 45 degrees or less. 1 or 0

Correct size: Correct size of each feature as proportional to other features of the letter. 1 or 0

Correct overlap: Features overlap each other correctly, fit together without incorrect spaces between features. 1 or 0

Extra features: check mark if there are added features that are not needed. Not figured in total score value.

A blank score sheet for the LCS assessment is found below:

Letter	# of Correct Features	Correct Orientation	Correct Size of Features	Correct Overlap	Total Score/ letter	Extra Features
h						
z			X	X		
f				X		
x			X	X		
p						
w						
s						
j			X	X		
r						
t		X		X		
q						
e						
c			X	X		
a						
k						
m						
o		X	X	X		
				Final Score		

A score sheet showing points possible for each letter is shown below:

Letter	# of Correct Features	Correct Orientation	Correct Size of Features	Correct Overlap	Total Score	Extra Features- not added in total
h	2	1	1	1	5	
z	3	1	X	X	4	
f	2	1		X	4	
x	2	1	X	X	3	
p	2	1	1	1	5	
w	4	1	1	1	7	
s	2	1	1	1	5	
j	2	1	X	X	3	
r	2	1	1	1	5	
t	2	X	1	X	3	
q	2	1	1	1	5	
e	2	1	1	1	5	
c	1	1	X	X	2	
a	2	1	1	1	5	
k	3	1	1	1	6	
m	3	1	1	1	6	
o	1	X	X	X	1	
				Final Possible Score	74	

Raw score (LCS): Total points for all letters per student

Time-per-minute score (LCPM): Raw score, divided by number of seconds for completion of all letters, multiplied by 60, to yield number of points earned per minute.

4. Letter-writing fluency Assessment (LWF)

Directions for administration and scoring of the letter fluency test used by Kim et al. (2011, p. 520) and Kim et al. (2013, p. 244):

"Research assistants asked children to write all the letters in the alphabet in order, using lower case letters. The directions were: *We're going to play a game to show me how well and quickly you can write your abc's. First, you will write the lowercase of*

small ABCs as fast and carefully as you can. Don't try to erase any of your mistakes, just cross them out and go on. When I say ***"****ready begin****"****, you will write the letters. Keep writing until I say stop. Ready, begin*. After 1 minute, tell the students: ***"****Stop and put down your pencils****"***. Children received a score for the number of correctly written letters. The possible range of scores was 0 to 26; with one point awarded for each correctly formed and sequenced letter. Given that children were in kindergarten, we allowed a 0.5 for each poorly formed letter that could only be recognized in context or was reversed. The following responses were scored as incorrect and earned a score of zero: (a) letters written in cursive; (b) letters written out of order; or (c) uppercase letters."

Materials needed:

Lined paper (as presently used in their kindergarten classroom) and pencil for each child

Pencils

Timer

Scoring (LWF):

One point was assigned for each correctly formed lowercase alphabet letter written.

.5 point was given for each recognizable but poorly formed letter (unrecognizable out of context).

.5 point was given for each uppercase letter, and .5 point was given for each reversed letter

Raw score (LWF): Number of letters written correctly per minute

Appendix E

Identified Critical Features of Lowercase Alphabet Letters

Seven Identified Critical Features of Lowercase Alphabet Letters

Lower-case letters	short line	long line	closed circle	open circle	short hook	long hook	dot	
a	x		x					
b		x	x					
c				x				
d		x	x					
e	x			x				
f	x					X		
g			x			X		
h		x			x			
i	x						x	
j						x	x	
k	xx	x						
l		x						
m	x				xx			
n	x				x			
o			x					

Lower-case letters	short line	long line	closed circle	open circle	short hook	long hook	dot	
p		x	x					
q			x			x		
r	x			x				
s				xx				
t	x	x						
u	x				x			
v	xx							
w	xxxx							
x	xx							
y	x	x						
z	xxx							

Note: Seven critical features were used for the CFP assessment, writing of pseudo-letters. One additional feature, the u-turn or hump, was added to those seven for the letter construction task (LCS) to offer a convenient way to make letters, such as m and h, in the interest of time for this test.

Appendix F

Rationale for Creation of Pseudo-Letters

Rationale for Creation of Pseudo-letters

1. The English alphabet contains the following features:

Short lines—23 times
Long lines—8 times
Open curves—4 times
Closed curves—7 times
Short hooks—6 times
Long hooks—4 times
Dots—2 times

2. Lowercase alphabet letters come in combinations of 1 to 4 features:

*3 letters contain only 1 feature: c, l, and o
*19 letters contain 2 features: a, b, d, e, f, g, h, i, j, p, q, r, l, s, t, u, v, x, y
*3 letters contain 3 features: k, m, and z
*1 letter contains 4 features: w

3. A critical feature was defined as a continuous stroke, before changing direction if it is a straight line, or turning back on itself if it is a curved line.

In the following set of pseudo-letters, each of the seven identified critical features was used a minimum of four times. Each critical feature was represented one time as a pseudo-letter by itself. It was then presented as a part of other pseudo-letters using other critical features.

4. The following set of pseudo-letters allows students to show ability to use each of the critical features common in the English alphabet. This set doesn't directly match the proportionality of critical features that occurs in lowercase letters in the English alphabet, but all common features are included.

Score Sheet for Assessment
Critical Feature Production through Pseudo-letters