

**THE ROLE OF EXECUTIVE FUNCTION IN WRITING ACHIEVEMENT IN
FIRST GRADE**

by

Allison F. Jackson

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Education

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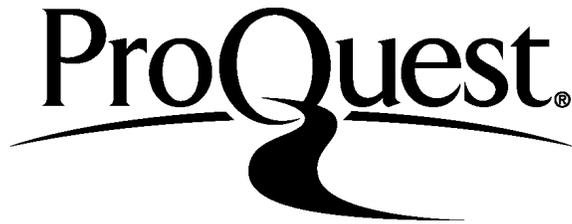
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by

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ABSTRACT

Executive function is an umbrella term used to describe the cognitive processes that allow an individual to regulate and control one's thoughts and behaviors in order to plan and achieve a goal. Research on the relation of executive function and academic achievement has primarily focused on reading and math. This study examined the role of executive function in writing achievement in first grade. The theoretical framework for this study is the Not So Simple View of Writing (Berninger & Winn, 2006). First grade students ($N = 231$) from two school districts were assessed on measures of handwriting fluency, spelling, oral vocabulary, and reading. Results from structural equation modeling analyses found that executive function did not directly contribute to writing achievement; however, executive function indirectly contributed to writing achievement through handwriting fluency and oral vocabulary. The findings of this study were inconsistent with other research (Hooper et al., 2011; Kent, Wanzek, Petscher, Al Otaiba, & Kim, 2014) that found a direct relationship between executive function and writing achievement. Further research is necessary in order to fully understand the relation between executive function and beginning writing.

Chapter 1

INTRODUCTION

The purpose of this dissertation study is to examine executive function and writing. More specifically, the study examines the relation between executive function and the beginning writing achievement of first-grade students. This chapter provides an introduction to the dissertation study and includes discussion of the importance of writing and the writing challenges faced by students. The theoretical framework guiding this study and the potential importance of executive function in writing are described. The purpose of the study, statement of the problem, and research questions will be presented. The chapter concludes with definitions of terms relevant for this dissertation study.

The Importance of Writing

Learning to write is a multi-faceted process essential not only for academic success but for later professional success (Graham, Gillespie, & McKeon, 2013; Graham & Harris, 2005). Writing is essential for learning and is one way that learning can be evaluated (Graham & Harris, 2011). Skilled writers are able to effectively translate ideas into written text that clearly communicates a purpose, whether it is in a classroom or at a job. However, many students lack the most basic writing skills. Increased efforts are being made to address the need for bringing writing back to the forefront, especially in the classroom. A report issued by the National Commission on Writing for America's Families, Schools, and Colleges (2003) argues that “despite its importance to learning,

formal attention to writing leaves a lot to be desired, in both school and college” (p. 14). Additionally, increased emphasis on writing in schools has been targeted by the implementation of the Common Core State Standards (CCSS, National Governors Association & Council of Chief School Officers, 2010), which define expected grade-level writing standards for kindergarten through twelfth grade. For beginning writers (i.e., students in kindergarten and first grade), the curriculum standards include specific expectations for handwriting, spelling, and using writing to communicate for a variety of purposes (e.g., write a narrative that includes events). These standards are likely to require changes in writing instructional practices as the expectations for beginning writers are higher than those presented in previous curriculum standards.

Becoming a skilled writer is dependent on many factors; however, unless foundational component skills such as handwriting and spelling are acquired, writing development may be hindered. Furthermore, other components, such as executive function, may also be important. This study aims to contribute to the literature examining beginning writing with an emphasis on executive function. Understanding executive function in relation to writing may help improve writing instruction.

Writing Difficulty

Writing is essential for academic success; however, many students have difficulty writing. Recent national assessment data and research on the prevalence of writing problems (including students with writing disabilities) suggest that more attention is needed to understand how to provide writing instruction and ways to address and prevent writing failure. National reports suggest that students leave high school and enter the

workforce with inadequate writing proficiency. Data from the most recent National Assessment of Educational Progress (NAEP, National Center for Education Statistics, 2012) suggest that the writing performance of U.S. students is deficient. The basic level of writing represents partial mastery of prerequisite knowledge and skills needed for proficient work at each grade level. In this report, 54% and 52% of the students in Grade 8 and Grade 12, respectively, were at the basic level of writing performance for their respective grade level. In Grades 8 and 12, 20% and 21% of students, respectively, were below basic. According to NAEP, students performing at the proficient level have demonstrated their ability to “accomplish the communicative purpose of writing” (p. 1). Only 24% of students at both Grades 8 and 12 performed at the proficient level of writing performance. These results suggest many students are leaving middle school and high school with basic or below-basic writing skills.

Beginning writers may struggle with the cognitive processes involved in writing. Specifically, lower-level cognitive processes such as transcription, text generation, and executive function may impede their ability to fluently produce quality written text (Feifer & De Fina, 2002; Graham, Harris, & Olinghouse, 2007). Additionally, difficulty in any one component of writing can result in difficulty in another component (Mather & Wendling, 2011). For example, until a beginning writer develops fluent handwriting skills it is likely that any written text will be short, lack organization, and lack details. Lower-level cognitive processes can be especially challenging for young students and for students with disabilities. Additionally, not only is writing difficult for typically-developing students it can be especially challenging for students with disabilities (Harris,

Graham, & Mason, 2003; Hooper et al., 2011). Based on an epidemiologic study, the incidence of writing disability ranges from 6.9% to 14.7% of all students, and there is a higher prevalence rate for boys than girls (Katusic, Colligan, Weaver, & Barbaresi, 2009). However, these incidence rates may not present a full picture because many students struggling with writing are not formally identified as having a writing disability. Graham and Harris (2011) note that “19 of every 20 student with disabilities do not acquire the writing skills needed for success in school” (p. 422). Given the prevalence of writing difficulty and the challenges associate with learning to write, additional research in the area of writing is needed.

Theoretical Framework

Berninger and Winn’s (2006) Not So Simple View of Writing was selected as the theoretical framework for this dissertation study. This model evolved from models of adult writers (Hayes & Flower, 1980; Hayes, 1996) and represents the cognitive components of writing that are necessary for developing writing skills. The three components of the Not So Simple View of Writing are transcription, executive function, and text generation.

Transcription (i.e., handwriting and spelling) involves processes by which the writer translates ideas in his or her mind into written text. Executive function describes cognitive processes that include supervisory attention, planning, goal setting, monitoring, reviewing, and revising. Text generation is the process of turning ideas into words, sentences, and larger units of discourse within working memory (McCutchen, 2011).

Text generation is the mental production of text, whereas transcription is the physical production of text.

In the Not So Simple View of Writing, long-term memory is activated during planning, composing, reviewing, and revising. Short-term memory is activated by working memory during reviewing and revising. The model also describes the role of the supervisory attention system which allows the writer to stay focused and switch between mental sets as he or she writes, also referred to as inhibition and cognitive flexibility. Specifically, this study will examine executive function in relation to the written expression skills of students in first grade. Additionally, this study will examine transcription, oral vocabulary, and reading skills because these components have been posited as important components of beginning writing (Abbott & Berninger, 1993; Coker, 2006; Jones & Christensen, 1999; Kim, Al Otaiba, Puranik, Greulich, & Wagner, 2011; Kim, Al Otaiba, Sidler, & Gruelich, 2013; Puranik & Al Otaiba, 2012; Wagner et al., 2011).

What is Executive Function?

Executive function, broadly defined, refers to cognitive processes necessary for controlling one's thoughts and behaviors for the purpose of regulating mental functions and for guiding one's behavior toward a future goal (Altemeier, Abbott, & Berninger, 2008; Jacques & Marcovitch, 2010). In relation to beginning writing, low-level executive function processes (i.e., inhibition, working memory, and cognitive flexibility) are proposed to provide the underpinnings for the supervisory attention system (Berninger & Richards, 2002; Berninger & Winn, 2006; Feifer & De Fina, 2002). Low-level executive

function processes are posited as providing support for high-level executive function skills (e.g., planning and revising) important for skilled writing (Diamond, 2013; Drijbooms, Groen, & Verhoeven, 2015). Inhibition is the ability to inhibit an automatic, dominant response (Miyake et al., 2000). Working memory is a temporary storage system involved in maintaining and manipulating information during a task (Baddley, 2006). Cognitive flexibility is the ability to switch flexibly between tasks or mental sets (Miyake & Friedman, 2012). These three low-level executive function processes will be discussed in detail in the next chapter.

According to Feifer and De Fina (2002), a beginning writer with poor inhibition may have difficulty stopping a thought on paper. For example, poor inhibition may result in having additions to words when spelling (e.g., goood). Furthermore, a beginning writer with poor working memory may have difficulty holding ideas in mind during the transcription process. Poor cognitive flexibility may result in a beginning writer getting stuck on one topic during writing (Feifer & De Fina, 2002). Low-level executive function processes allow a writer to maintain attention to the writing task during which he or she shifts between text generation and translating ideas while physically producing written text.

Executive Function as a Predictor of Writing

There is a small, but growing, body of research studying the relationship between executive function and academic outcomes for young children. Much of the research has focused on reading and math outcomes (Blair & Razza, 2007; McClelland, Cameron,

Connor, Farris, Jewkes, & Morrison, 2007; Monette, Bigras, & Guay, 2011). These results suggest that executive function is related to academic achievement.

With respect to executive function and writing, two studies (Hooper et al., 2011; Kent, Wanzek, Petscher, Al Otaiba, & Kim, 2014) were located that included students in kindergarten through second grade. These two studies will be discussed in depth in Chapter 2. This research has focused on identifying the contribution of executive function to writing in addition to other acknowledged correlates (i.e., reading skills, oral vocabulary, handwriting, and spelling) of writing.

Kent and colleagues (2014) examined the relation of kindergarten component skills (i.e., transcription, reading, oral language, attention, and self-regulation) with writing outcomes at the end of kindergarten and first grade. Kindergarten component skills had a direct effect on writing fluency and quality. Hooper and colleagues (2011) examined the relation of neuropsychological components (i.e., fine-motor skills, language, short- and long-term memory, working memory, and executive function) to early written language of first and second grade students. The first grade latent trait model accounted for 51 and 55% of the variance in second grade written expression and spelling, respectively. These two studies suggest that executive function contributes to the writing skills of young children. Differences in the selected component skills, grade levels, and the type of measures for executive function and writing suggest that additional research is needed in this area.

Studies examining the relation between beginning writing and executive function for first-grade students are few. Understanding the role of executive function in writing

may help to explain writing problems. Hooper, Swartz, Wakely, de Kruif, and Montgomery (2002) found that that fourth- and fifth-grade students with and without writing problems demonstrated differences in executive function (e.g., initiation, set shifting, sustaining, and inhibition). Students who were poor writers had lower performance in the four executive function domains as compared to students who were good writers. This study suggests that there may be important differences in executive function for younger students. Additional research could inform instruction and intervention efforts.

Executive Function and Writing Strategies

Skilled writing can take more than two decades to develop, during which time the individual's mental writing processes are undergoing changes (Bereiter & Scardamalia, 1987; Kellogg, 2008; Kellogg & Whiteford, 2012). Beginning writers, including first-grade students, often use a knowledge telling strategy (Bereiter & Scardamalia, 1987) during early writing. As noted by Bereiter and Scardamalia (1987), the knowledge telling strategy pertains to the "mental processes by which texts are composed and not to the texts themselves" (p. 13). For beginning writers, this strategy would involve writing whatever is known about the topic with limited involvement of high-level executive function processes such as planning and revising (Bereiter & Scardamalia, 1987; Graham et al., 2007). McCutchen (2006) further notes that the writing assignment itself functions as the plan for beginning writers. The knowledge telling strategy may result in text that lacks organization and may also fail to relate to the assigned topic. Furthermore, this

strategy is dependent on the premise that the student will have a basic knowledge base related to the assigned topic.

According to Graham, Harris, and Olinghouse (2007), knowledge telling makes the writing task manageable for beginning writers by reducing the use of executive function processes such as planning and revision. In contrast, the knowledge transforming strategy involves the writer's ability to mentally engage in planning, reviewing, and revising during composition (Bereiter & Scardamalia, 1987), which is characteristic of a skilled writer. Overall, executive function is an important component of not only beginning writing but skilled writing as well.

Statement of the Problem and Rationale

Becoming a skilled writer is essential not only for academic success but for future professional success (Graham & Harris, 2005). However, many students are performing below expectations in writing. Research examining the cognitive processes that contribute to beginning writing is relatively novel, especially compared to research for other academic areas such as reading and math. There has been extensive research examining executive function; however, little of this research specifically targets beginning writing. Further research examining the relation between executive function and beginning writing is needed in order to better comprehend its contribution to beginning writing as posited by the Not So Simple View of Writing (Berninger & Winn, 2006). Understanding the role of executive function during the early stages of writing development could contribute to the design of effective instruction and early intervention for typically-developing students and students with writing problems.

Purpose and Research Questions

The purpose of this study is to examine executive function in relation to the writing achievement of students at the end of first grade. This study will explore the role of executive function using structural equation modeling (Kline, 2005; Tabachnick & Fidell, 2007). Structural equation modeling is a group of statistical methods used to examine relationships between one or more independent variables and one or more dependent variables (Kline, 2005; Ullman, 2007). Structural equation modeling allows simultaneous regression equations and allows for differentiating between observed variables and latent variables (Kline, 2005).

Specifically, the following research question will be addressed:

What are the direct and indirect relations of executive function, handwriting fluency, spelling, oral vocabulary, and reading to beginning written expression assessed at the end of first grade?

Definition of Terms

Cognitive flexibility is a core component of executive function. Cognitive flexibility refers to the ability to switch flexibly between tasks or mental sets and is also referred to as set shifting or task shifting (Garon, Bryson, & Smith, 2008; Miyake & Friedman, 2012).

Composition involves generating text, which includes such processes as planning, producing, reviewing, and revising text (Zins & Hooper, 2012).

Executive function is an umbrella term used to describe the cognitive processes that allow an individual to regulate and control one's thoughts and behaviors in order to plan and achieve a goal. Executive function is a subcomponent of self-regulation (Calkins & Marcovitch, 2010; Jacques & Marcovitch, 2010; Moran & Gardner, 2007). The core components of executive function are cognitive flexibility, inhibition, and working memory.

Handwriting is the physical act of using the hand to produce letters, words, sentences, and connected text (Berninger, 2012).

Inhibition is another core component of executive function. It is the ability to inhibit an automatic, dominant response (Miyake et al., 2000).

Mediation involves testing whether or not a hypothesized relationship between an independent variable and a dependent variable is partially or completely explained by a third variable (Bowen & Guo, 2012). Mediation is also referred to as an indirect effect.

Self-regulation is a multidimensional construct that pertains to the regulation of cognition, behavior, and emotion (McClelland, Ponitz, Messersmith, & Tominey, 2010).

Spelling is the ability to write words by encoding (Gentry, 1982).

Structural equation modeling (SEM) is a group of statistical methods used to examine the relationships between one or more independent variables and one or more dependent variables (Kline, 2005; Ullman, 2007). Independent variables and dependent variables can be either discrete (e.g., categorical) or continuous (Kline, 2005).

Transcription is the translation of internal linguistic representations from working memory into written text using by means of handwriting or keyboarding and spelling (Berninger, 1999; Berninger, Abbot, Augsburger, & Garcia, 2009).

Text generation is the translation of ideas into language representations within the working memory storage system (Abbott & Berninger, 1993; Berninger, 1999).

Working memory is a temporary storage system involved in maintaining and manipulating information during a task for a brief period of time (Alloway, Gathercole, & Pickering, 2006; Baddley, 2006; Yeager & Yeager, 2013).

Chapter 2

LITERATURE REVIEW

The purpose of this study is to examine the relation between executive function and the beginning writing achievement of first-grade students. The study of the cognitive processes of beginning writers is relatively recent. The majority of empirical research investigating executive function and young children targets reading and math achievement; however, as noted in Chapter 1, writing is also important for academic and professional success. Therefore, this study aims to contribute to the understanding of executive function and beginning writing achievement.

In this chapter, the relevant literature will be reviewed. Early writing models that influenced the Not So Simple View of Writing will be described (Berninger & Amtmann, 2003; Berninger & Winn, 2006; Hayes, 1996; Hayes & Flower, 1980; Juel, Griffith, & Gough, 1986). The Not So Simple View of Writing will be discussed followed by executive function. The literature review continues by describing the types of executive function, the structure of executive function, the core components of executive function, and how these components are related. Research examining executive function and academic achievement will be presented. The chapter concludes with a discussion of the correlates of writing for kindergarten and first grade.

Cognitive Models of Written Language

Initial research on cognitive processes in writing examined the skilled writing of

adults in an attempt to organize and explain the cognitive processes involved in skilled writing. This research revealed the complexity of the writing process. The Hayes and Flower (1980) model provided the foundation for models applicable to novice writers, especially young children. In the following sections, the original Hayes and Flower (1980) model, including revisions later made by Hayes (1996), will be discussed. The Simple View of Writing, as conceptualized by Juel, Griffith, and Gough (1986) and Berninger and Amtmann (2003), will follow. This section will conclude with the Not So Simple View of Writing, which further expands upon the Simple View of Writing.

Hayes and Flower Model

One seminal writing model was developed by Hayes and Flower (1980), which was later revised by Hayes (1996). The Hayes and Flower cognitive model of writing provided a framework for understanding the cognitive processes of skilled writers (i.e., adults). The Hayes and Flower model also provided a framework for later models seeking to explain the cognitive writing processes involved in beginning writing.

Hayes and Flower (1980) identified three components of writing: (1) the task environment, (2) the writer's long-term memory, and (3) the writing process. The task environment includes all external influences beyond the writer such as the writing assignment, which includes the topic and audience. The writer's long-term memory stores knowledge about the topic in order to generate ideas. The writing process consists of three major parts: planning, translating, and reviewing. Planning involves taking the information from the task environment and from long-term memory to organize and set writing goals. Translating then uses the writing plan to produce text that

corresponds with the information in the writer's memory. Reviewing involves reading and editing the generated text for the purpose of improving the written product. Their model describes how adult writers engage in the process of writing and provides understanding of how these processes work together during the act of writing. Furthermore, their research examined the processes involved in writing but did not examine the products that result from writing.

Hayes (1996) revised the model to reflect research findings spanning the years since the original Hayes and Flower (1980) model was proposed. The original model was reconfigured for clarification to include two major components: the task environment and the individual. The most important difference is the emphasis on working memory. The revised model now addresses the importance of visual-spatial representation in writing (i.e., tables, graphs, and diagrams).

Additionally, the revised model incorporates the writer's motivation and affect among the factors that support the individual during writing. Last, the revised model has reorganized the cognitive process component. This component includes planning and is now subsumed in the general label of reflection. Translation is now part of the general label of text production process. The revised model continues to focus on adult skilled writing; however, Hayes (1996) noted that this revised model was incomplete and was intended to provide a framework for future writing research. Research examining beginning writing was influenced by these seminal models of adult writing.

The Simple View of Writing Models

More recently, writing research has extended its focus to understanding the developmental processes of beginning writing. This research has been fundamental to the development of models examining beginning writing processes. The Simple View of Writing was first posited by Juel, Griffith, and Gough (1986). In the Simple View, reading skill is theorized to include decoding and comprehension (Gough & Tunmer, 1986) and writing is theorized to include spelling and ideation (Juel et al., 1986). Ideation is the ability to generate and organize ideas. Juel (1988) noted that ideation is a broad term that includes generating “creative thoughts and their organization into sentence and text structures” (p. 438). Juel and colleagues addressed the importance of spelling-sound knowledge in relation to reading and writing. Specifically, spelling-sound knowledge is a basic component of decoding and spelling. They purposively kept the writing model simple by only including one lower level component (i.e., spelling) and one higher level component (i.e., ideation). Furthermore, they aimed to develop a simple writing model that represented research at the time and could be easily studied.

Berninger and Amtmann (2003) extended the Simple View of Writing model posited by Juel and colleagues (1986). According to Berninger and Amtmann, transcription (i.e., handwriting and spelling) and executive function (i.e., planning, reviewing, editing, and self-regulation) are fundamental components necessary for text generation. Text generation involves generating ideas and translating the ideas into text. Their Simple View of Writing posits that transcription and executive function support text generation in a working memory environment. Transcription development requires

fluent and accurate handwriting and a comprehensive knowledge of spelling (Berninger & Swanson, 1994). As transcription skills become automated, text generation skills progress. Transcription and text generation are two core components involved in producing text (McCutchen, 2006). Guided by research, Berninger and Amtmann's model (2003) incorporated three additional components: working memory, short-term memory, and long-term memory. Compared to Hayes and Flower's (1980) model specifically examining skilled writing, the revised Simple View of Writing represents important developmental processes for beginning writing.

Not So Simple View of Writing

Berninger and Winn (2006) further revised the Simple View of Writing model, and referred to it as the Not So Simple View of Writing (see Figure 2.1). This revision stemmed from studies using brain imaging technology to examine brain function during writing tasks. This technology made it possible for researchers "to scan the brains of *living* people while they performed mental tasks" (Berninger & Winn, 2006, p. 96). However, most of these studies included adults (i.e., skilled writers). Berninger and Winn (2006) noted that brain imaging studies with adults engaged in writing have replicated previous studies but further studies with children is needed.

The Not So Simple View of Writing incorporates three cognitive processes of writing (i.e., planning, translating, and reviewing), which are included in the Hayes and Flower model. The translation component is reorganized so that transcription and text generation are presented in relation to beginning writing. This is a key revision because translation emerges before the planning and reviewing components in beginning

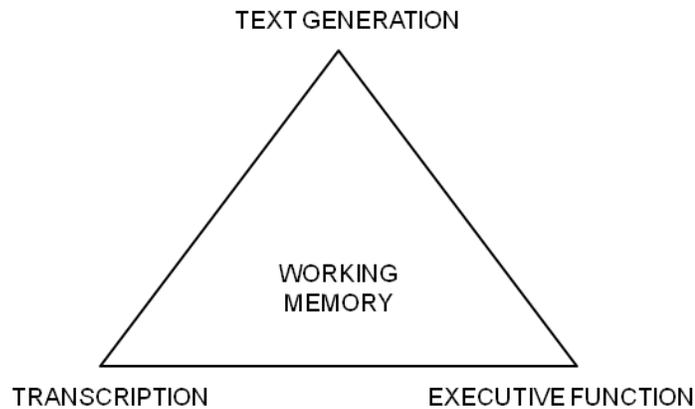


Figure 2.1. Not So Simple View of Writing (Berninger & Winn, 2006).

writers (Berninger & Swanson, 1994). The executive function component of the Not So Simple View of Writing includes supervisory attention. Additionally, planning and reviewing are incorporated within the executive function component.

In sum, the Hayes and Flower model and the Hayes model provide a framework for understanding skilled writing. The Simple View of Writing (Juel, 1986) sought to begin to explain the cognitive processes involved in beginning writing. Berninger and Amtmann (2003) proposed a Simple View of Writing extending the model first proposed by Juel and colleagues (1986). The revised model was based on brain imaging technology which provided new insight into the writing brain. This revised model, now called the Not So Simple View of Writing, provides a framework for this study in which executive function and the written expression of first-grade students will be examined. The Not So

Simple View of Writing provides a framework that better represents the many processes important for developing beginning writing skills. Specifically, this model continues to expand understanding of the relation between executive function and beginning writing. The next section will further discuss the executive function component as posited by the Not So Simple View of Writing.

Executive Function

This study will focus on the relation of executive function to writing achievement in first grade. Defined broadly, executive function refers to inter-related cognitive skills responsible for formulating and planning how to achieve goals (Anderson, 2008; Lezak, 1982). Executive function requires the ability to control and focus attention, thinking, and actions (Best & Miller, 2010; Diamond & Lee, 2011). Models and frameworks of executive function have included the working memory model, the model of executive (self-regulation) function, and the supervisory attentional system model (Anderson, 2008). In this section the types of executive function, the structure of executive function, the core components of executive function, and executive function in relation to academic achievement will be reviewed.

According to Barkley (2012), there are many definitions of executive function but no clear, universally-accepted operational definition. There is disagreement about the components included in executive function, and in the literature up to 33 components have been posited (Barkley, 2012; Best, Miller, & Jones, 2009). Many researchers concur that inhibition, working memory, and cognitive flexibility represent core components of executive function (Diamond, 2013; Garon, Bryson, & Smith, 2008, Jacques &

Marcovitch, 2010; Miyake et al., 2000). These core components provide the foundation for complex executive functions such as planning and problem solving (Diamond, 2013).

In their Not So Simple View of Writing, Berninger and Winn (2006) define executive function as a “complex system that regulates focused attention - selecting what is relevant and inhibiting what is not relevant, switching attention between mental sets, attention maintenance (staying on task), conscious attention (metalinguistic and metacognitive awareness), cognitive presence, and cognitive engagement” (p. 97). Essentially, Berninger and Winn’s definition aligns with the three core components of executive function frequently posited in the literature.

Types of Executive Function

Executive function has been differentiated into two distinct types: emotional/behavioral processes and cognitive processes (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; McClelland, Ponitz, Messersmith, & Tominey, 2010). Emotional/behavioral regulation (i.e., hot executive function) emphasizes the affective and motivational aspects of self-regulation. For example, first-grade students have difficulty regulating emotions such as anger. This inability to regulate anger may result in a response of yelling when angry and frustrated. Cognitive regulation (i.e., cool executive function) involve processes such as planning and problem solving (Anderson, Anderson, Jacobs, & Smith, 2008; McClelland et al., 2010). Although the emotional/behavioral processes are important, this dissertation study specifically examined the cognitive processes of executive function in relation to beginning writing development.

Is Executive Function Unitary or Diverse?

Researchers continue to question whether executive function is a unitary construct or whether executive function is a diverse construct that consists of independent, but interrelated, components (e.g., Best & Miller, 2010; Espy & Kaufmann, 2002; Huizinga, Dolan, & van der Molen, 2006; Isquith, Gioia, & Espy, 2004; Miyake et al., 2000). Miyake and colleagues (2000) posited that the executive function construct consists of “separable but related functions that share some underlying commonality” (p. 87). They studied executive function in adults, and the following three executive function skills were examined: mental set shifting, information updating and monitoring, and inhibition. Miyake and colleagues noted that these three executive function skills were selected because they are low-level functions (i.e., in comparison to other high-level executive functions such as planning) and as such are relatively easy to operationally define.

In one study, 137 undergraduate students completed multiple assessments of executive function. Confirmatory factor analysis results indicated that mental set shifting, information updating and monitoring, and inhibition were moderately correlated (r 's ranging from .42 to .63), but the cognitive processes existed independently of each other. Their findings have become an influential framework within executive function research, and this framework is commonly referred to as the “unity and diversity of executive functions” perspective.

Studies examining the development of executive function in school-aged children have found similar results supporting the unitary and diversity of executive function framework (e.g., Huizinga et al., 2006; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003). In

a longitudinal study conducted by Lehto and colleagues (2003), the development of executive function in children between 8 and 13 years of age was examined. Both exploratory and confirmatory factor analysis yielded three interrelated factors: working memory, inhibition, and shifting. Similarly, Huizinga and colleagues (2006) studied the developmental trajectories of inhibition, working memory, and shifting with 7-, 11-, 15-, and 21-year-olds. Confirmatory factor analysis identified two latent factors: working memory and shifting. Furthermore, shifting was found to develop into adolescence and working memory was found to develop into adulthood.

In contrast to studies demonstrating that executive function can be described as both unitary and diverse, developmental research with preschoolers and young children suggests that executive function is unitary (i.e., one construct) (e.g., Brydges, Reid, Fox, & Anderson, 2012; Shing, Linderberger, Diamond, Li, & Davidson, 2010; Wiebe, Espy, & Charack, 2008). Wiebe et al. (2008) administered a large battery of executive function tasks targeting inhibition and working memory to a sample of 243 children between 2.25 and 6 years of age. Several models were tested using confirmatory factor analysis. A single-factor executive function model was the most parsimonious fit to the data when compared to other multifactor models. As noted by the authors, the single-factor executive function model (i.e., unitary framework) may be specific to the preschool years because different components of executive function are identifiable in school-age children.

Shing et al. (2010) also investigated the organization of inhibition and working memory of 263 children between 4 and 14 years of age. The purpose was to determine if

and when these two executive function components differentiate during development. Confirmatory factor analysis indicated that inhibition and working memory represented a unitary construct in children 4.7 to 7.9 years of age. However, the components differentiated in the older children (9.5 - 14.5). These two studies suggest that inhibition and working memory are unitary in young children between 2.5 and 9.5 years of age. These results further suggest that inhibition and working memory are unitary for children in first grade.

As demonstrated by the previously discussed research, the executive function construct has been theorized as unitary but diverse. Specifically, executive function may be unitary in young children but begins to differentiate into separate components with maturity. However, some of the previously discussed studies suggest that executive function may also be diverse in young children. There are possible explanations for these findings. Some researchers argue that one problem with executive function tasks is that of “task impurity.” This means that the task which is posited to capture multiple executive function components may also be capturing nonexecutive function components unrelated to the task (Hughes & Graham, 2002; Miyake et al., 2000). In addition, executive function research initially excluded children because these skills were traditionally viewed as only being developmentally mature in adults (Salimpoor & Desrocher, 2006). Much of what is posited about executive function in relation to children has been influenced by empirical research with adults. However, adult executive function measures are not developmentally sensitive for young children (Carlson, 2005).

The differences in executive function could also be due to the individual developmental trajectories of inhibition, working memory, and cognitive flexibility from preschool-age to adulthood. Executive function begins to emerge as young as 8 months of age (Diamond, 2006) and continues to develop into adulthood, with rapid developmental changes occurring during the preschool period for children between 3 and 5 years of age (Diamond, 2002). Additionally, there is evidence that the core executive function skills do not develop uniformly (Best et al., 2009).

Although debate continues regarding the executive function construct, this dissertation study will be grounded in the perspective that the core components of executive function are inter-related and represent a single construct for students in first grade. Furthermore, it is difficult to individually measure each core component without capturing the other two components. As such, for this dissertation study executive function is assessed using a measure that captures all three core components: inhibition, working memory, and cognitive flexibility. In the following section, the core components of executive function are described.

Core Components of Executive Function

The following section will discuss the following three core components of executive function: inhibition, working memory, and cognitive flexibility. Unlike working memory, there is very little literature regarding writing in relation to inhibition and cognitive flexibility. In addition, the section will discuss the interrelations between inhibition and working memory in relation to cognitive flexibility.

Inhibition. Inhibition, a core component of executive function, is the ability to ignore distraction and stay focused (Diamond, 2006), while also suppressing a “dominant, automatic or prepotent response” (Miyake et al. 2000, p. 57). For example, a task requiring inhibiting a prepotent response is the Stroop task. This task presents a word written in colored ink and requires one to say the color of the ink rather than read the word (i.e., correct response to the word *red* printed in blue ink would be “blue”). The response that must be inhibited during this task is the automatic response to focus on reading the word and to focus on surface characteristics (i.e., the color the word is printed). In school, for example, inhibition might include ignoring a distraction to stay focused during tasks involving reading or writing. Children with weak inhibitory control are often described as impulsive, disruptive, careless, and tend to be very active (Howard, Anderson, & Taylor, 2008).

Research has demonstrated that inhibition develops rapidly during early childhood (Diamond, 2002). Inhibition begins to present between six months to one year of age; however, this initial inhibition structure changes in the preschool years (Garon et al., 2008). Between 3 and 8 years of age, children become increasingly able to inhibit impulsive responses (Carlson, Zelazo, & Faja, 2013; Diamond, 2006; Diamond & Taylor, 1996; Romine & Reynolds, 2005). Significant improvements in inhibition occur between 3 and 6 years of age (Diamond, 2006; Montgomery & Koeltzow, 2010). By the age of 10, inhibition is moderately complete, with minimal age related improvement between 11 and 14 years of age (Romine & Reynolds, 2005). According to Romine and Reynolds, there is no significant change in inhibition performance after the age of 14.

Working memory. The second core component of executive function is working memory. Working memory involves cognitive processes that are used to hold information in the mind, organize it, and to manipulate it for brief periods of time (Best et al., 2009; Diamond, 2006; Yeager & Yeager, 2013). Working memory is essential for classroom learning as it “acts as a kind of mental storage workspace that can be flexibly used to meet the storage demands of complex activities” (Gathercole & Alloway, 2008, p. 18). In the classroom, children frequently have to hold information in mind while engaged in an effortful activity. For example, writing a sentence while trying to spell an individual word and remembering the sentence or remembering instructions while completing individual steps in a task (Alloway & Alloway, 2013).

Working memory is present in young children although it is still not fully developed. Children 5 years of age begin to demonstrate an increased skill at holding and manipulating information in memory (De Luca & Leventer, 2008). Gathercole, Pickering, Ambridge, and Wearing (2004) conducted a cross-sectional study of 700 children, between 4 and 15 years of age, examining the structure and development of working memory. Gathercole et al. (2004) found that each component of working memory (central executive system, phonological loop, and visuospatial sketchpad) showed a linear increase in capacity from the age of 4 to 15. The structure of the working memory system across this age span closely resembled the three component adult model (consisting of the phonological loop, the visuospatial sketchpad, and the central executive) proposed by the Baddeley and Hitch (1974). Results suggested that this working memory model is in place by at least 6 years of age.

Cognitive flexibility. Cognitive flexibility, also known as set shifting or task shifting, is another core component of executive function. Cognitive flexibility involves the ability to shift between mental states, operations, or tasks (Miyake et al., 2000). For example, cognitive flexibility is evident in the classroom during times of transition such as stopping one activity in order to transition to a new activity.

One continued debate is whether cognitive flexibility is present and measurable in young children. Espy (1997) examined the age-related changes in cognitive flexibility in 70 preschool children between 2 and 5 years of age. Results suggested developmental improvement occurred in cognitive flexibility for children between 4 and 5 years of age. Luciana and Nelson (1998) examined the cognitive flexibility of 181 children between 4 and 8 years of age and a group of 24 young adults. The set-shifting task consisted of nine stages, which became increasingly more difficult and complex. This task “measures discrimination and reversal learning under conditions whereby the subject is required shift attention to changing patterns of visual stimuli” (Luciana & Nelson, 1998, p. 278).

For example, in the first stage the child sees two lined patterns on the computer screen and is told that one of the lines is correct and the other line is incorrect. The child must decide which pattern is correct by touching one or the other on the computer screen. If correct, the computer screen flashes green; if incorrect, the computer screen flashes red. This stage requires the child to learn a two-alternative forced-choice discrimination of two lined drawings using immediate feedback provided on the computer screen. Additionally, the child is told that as he or she progresses a rule will become evident which will guide the selection of subsequent choices. However, once the computer

program determines the child has learned the rule, the rule changes. The child is told that in spite of these changes to select as many correct choices as possible. Key improvement occurred at the seventh stage for children 5 and 6 years of age. There was also a steady increase in successful completions of all nine stages of the task up to the young adults. Further improvement in cognitive flexibility takes place in children between 7 and 9 years of age, and is hypothesized to reach relative maturity by 13 years of age (Davidson, Amsoa, Anderson, & Diamond, 2006).

How these core components are related. Cognitive flexibility is considered the most complex of the three core components of executive function (Garon et al., 2008) and is built on inhibition and working memory (Best & Miller, 2010; Cragg & Chevalier, 2012; Davidson et al., 2006; Diamond, 2013; Garon et al., 2008). As inhibition and working memory develop, cognitive flexibility develops as well (Garon et al., 2008). Several studies have examined the relationship of inhibition and working memory as correlates of cognitive flexibility.

Extensive research has been conducted on cognitive flexibility in preschool children. Cragg and Chevalier (2012) examined the contributions of inhibition and working memory to cognitive flexibility across preschool. Participants ($N = 250$) were administered executive function tasks for inhibition, working memory, and cognitive flexibility every nine months from the ages of 3 years to and 5 years 3 months. Data from three time points were included for analysis: 3 years 9 months, 4 years 6 months, and 5 years 3 months. Multilevel modeling indicated that the inhibition and working memory

of older preschoolers (4 years 6 months and 5 years 3 months) were components underlying cognitive flexibility.

Senn and colleagues (2004) also examined the contributions of inhibition and working memory to cognitive flexibility of 117 preschoolers between 2 and 6 years of age. The preschoolers completed several executive function tasks and path analysis was used to determine the relations between inhibition, working memory, cognitive flexibility and problem solving. Results suggested that performance on an inhibition task and working memory task predicted performance on a complex problem solving task and predicted cognitive flexibility.

In sum, there are three core components of executive function. Each component has been reported in children as young as preschool, and several studies (Best et al., 2009; Cragg & Chevalier, 2012; Davidson et al., 2006; Espy, 1997; Garon et al., 2008; Lehto et al., 2003; Shing et al., 2010; Swanson & Berninger, 1996) have described the developmental changes during preschool and elementary grades. The components are also inter-related (Cragg & Chevalier, 2012; Senn et al., 2004). Across these studies, executive function was assessed using direct measures (i.e., the child completed the task). In the following section, the research literature describing the relationships between executive function and writing, reading, and math will be reviewed.

Executive Function and Academic Achievement

In this section, studies that examined the relationships of executive function and focus on children in prekindergarten through second grade were included. This age range was selected because it represents a span of time during which beginning writing skills

are developing. Specifically, executive function in relation to writing, reading, and math will be discussed. For studies that include multiple academic domains, each domain will be discussed separately.

Executive Function and Writing

Two studies that examined executive function and writing were identified. Hooper et al. (2011) examined the neuropsychological contributors to early written language of first and second grade students. They proposed a model for the neuropsychological underpinnings of early writing ability consisting of six domains: (1) fine-motor control, (2) short-term memory, (3) long-term memory, (4) language latent variable (i.e., rapid letter naming task and word orthographic coding task), (5) working memory, and (6) attention/executive function.

Confirmatory factor analyses and structural equation modeling were used to evaluate the models. The results for the parsimonious model had three core latent variables: fine-motor, attention/executive function, and language. Two writing outcomes were the dependent variables for first and second grades: Wechsler Individual Achievement Test-II (WIAT-II) Written Expression and Spelling. Confirmatory factor analyses resulted in combining the long-term memory latent variable with the working memory latent variable which was labeled the attention/executive function latent variable. The final model consisted of a language latent variable, an attention/executive function latent variable, and a fine motor latent variable. This final latent variable model was highly related to spelling and written expression at both first and second grades. The first-grade latent variable model accounted for 51 and 55% of the variance in second-

grade written expression and spelling, respectively. Results suggest that attention/executive function significantly predicted early writing development.

The second study examined the contribution of executive function to compositional fluency and quality for kindergarten and first-grade students (Kent et al., 2014). Kent et al. examined the relation of kindergarten component skills (i.e., transcription, reading, oral language, attention and self-regulation) to writing outcomes at the end of kindergarten and first grade. The writing outcome for kindergarten was a writing sample in response to a prompt. The kindergarten writing sample was scored for total number of words, sentences, and ideas produced. These three scores were combined to represent kindergarten writing fluency. Kent et al. did not include a kindergarten writing quality score. The writing outcome for first grade was composing a narrative text in response to a story prompt. The first-grade narrative prompt was scored for writing quality (i.e., word choice, ideas, structure, and grammar) and writing fluency (i.e., correct writing sequences).

For this study, executive function was identified as supervisory attention and situated within Berninger and Winn's (2006) Not So Simple View of Writing model. A measurement model included latent factors representing transcription, oral language, reading, and attention/executive function. This model indicated that the predictor variables for each latent factor were positively and significantly related (r 's range from .33 to .95). However, the reading and spelling factors were very highly related ($r = .95$) in the measurement model and were combined to represent an early literacy skills latent construct.

Structural equation modeling examined models of writing development comprised of handwriting fluency, early literacy, oral language, and attention. The authors examined the unique and shared relations of component skills to kindergarten writing fluency. Early literacy ($\gamma = .58, p < .001$) and letter-writing fluency ($\gamma = .13, p = .047$) were uniquely and significantly related to kindergarten writing fluency. After controlling for early literacy and letter-writing fluency, attention-related skills ($\gamma = .16, p = .001$) were also uniquely and significantly related to kindergarten writing fluency. Oral language ($\gamma = -.10, p = .237$) did not contribute to kindergarten writing fluency. This model accounted for approximately 49% of the variance in kindergarten compositional fluency. Furthermore, comparing a model with attention-related skills and without attention-related skills resulted in a statistically significant better fit ($\Delta\chi^2 = 73.5, df = 4, p < .001$) than the model with only letter-writing fluency, oral language, and early literacy skills.

The study also examined kindergarten component skills in relation to first-grade writing. After accounting for letter writing fluency, oral language, and early literacy skills, attention in kindergarten was uniquely related to first-grade writing fluency ($\gamma = .23, p < .001$) and writing quality ($\gamma = .19, p = .001$). Kindergarten early literacy skills were also uniquely and positively related to first-grade writing fluency ($\gamma = .60, p < .001$) and writing quality ($\gamma = .36, p < .001$). Kindergarten oral language was uniquely related to first-grade writing quality ($\gamma = .16, p = .05$) but not first-grade writing fluency. This model accounted for 33 and 45% of the variance in first-grade writing quality and fluency.

Last, Kent et al. (2014) identified whether kindergarten component skills had a direct or indirect effect on first-grade writing fluency and quality. After accounting for kindergarten compositional fluency and the other component skills, kindergarten early literacy ($\gamma = .36, p < .001$), oral language ($\gamma = .16, p = .05$), and attention ($\gamma = .19, p < .01$) were statistically significant direct paths to first grade writing quality. Only the attention-related skill ($\gamma = .22, p < .01$) and early literacy ($\gamma = .53, p < .01$) had statistically significant direct effects to first grade writing fluency. This model accounted for approximately 33% of the variance in first-grade writing quality and 45% of the variance in first-grade writing production.

A common finding from both Hooper et al. (2011) and Kent et al. (2014) is that measures of executive function were statistically significant and important to consider in models of early writing. The executive function factor in both studies explained variance above and beyond other factors such as early literacy and oral language which are component skills necessary for early writing. In contrast to the direct executive function measure used by Hooper et al., Kent and colleagues used a teacher report, the Strengths and Weaknesses of ADHD-Symptoms and Normal Behavior (SWAN; Swanson et al., 2006), as a measure of executive function. One possible limitation in using a teacher rating scale to measure executive function is that the scale is the opinion of the teacher. Similar to the Hooper et al. study, this dissertation study used a measure that directly assesses executive function.

Executive Function and Reading

Several studies have investigated executive function and reading. Blair and Razza (2007) measured executive function, specifically the inhibitory control and attention-shifting of 141 preschool children. Inhibitory control and attention shifting were measured again in kindergarten in addition to reading readiness (i.e., phonemic awareness and letter knowledge). After controlling for age, multiple regression analyses were conducted with each predictor and the reading outcome. Kindergarten inhibitory control independently contributed to phonemic awareness ($\beta = .27, p < .01$) and letter knowledge ($\beta = .17, p < .05$).

In another study, the relations between inhibition, emergent literacy and vocabulary of 310 preschool children were examined (McClelland et al., 2007). The Heads-to-Toes Task was used to measure behavioral regulation. McClelland and colleagues note that this measure of behavioral regulation requires three processes (attention, inhibition, and working memory) which are considered to be cognitive components of executive function. The children were assessed in the fall and spring of prekindergarten. Hierarchical linear modeling was used to account for the nesting of children in classrooms. Control variables were entered for age, gender, and language of administration for the Head-to-Toes task (in English or Spanish). Results suggested that stronger growth in behavioral regulations from fall to spring was related to growth in emergent literacy assessed in the spring.

In a more recent study, Monette, Bigras, and Guay (2011) examined the role of kindergarten executive function (i.e., inhibition, flexibility, and working memory) in

predicting reading/writing skills at the end of first grade. Eighty-five kindergarten students were assessed at the middle of the kindergarten year and again at the end of first grade. The outcome measures for reading/writing skills were represented by the WIAT-II Written Language Composite score consisting of the Word Reading, Reading Comprehension, and Spelling.

Additionally, a battery of executive function tasks was administered and measured inhibition, working memory, and flexibility. Kindergarten teachers also completed the Social Competence and Behavior Evaluation-30 (SCBE-30) for each student. The SCBE-30 has three subscales: Social Competence, Anxiety-Withdrawal, and Anger-Aggression. Factor analysis resulted in three executive function factors: working memory, flexibility, and inhibition. When reading/writing was the outcome, working memory had a significant total effect ($\beta = .31, p < .01$); however, neither inhibition nor flexibility had a direct effect. Working memory and inhibition did have small but significant indirect effects ($\beta = .11$ and $\beta = .09$) on reading/writing through SCBE Anger-Aggression. The relation between working memory and reading/writing had a moderate effect size ($r = .51, p < .01$) and the relation between inhibition and reading/writing had a small but significant effect size ($r = .24, p < .05$).

Taken together, these studies suggest that executive function is related to beginning reading. Additionally, these studies accounted for student characteristics (e.g., age and gender) as these have been found to contribute to early reading ability. Including control variables allowed analysis to solely examine the independent and combined variance for executive function.

Executive Function and Math

In addition to examining executive function and reading, Blair and Razza (2007) also examined executive function and math knowledge (i.e., knowledge of shapes, basic numeracy, subtraction, addition, simple graphic relations, quantity, and relative size) in preschool and in kindergarten. After controlling for age, multiple regression analyses were conducted with each predictor and math knowledge. Preschool and kindergarten inhibitory control measures each independently contributed to math knowledge ($\beta = .17, p < .05$; $\beta = .20, p < .01$, respectively). Attention-shifting measured in kindergarten was only moderately related to math knowledge ($\beta = .15, p < .10$).

McClelland et al. (2007) also examined the relation between inhibition and math skills in their study of preschool children. Beginning math skills were assessed using the Woodcock-Johnson-III (WJ-III) Applied Problems. Similar to the findings for reading, children who exhibited more growth in behavioral regulation from fall to spring of prekindergarten had growth in math skills ($t = 2.05, p < .05$). Monette et al. (2011) also examined math skills in relation to kindergarten executive function (i.e., inhibition, flexibility, and working memory). A math composite score consisted of WIAT-II Numerical Operations and Mathematical Reasoning. Working memory had a statistically significant total effect ($\beta = .40, p < .01$) and a significant direct effect ($\beta = .32, p < .05$) for math achievement. These three studies demonstrate the relation between executive function and math either with direct or indirect effects. Specifically, inhibition, working memory, and attention-shifting were directly related to math, after controlling for age and gender.

Summary. Executive function has been proposed as an important cognitive process and is included as a component of writing in Berninger and Winn's (2006) Not So Simple View of Writing. Although there is continued debate over whether executive function is a unitary construct or a diverse construct, research suggests that the three core components of executive function are highly related to early academic achievement. Furthermore, this research suggests that executive function is present and can be assessed in children as young as preschool.

A small body of research has examined the relationship between executive function and academic achievement in preschool through second grades. Specifically, inhibition and working memory have been shown to have a direct relationship with writing (Hooper et al. (2011; Kent et al., 2014), reading (Blair & Razza, 2007; McClelland et al., 2007; Monette et al., 2011), and math (Blair & Razza, 2007; McClelland et al., 2007). Studies of other predictors of writing are described in the next section. Specifically, kindergarten and first-grade studies examining correlates of writing will be discussed.

Correlates of Writing

Developmental models of writing identify many component skills that are important for beginning writing. Berninger and Winn's (2006) Not So Simple View of Writing model identified transcription, text generation, and executive function as important components of beginning writing. Additionally, oral vocabulary and reading are posited as being related to early writing development. The following section will review studies that examine predictors of writing in kindergarten and first grade. Most of

the studies examine only child-level predictors; however, two studies also examine classroom-level predictors (i.e., instructional quality and classroom literacy environment). Studies with kindergarten and first-grade children are included in this discussion because the purpose of this dissertation study is examining beginning writing in relation to executive function. Kindergarten studies will be presented first to be followed by first-grade studies.

Kindergarten

Most children begin to write by the end of kindergarten (Kim et al., 2011). During kindergarten, many children are learning the names of letters, sounds of letters, and how to write letters (Moats, 2000; Ritchey, 2008). Additionally, children begin to spell as they begin to make the connection between letter sounds and written letters (Moats, 2000). Several studies have examined these relations in kindergarten. Kim and colleagues (2011) examined component skills of beginning writing for 242 kindergarten students. They examined the shared and unique relations of letter-writing fluency, spelling, reading, and oral language (i.e., expressive vocabulary, sentence imitation, and grammatical knowledge) to a narrative writing task. The narrative text was scored for total number of words, sentences, and ideas. Letter-writing fluency was assessed using a handwriting automaticity task. Spelling was assessed using a real- and non-words spelling task. Reading was assessed using WJ-III Letter-Word Identification, Test of Word Reading Efficiency (TOWRE; Torgenson, Wagner, & Rashotte, 1999) Sight Word Efficiency and Phonemic Decoding Efficiency, WJ-III Passage Comprehension, and Word Identification Fluency (Fuchs, Fuchs, & Compton, 2004).

Structural equation modeling examined the structural relations between the latent variable predictors. Results suggest that spelling ($\gamma = .30, p < .001$), letter writing fluency ($\gamma = .26, p = .003$), and oral language ($\gamma = .16, p = .03$) were uniquely and significantly related to writing. After accounting for the other skills, reading was not significantly related to writing fluency. Spelling, letter writing fluency, and oral language explained 33% of the total variance in the narrative writing outcome.

In a similar analysis, Puranik and Al Otaiba (2012) examined the contribution of handwriting fluency and spelling to writing skills, but also controlled for cognition. Writing, spelling, and handwriting were assessed. Cognition was assessed using the Kaufman Brief Intelligence Scale (K-BIT-2; Kaufman & Kaufman, 2001) Matrices and Verbal Knowledge subtests. Oral language was assessed using the WJ-III Picture Vocabulary and the Test of Language Development-Primary: Third Edition (TOLD-P:3; Newcomer & Hammill, 1997) Sentence Imitation and Grammatical Completion subtests. Reading was assessed using the WJ-III Word Attack and Letter-Word Identification. Phonological awareness was assessed using the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) Elision and Blending but summed to create a composite score. Writing was assessed using a writing sample task, which was scored for total number of words (TNW) and number of ideas expressed (Ideas).

Multiple regression analysis was used to examine the shared and unique contributions of language, reading, cognition, and transcription to written samples. The two scores of the writing sample (total number words and number of ideas) were highly

correlated ($r = .94$); therefore, analysis was only conducted for total number of words. Results found that the control variables (age, gender, oral language, cognition, reading, free and reduced lunch status) accounted for a significant proportion of variance in writing total numbers of words. Three variables accounted for a significant amount of unique variance: age (2.8%), free and reduced lunch status (1.8%), and word reading (4.2%).

Handwriting fluency and spelling were then added as a block to the model to determine if both accounted for a statistically significant increase in amount of variance. Handwriting fluency and spelling explained an additional 9.6% of the variance in predicting kindergarten writing. In the structural model, handwriting fluency accounted for approximately 4.1% of the unique variance, free and reduced lunch status accounted for 2% of the unique variance, and spelling accounted for 2.3% of the unique variance in predicting kindergarten writing.

In sum, these studies demonstrate that handwriting and spelling in kindergarten are important for beginning writing. One challenge is the ability of kindergarten students to produce a lot of written text. This was noted by Kent et al. (2014) as a study limitation because 20% of the kindergarten writing samples were unscorable and may have been due to developmental constraints. Studies of first-grade writers are reviewed in the following section.

First Grade

Five studies were located that study the relationships between writing and other correlates in first grade. Abbott and Berninger (1993) examined the structural

relationships between latent factors underlying the development of beginning writing for 100 first-grade students. Structural equation modeling analyses was used to examine the data. The following factors were identified as skills important for the development of beginning writing: a fine motor factor, an orthographic factor, a reading factor, a phonological factor, an oral language-verbal reasoning factor, and a spelling factor. A handwriting factor, spelling factor, and composition factor were the outcome measures for writing components.

Fine-motor was assessed using the following finger tasks: finger lifting, finger spreading, finger succession, and finger localization. The orthographic factor was assessed using an orthographic coding task for whole words, letters, and letter clusters. The reading factor was assessed using Woodcock Reading Mastery Test-Revised (WRMT-R; Woodcock, 1987) Word Reading, Word Attack, and Passage Comprehension. The phonological factor was assessed using the Modified Rosner Test of Auditory Analysis. The oral language-verbal reasoning factor was assessed using the McCarthy Scales of Children's Abilities (McCarthy, 1972) Verbal Fluency subtest, the Stanford-Binet Intelligence Scale (4th ed.; Thorndike, Hagan, & Sattler, 1986) Sentence Memory subtest, and the Wechsler Intelligence Scale-Revised (WISC-R; Wechsler, 1974) Information, Similarities, Comprehension, and Vocabulary subtests. For the outcome measures, handwriting fluency was assessed using the alphabet task and the Group Diagnostic Reading Aptitude and Achievement Tests (GRADE, Monroe & Sherman, 1966) Copying subtest. The spelling factor was assessed using the Wide Range

Achievement Test-Revised (WRAT-R; Jastak & Wilkinson, 1984) Spelling. The composition factor was assessed using narrative and expository writing tasks.

Abbott and Berninger (1993) predicted that the paths from fine motor skills and orthographic coding would contribute to handwriting. In first grade, results suggested that only the path from orthographic coding to handwriting was statistically significant ($\gamma = .74, p < .05$). They predicted that phonological coding and orthographic coding would contribute to spelling. Similar to other findings in first grade, results suggest that only the path from orthographic coding to spelling was statistically significant ($\gamma = .54, p < .05$). Lastly, results suggest that oral language-verbal reasoning and reading were significantly related to first-grade composition ($\gamma = .07, p < .001$; $\gamma = .94, p < .001$, respectively). These results demonstrate that many skills are important for first-grade writing.

Jones and Christensen (1999) examined the relationship between handwriting and written expression for 114 first-grade students. Orthographic-motor integration (handwriting) was assessed using the Writing Speed and Accuracy Measure. Written expression was assessed using an independently produced text. Reading was assessed using the Southgate Group Reading Test (Southgate, 1962). Results indicated that the Writing Speed and Accuracy Measure explained 67% of the variance in written expression. To examine the relationship between orthographic-motor integration skills and written expression, a partial correlation was calculated and was significant ($r = .73, p < .001$). Additionally, handwriting fluency, after controlling for reading, accounted for 53% of the variance in first-grade writing quality. Specifically, speed and accuracy in writing letters did significantly influence generating written text. These results differ

from the Abbott and Berninger (1993) findings; however, oral language was not included in the current study. These findings suggest that handwriting fluency is important for predicting writing.

Coker (2006) examined predictors of early writing by analyzing the growth of descriptive writing skills for 309 students in first through third grades. Individual growth modeling was used to evaluate the following variables: student background (Socioeconomic status, gender, language status, and ethnicity), literacy skills (i.e., phoneme segmenting, phonological awareness, letter knowledge, and decoding), classroom literacy environment (i.e., book displays, genres, organization of the classroom, and writing materials and utensils), oral language (i.e., receptive vocabulary), first-grade teacher relationship (i.e., teacher-student interactions), and a descriptive writing task.

Reading was assessed using the Woodcock Diagnostic Reading Battery (WDRB: Woodcock & Johnson, 1989) Letter-Word Identification and Word Attack and the Yopp-Singer Test of Phoneme Segmentation (Yopp, 1995). Oral vocabulary was assessed using the Peabody Picture Vocabulary Test III (PPVT- 4). Writing was assessed using a descriptive writing task and was scored for spelling ability, sentence conventions, content elaboration, and genre features.

Individual growth modeling was used to analyze writing growth for individual students. Two models were tested: one for growth in the total writing score and one for word total as the outcome. Oral vocabulary (PPVT- 4) was associated with first grade writing ($\beta = .02, p < .001$) but not with writing growth. Letter-Word Identification was

the only reading measure associated with first-grade writing ($\beta = .11, p < .001$). These results are similar to the Abbott and Berninger (1993) study in that oral language and reading contribute to writing. One difference is that handwriting and spelling were not included. Furthermore, oral language was measured using one vocabulary measure.

Wagner et al. (2011) used confirmatory factor analysis to determine the underlying structure of written language composition for 98 first-grade writing samples. The writing samples were scored for the following four factors: macro-organization (topic, logical ordering of ideas, number of key elements), complexity (mean length of T-unit and clause density), productivity (total number of words and number of different words), and spelling and punctuation (number of spelling errors, number of capitalization errors, and number of errors involving a period). In addition, handwriting fluency was measured using an alphabet handwriting fluency task and a sentence copying fluency task.

Wagner and colleagues (2011) identified a five factor model consisting of the following: handwriting fluency, macro-organization complexity, productivity, spelling and punctuation, and number of errors involving a period. Confirmatory factor analysis supported the five-factor model. Furthermore, handwriting fluency was significantly and moderately related to macro-organization ($r = .32, p < .05$), productivity ($r = .40, p < .001$), and complexity ($r = .28, p < .05$). These results suggest that handwriting fluency is not just a mechanical skill but is also important for producing well organized texts and contributes to how well a student may convey information. Specifically, automatic handwriting reduces cognitive constraints and allows the beginning writer to attend to

cognitive processes such as planning and revising which can result in improved written texts.

In the last study of first-grade writing, Kim, Al Otaiba, Sidler, and Grulich (2013) examined letter writing fluency, spelling, student behavior (i.e., attentiveness and hyperactivity), reading (i.e., passage comprehension), and oral language (i.e., expressive vocabulary and grammatical knowledge) in relation to the written composition for first-grade students ($N = 527$). An instructional quality variable was also included. Written compositions were evaluated for writing conventions (spelling, mechanics, and handwriting) and substantive quality (word choice, organization, ideas, and sentence flow).

After accounting for instructional quality and child-level variables (age and free and reduced lunch status), multilevel model analyses suggests that reading comprehension, grammatical knowledge, letter writing fluency, and attentiveness were all uniquely and positively related for substantive writing quality. After accounting for all of the other variables, spelling ($p < .001$) and attentiveness ($p < .001$) were uniquely related to writing conventions (spelling, mechanics, and handwriting). One significant difference from the previously discussed kindergarten and first-grade studies is that this study also examined student behavior (i.e., attention).

Student Background Characteristics and Writing

In addition to the correlates of writing just discussed, studies have demonstrated relationships between student background characteristics (i.e., socioeconomic status and gender) and writing. For example, students' performance on the 2011 NAEP writing

assessment differed based on socioeconomic status (i.e., family income) and gender. Students from higher-income families scored higher on average than students from lower-income families and girls scored higher on average than boys. Findings from research studies further suggest that girls outperform boys in writing (Malecki & Jewell, 2003; Olinghouse, 2008). For example, Olinghouse (2008) found that girls outperformed boys on measures for composition fluency and quality. This dissertation study will include gender as a covariate in order to control for possible gender differences.

Summary. Across the studies, handwriting was the primary predictor examined in relation to writing (Jones & Christensen, 1999; Kim et al., 2011; Kim et al., 2013; Wagner, 2011). One study (Coker 2006) did not include handwriting or spelling as predictors. Across these studies, handwriting, spelling, reading and oral language were the four principal predictors examined in relation to writing. All of the studies assessed writing by having students produce a writing sample. However, there was variability in the types of writing samples (i.e., narrative and expository) and how the samples were scored. Additionally, all of the studies collected a single writing measure.

Two studies included variables that are understudied in relation to beginning writing development. Coker (2006) and Kim et al. (2013) included predictors that were related to the instructional environment. Coker (2006) included a classroom literacy environment variable as well as a first-grade teacher variable. The first-grade teacher variable included teacher experience, instructional practices, background knowledge, classroom management methods, and certification status. Kim and colleagues (2013) included an instructional quality variable. These two studies demonstrated that beginning

writing ability is not just student centered and that the instruction provided to them may be important. Furthermore, Kent et al. (2014) and Kim et al. (2013) are unique in that both studies included a variable for executive function and attention and both studies found positive results. This suggests that beginning writing requires more than just handwriting, spelling, vocabulary, and reading even though these have been the primary areas examined by researchers.

Chapter Summary

This chapter reviewed the relevant literature for this study. The theoretical models for writing development informing this study were reviewed. Some models of writing represent skilled writers (Hayes & Flower, 1980) while others represent beginning writers (Berninger & Winn, 2006; Juel et al., 1986). These models provide a framework for examining the cognitive processes spanning beginning writing to skilled writing. The Not So Simple View of Writing provides a framework for examining beginning writing. This model includes transcription, executive function, and text generation, within a working memory environment, as processes important for beginning writing.

Executive function is important to understand in relation to beginning writing. Empirical research suggests that executive function is a construct that consists of independent, but interrelated, components (Best & Miller, 2010; Espy & Kaufmann, 2002; Huizinga et al., 2006; Isquith et al., 2004; Miyake et al., 2000). According to Miyake et al. (2000), the executive function construct consists of inhibition, working memory, and cognitive flexibility. Although this is based on research conducted with adults, this perspective has been applied to research examining children's executive

function in relation to academic achievement (Blair & Razza, 2007; McClelland et al., 2007; Monette et al., 2011). This study will use one direct measure of executive function and a measure of working memory to represent an executive function latent factor.

Executive function is related to young children's academic achievement (Blair & Razza, 2007; Hooper et al., 2011; Kent et al., 2014; McClelland et al., 2007; Monette et al., 2011). Hooper et al. (2011) and Kent et al. (2014) examined executive function in relation to beginning writing. Results from both studies revealed that executive function is related to writing among young children. This dissertation study will extend this line of research by examining executive function in relation to first-grade writing.

While few studies have examined executive function in relation to beginning writing, other components of beginning writing have been identified. Components such as handwriting, spelling, oral language, and reading are related to beginning writing (Abbott & Berninger, 1993; Coker, 2006; Jones & Christensen, 1999; Kim et al., 2011; Kim et al., 2013; Puranik & Al Otaiba, 2012; Wagner et al., 2011). Background variables such as gender and socioeconomic status were also identified as important predictors (Coker, 2006; Puranik & Al Otaiba, 2012). In summary, further research is needed in understanding the role of executive function in writing achievement in first grade. In the next chapter, the method, procedures, hypothesized measurement model and hypothesized structural model will be presented.

Chapter 3

METHOD

The purpose of this study was to examine the relation between executive function and the writing achievement of first-grade students. This chapter will discuss the methodology of this dissertation study. First, participants will be discussed. Then a description of the measures, data collection procedures, and data analyses will follow. The chapter concludes with discussion of the proposed hypotheses.

Participants

The participants for this dissertation study were part of a larger research project (Coker, MacArthur, & Farley-Ripple, 2014) of first-grade teachers' instructional practices in writing. The participants for this dissertation study were part of the third year cohort. Students were enrolled in first grade in two school districts in the mid-Atlantic region (see Table 3.1 for district demographics). Sixteen classrooms were recruited from School District A, and 13 classrooms were recruited from School District B (see Table 3.2 for school demographics). School District A used the Houghton Mifflin Harcourt *Journeys* reading curriculum which included an integrated writing curriculum (Bauman et al., 2011). School District B did not use a standard reading or writing curriculum.

An informed consent form was sent to each family, and a sample of students was selected to participate from those who gave consent. The sampling plan used to select participants in the larger research project is described in the procedures section. For the

Table 3.1
Demographic Information by School District for 2013-2014

	District A (<i>n</i> = 16,721) %	District B (<i>n</i> = 9,976) %
Ethnicity		
African American	40.6	43.8
Caucasian	34.3	31.4
Hispanic	18.8	19.7
Asian	4.4	2.9
Hawaiian	0.1	0.1
Multiracial	2.9	2.0
American Indian	0.2	0.2
Special Education status	17.0	13.5
English Language Learner status	8.5	8.7
Low Income status	43.6	43.9

research, participants were 231 first-grade students. Student demographic information is presented in Table 3.3.

Measures

The measures (see Table 3.4) selected for this study were chosen based on theoretical and empirical importance to beginning writing. A detailed description of each measure follows.

Executive function. Executive function was assessed using the Conflict Executive Function Scale (CEFS; Carlson & Schaefer, 2012). This measure of executive

Table 3.2
Demographic Information by School for 2013-2014

School	1	2	3	4	5	6	7	8	9
	%	%	%	%	%	%	%	%	%
Gender									
Male	48	50	100	44	35	45	57	48	43
Female	52	50	-	56	65	55	43	52	57
Ethnicity									
African American	10	21	-	19	18	68	50	27	13
Caucasian	62	43	100	63	59	10	25	58	56
Hispanic	14	21	-	-	12	15	25	8	30
Other	3	14	-	19	12	8	-	6	
Special Education status	3	-	60	19	21	-	21	10	9
English Language Learner status	-	14	20	25	-	5	-	6	-

Note. $N = 231$. Other includes Asian, Multiracial, Native American, and Native Hawaiian.

Table 3.3
Demographic Information for Participants

	Mean (SD)	Range
Age at testing (months)		
Fall	80 (4.68)	70-94
Spring	90 (4.67)	78-100
	%	
Race		
African American	22.6%	
Caucasian	47.6%	
Hispanic	12.5%	
Other	6.2%	
Gender		
Male	50.2%	
Female	49.8%	

Note. $N = 231$. Other includes Asian, Multiracial, Native American, and Native Hawaiian.

function assesses cognitive functioning for inhibition, working memory, and cognitive flexibility. This assessment is easily administered and was designed to be used with young children (Zelazo, 2006). There are different versions of this measure such as the Dimensional Change Card Sort task. The CEFS was selected because this task has been used in research examining executive function of young children (Carlson, 2005; Carlson & Moses, 2001; Chu, vanMarle, & Geary, 2015; Henning, Spinath, & Aschersleben, 2011; Hongwanishkul, Happaney, Lee, & Zelazo, 2005; McClelland et al., 2014; Wiebe, Morton, Buss, & Spencer, 2014). The CEFS is appropriate for children between two and seven years of age.

Table 3.4
List of Measures

	Fall 2013	Spring 2014
Transcription		
Alphabet Copy	✓	
WJ-III Spelling	✓	
Executive Function		
CEFS	✓	
PAL-II Verbal Working Memory	✓	
Oral Vocabulary		
PPVT- 4	✓	
EOWPVT- 4	✓	
Reading		
WJ-III L-W Id	✓	
WJ-III Word Attack	✓	
WJ-III Passage Comprehension	✓	
Writing		
WJ-III Writing Fluency		✓
WJ-III Writing Samples	✓	✓

Note. CEFS = Conflict Executive Function Scale; PAL-II = Process Assessment of the Learner-Second Edition: Diagnostics for Reading and Writing; PPVT- 4 = Peabody Picture Vocabulary Test-4th Edition; EOWPVT- 4 = Expressive One-Word Picture Vocabulary Test-4th Edition; WJ-III = Woodcock-Johnson III Test of Achievement Letter-Word Identification.

CEFS has seven levels; each level has two parts, which increase in difficulty. For each level, the student sorts a set of 3 x 5 in. cards into two black, index-card boxes based on a set of rules. These boxes are positioned in front of the student, and each box has one of the two targets cards on the front of the box. When the task is introduced, the student is told that they will play a card-sorting game. Before presenting the test card, the examiner states the rule and demonstrates sorting according to the rule by placing an example card in the correct box. The examiner cannot repeat the rule.

For each level, the student must correctly answer at least four out of five turns for each dimension (color and shape) in order to continue to the next level. If the student correctly answers at least four out of five turns the student proceeds to the next level. If the student incorrectly answers four out of five turns for either the color or shape dimension, the examiner reverses and administers the previous level to establish a basal. A basal is the lowest level of the task that the student can successfully complete four out of five turns for both dimensions (i.e., color and shape). The task is stopped once the student fails two or more of the five turns on either dimension. Based on pilot testing, Level 4 was identified as the starting level because the test items for Levels 1, 2, and 3 were consistently answered correctly suggesting these three levels would be too easy. A description for Level 3 will also be discussed because this level is administered if a basal is not established for Level 4.

For Level 3, the student is shown test cards with either a red or blue background with a black shape (star or truck) in the middle of the card. This level begins with the shape game, in which cards are sorted based on the shape of the black star or truck. The student is then asked to play the color game, which requires the student to ignore the shape and instead focus on the background color of the card.

For Level 4, the student is shown white test cards with a colored (red or blue) shape (star or truck) in the center of each card. The color game is played first in which cards are sorted according to the color of the shape. At the mid-point, the game switches and the remaining test cards are sorted according to shape.

For Level 5, the student continues to sort the same test cards used for Level 4 according to the either color or shape. In contrast for Level 4, the student is told to either “Play the color game” or “Play the shape game” as each test card is presented. For Levels 6 and 7, the same test cards as Level 4 and 5 are used; however, at this level, half of the test cards have a black border around the outer edge of the card. For Level 6, the student is told to play the color game if the card has a border and to play the shape game if the card does not have a border. For Level 7, the rules are reversed and cards with a border represent playing the shape game and cards without a border represent playing the color game. The CEFS has a possible total score of 70 points, which represents the total correct. The raw score was used for analyses.

The CEFS has high test-retest reliability with an intraclass correlation coefficient of .93 (Beck, Schaefer, Pang, & Carlson, 2011; Carlson & Schaefer 2012). According to the CEFS manual, there is strong evidence of technical adequacy for content validity, convergent validity (i.e., high correlation with the National Institutes of Health Toolbox Cognition Battery for Executive Function (Zelazo, Anderson, Richler, Wallner-Allen, Beaumont, & Weintraub, 2013)).

Working memory. Verbal working memory was assessed using the Process Assessment of the Learner-Second Edition: Diagnostics for Reading and Writing (PAL-II RW; Berninger, 2007) Letters and Words subtests. The subtests measure the ability to store and manipulate letters and words in working memory. For the Letters subtest, the student is asked to name letters that come one, two, or three letters (i.e., alphabetical order) before or after a spoken letter of the alphabet. For the Words subtest, the student is

asked to spell words forward (with the examiner) and backward (independently) and identify letters in various positions within the words (e.g., “Spell *ball* forward with me. Now close your eyes and spell it backward on your own. Tell me the first letter in the word when it is normally spelled.”). The Verbal Working Memory composite score is obtained by adding the scaled scores from the Letters and Words subtests. The composite scaled score was used for data analyses.

For students in first grade, the internal reliability coefficients for the Letters subtest and Words subtest are .89 and .91, respectively, and the internal reliability for the composite score is .93 (Berninger, 2007). The test-retest reliability coefficients for the Letters subtest, Words subtest, and Letters-Words composite are .82, .87, and .86, respectively. The PAL-II RW Verbal Working Memory Letters and Words Composite is moderately correlated ($r = .56$) with the Working Memory cluster of the Differential Ability Scales-II (Elliott, 2007). According to the technical manual, evidence of content validity was established through empirical and qualitative examinations of response processes (i.e., that the frequency of incorrect responses were occurring greater than chance).

Oral vocabulary. Receptive and expressive vocabulary were assessed.

Expressive vocabulary was assessed using the Expressive One-Word Picture Vocabulary Test- 4th Edition, Form A (EOWPVT- 4; Martin & Brownell, 2011). The EOWPVT- 4 is an individually-administered, norm-referenced measure of expressive vocabulary. The student is asked to verbally identify (in one word) the actions, concepts, and objects pictured in color illustrations. Test-retest reliability was high for raw scores and standard

scores ($r = .98$ and $.97$, respectively; Martin & Brownell, 2011). The EOWPVT- 4 has high internal consistency in children between 6 and 7 years of age ($\alpha = .97$ and $.95$, respectively). The criterion-related validity coefficient between EOWPVT- 4 and Wechsler Intelligence Scale for Children-Fourth Edition (WISC-4; Wechsler, 2004) is $.43$ (Martin & Brownell, 2011).

Receptive vocabulary was assessed using the Peabody Picture Vocabulary Test- 4th Edition, Form A (PPVT- 4; Dunn & Dunn, 2007). The PPVT- 4 is an individually-administered, norm-referenced measure of receptive vocabulary. The student is asked to select one picture from a choice of four that best illustrates the meaning of a word. Test-retest reliability for ages 5-6 and 7-10, respectively, is $.94$ and $.91$ (Dunn & Dunn, 2007). The PPVT- 4 has high internal consistency in children between 6 and 7 years of age ($\alpha = .97$). The criterion-related validity coefficient between PPVT- 4 and the Clinical Evaluation of Language Fundamentals-Fourth Edition (CELF-4; Semel, Wiig, & Secord, 2003) and the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999) is high ($r = .60$ s to $.70$ s). The raw scores for EOWPVT- 4 and PPVT- 4 were used for data analyses.

Handwriting fluency. Handwriting fluency was assessed using Alphabet Copy (Abbott & Berninger, 1993). The student is asked to print the lowercase alphabet, in order, as quickly and as accurately as possible from memory. The student is given lined paper and a pencil without an eraser and is instructed to cross out any mistakes. During the 1 min task, the examiner makes a mark on the paper every 15 s to indicate progress. Reversals, omissions, use of capital letters, substitutions, and transpositions are counted

as errors. The score is the number of correctly written letters within the first 15 s and represents the speed and accuracy with which the letters were written. Inter-rater reliability for accuracy ratings is .97 (Berninger et al., 1997). The raw score (i.e., total correct) was used for data analyses.

Spelling. Spelling was assessed using WJ-III Tests of Achievement (Woodcock, McGrew, & Mather, 2001) Spelling subtest. The student is asked to draw lines, trace letters, produce letters, and spell words. As the student progresses, the items increase in difficulty. The split-half reliability for six and seven year olds is .92 and .91, respectively (McGrew, Schrank, & Woodcock, 2007). The *W* score was used for data analyses.

Reading achievement. Reading achievement was assessed using the WJ-III Letter-Word Identification, Word Attack, and Passage Comprehension subtests. For Letter-Word Identification, students are asked to identify individual letters and to read words in isolation. The split-half reliability for six and seven year olds is .98 and .97, respectively (McGrew et al., 2007).

For Word Attack, students are asked to identify the sounds of individual letters and letter combinations and then to read pseudo words aloud. Split-half reliability for six and seven year olds is .94 and .92, respectively (McGrew et al., 2007). The criterion validity coefficient between WJ-III Basic Reading (i.e., Letter-Word Identification and Word Attack) and the Kaufman Test of Educational Achievement (KTEA; Kaufman & Kaufman, 1985) Reading is .76 (McGrew & Woodcock, 2001).

Reading comprehension was assessed using the Passage Comprehension subtest. For Passage Comprehension, students are asked to match a picture representation of a

word with a picture of the object, to point to a picture represented by a phrase, and to read a short passage and identify a missing key word that makes sense. The split-half reliability for six and seven year olds is .96 (McGrew et al., 2007). The criterion validity coefficient for WJ-III Broad Reading (i.e., Passage Comprehension and Letter-Word Identification) and KTEA (Kaufman & Kaufman, 1985) Reading is .66 (McGrew & Woodcock, 2001). The *W* scores for each subtest were used for data analyses.

Writing achievement. Writing achievement was assessed using the WJ-III Writing Fluency and Writing Samples subtests. For Writing Fluency, the student is asked to write sentences related to a stimulus picture and include a given set of three words. The split-half reliability for seven year olds is reported to be .72 (McGrew et al., 2007). Using Rasch analysis procedures, the median reliability coefficient is .88 (Schrank, McGrew, & Woodcock, 2001). For Writing Samples, the student is asked to write a phrase, sentence, or sentences in response to a variety of tasks. The split-half reliability for six and seven year olds is .89 and .86, respectively (McGrew et al., 2007). The median reliability coefficient is .87 (Schrank et al., 2001).

For the WJ-III Written Expression composite, the split-half reliability for six and seven year olds is .83 and .89, respectively (McGrew et al., 2007). The criterion validity coefficient for WJ-III Written Expression with KTEA Spelling is .57. The criterion validity between WJ-III Written Expression and Wechsler Individual Achievement Test (WIAT; Wechsler, 1992) Written Expression is .31. The Written Expression composite *W* score was used for data analyses.

Procedures

Participant selection procedures. Participants were selected to participate in the larger study (Coker et al., 2015) using the following procedures. After the signed informed consent form was returned, the Dynamic Indicators of Basic Early Literacy Skills (DIBELS, Good & Kaminski, 2002) Phoneme Segmentation Fluency (PSF) score was obtained from each student's teacher. These data were collected as part of a school-wide universal screening conducted in September of the school year. PSF scores were used to form three groups representing three performance levels (i.e., low, middle, high). Three students were randomly selected from each performance level (nine students per classroom). This was done so the sample would represent a range of skill levels for the larger research project.

Data collection procedures. Data were collected by trained research assistants who administered the measures according to standardized procedures. Most measures were administered individually with the exception of WJ-III Spelling, WJ-III Writing Fluency, and WJ-III Writing Samples which were administered in small groups of three to four students. All data for this study were collected during the 2013-2014 school year. All predictor measures were collected mid-October through early December. WJ-III Writing Fluency and WJ-III Writing Samples were collected mid-April and May.

Data scoring procedures. Trained research assistants scored all measures according to standardized procedures. Assessments were scored by at least two research assistants. Any disagreements were discussed and resolved. Interrater agreement was calculated for 20% of the WJ-III Writing Samples and WJ-III Writing Fluency subtests

and Alphabet Copy. Interrater agreement was established using the following formula:
number of agreements / (number of agreements + number of disagreements) x 100.

Interrater reliability for the WJ-III Writing Samples and WJ-III Writing Fluency subtests were 91% and 97%, respectively. Interrater reliability for Alphabet Copy was 97%.

Data screening procedures. Before analysis, the data was prepared by screening the independent and dependent variables for outliers, normality, and multicollinearity. Data screening ensured accurate data entry and that the data met the criteria necessary for confirmatory factor analysis (Weston & Gore, 2006). Data were screened using Statistical Package for the Social Sciences version 22 (SPSS; IBM Corp). Univariate outliers were evaluated by examining the frequency distributions of z scores. Cases with z scores above ± 3.29 are potential outliers. Multivariate outliers were checked using the Mahalanobis D test. Mahalanobis distance is distributed as a chi-square (χ^2) statistic with degrees of freedom equal to the number of variables. A multivariate outlier can be identified if the Mahalanobis distance has a p value less than .001 (Kline, 2005; Tabachnick & Fidell, 2007).

Data were analyzed to check the assumption of univariate and multivariate normality based on measures of skewness and kurtosis. Absolute values of skew and kurtosis greater than 3.0 may indicate that the data are not normally distributed. (Kline, 2005). Tolerance and variance inflation factors (VIF) were examined to check for multicollinearity. Multicollinearity may be present if tolerance values are under .10 and VIF are greater than 10.0 (Kline, 2005).

Data analysis procedures. Structural equation modeling techniques were used to analyze the data (Tabachnick & Fidell, 2007). Data analysis was conducted using SPSS Analysis of Moment Structures version 22 (AMOS; Arbuckle, 2013). Structural equation modeling allows complex relationships between one or more independent variables and one or more dependent variables to be examined (Hoyle, 2012; Tabachnick & Fidell, 2007). Independent and dependent variables can be either observed or latent (Bowen & Guo, 2012; Tabachnick & Fidell, 2007). Observed variables are directly observable or measured (e.g., performance on a test) whereas latent variables are theoretical constructs not directly observable or measured (Bowen & Guo, 2012; Schumacker & Lomax, 1996).

A primary advantage of structural equation modeling is that it can be used to examine the relationships simultaneously among latent factors as indicated by multiple measures (Kline, 2005; Lei & Wu, 2007; Norman & Streiner, 2003). Another advantage is that the relationships are free of measurement error because the error is estimated and removed, leaving only the common variance remaining (Tabachnick & Fidell, 2007).

Structural equation modeling provides a method for exploring direct and indirect effects. A direct effect refers to the relationships among observed and latent variables and involves testing a single path (Tabachnick & Fidell, 2007). An indirect (i.e., mediated) effect, refers to the relationship between two latent variables that are not directly connected by a single path but are instead connected via a path from one or more other variables (Schumacker & Lomax, 1996).

Model building. The first step of analysis using structural equation modeling is to

specify a theoretically-based model (Hoyle, 2012; Kline, 2005; Lei & Wu, 2007). The model is comprised of two components: the hypothesized measurement model and the hypothesized structural model (Blunch, 2008; Schreiber, Nora, Stage, Barlow, & King, 2006; Weston & Gore, 2006). The hypothesized measurement model (sometimes referred to as a confirmatory factor analysis measurement model) relates the observed variables to latent variables (Schreiber et al., 2006; West, Taylor, & Wu, 2012). Specifically, the measurement model explains the relationships between the observed variables and the construct(s) the variables are hypothesized to measure (Weston & Gore, 2006).

According to Kline (2005), a valid measurement model is necessary before evaluating the structural model component of the hypothesized full structural equation model. The hypothesized measurement model will be examined using confirmatory factor analysis.

The hypothesized structural model explains the structural relationships among the constructs (Weston & Gore, 2006). Once the measurement model is specified, the measurement model and the structural models are combined to form the full structural model (Bowen & Guo, 2012; Lei & Wu, 2007; Weston & Gore, 2006). The hypothesized full structural model for this dissertation study is described in the final section of this chapter.

Path diagram. A model is typically presented visually as a figure known as a path diagram (Kline, 2005; Lei & Wu, 2007; Norman & Streiner, 2003). In path diagrams, latent variables are represented with ovals and observed variables are represented with rectangles (Byrne, 2010; Kline, 2005; Tabachnick & Fidell, 2007). Single-headed arrows (→) represent a hypothesized direct relationship between two variables (Byrne, 2010;

Kline, 2005) and the variable with the arrow pointing to it is the dependent variable (i.e., outcome) (Tabachnick & Fidell, 2007). Double-headed arrows (\leftrightarrow) represent a bidirectional relationship (i.e., covariance) without an implied direction of effect (Kline, 2005; Tabachnick & Fidell, 2007).

Model estimation. Before testing the full structural model, confirmatory factor analysis is performed to test the measurement model. Model estimation is performed to verify if the observed variables load on each latent construct as hypothesized. Specifically, the purpose of estimation is to determine the values for the free parameters that minimize discrepancy between the observed covariance matrix and the estimated covariance matrix (Byrne, 2010; Hoyle, 2012). Maximum likelihood is the most commonly used method of estimation.

Assessing model fit. Model fit reveals the extent to which the structural model fits the sample data (Schumacker & Lomax, 1996). There are several indices available for assessing model fit. As suggested by Weston and Gore (2006), model fit should be evaluated in terms of the following: (a) the variance accounted for in dependent observed and latent variables, (b) the significance and strength of estimated parameters, and (c) how well the overall model fits the observed data.

A non-significant χ^2 ($p > .05$) suggests that the model fits the data. The χ^2 test can also be used to compare models in determining the fit to the data (Blunch, 2008; Tabachnick & Fidell, 2007). However, the larger the sample size, the more likely the χ^2 will be significant resulting in rejection of the model (Lei & Wu, 2007; Weston & Gore, 2006). Despite this limitation, χ^2 continues to be universally reported (Weston & Gore,

2006). The following additional fit indices will be reported to address this limitation; comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR).

CFI compares the improvement of the fit of the hypothesized model to the independent model (Byrne, 2001; Weston & Gore, 2006). An independent (null) model is the baseline model in which no relationships are specified among the variables (Kline, 2005; Weston & Gore). CFI ranges from 0 to 1.00 with values $\geq .95$ indicating better fit (Blunch, 2008; Lei & Wu, 2007; Schreiber et al., 2006). RMSEA corrects for the complexity of the model by being sensitive to the number of estimated parameters in the model (Byrne, 2001; Weston & Gore, 2006). RMSEA values $\leq .05$ indicate approximate fit, and values between .05 and .08 suggest reasonable error of approximation (Kline, 2005). Additionally, it has become practice to report the 90% confidence intervals for RMSEA because this incorporates the sampling error associated with the estimated RMSEA (Weston & Gore, 2006). SRMR is a measure of the mean absolute correlation residual and is a summary of the level of difference between the observed data and the model (Kline, 2005). Values of SRMR less than .10 are generally considered good fit (Kline, 2005).

Evaluating parameter estimates. Once the measurement model met the fit criteria, the parameter estimates are interpreted (Bowen & Gou, 2012; Schumaker & Lomax, 1996). Examination of the parameter estimates can help in initially identifying a misspecified model (Schumaker & Lomax, 1996). In addition, the magnitude and statistical significance of loadings and factor variances should be examined in the

measurement model (Bowen & Gou, 2012). One issue relating to the stability of parameter estimates is sample size. There is no widely accepted rule regarding sample size; however, Kline (2005) states that sample sizes exceeding 200 can be considered large.

How well the model fits the data is first determined by examining the signs (i.e., -/+) of the path coefficients in order to verify that the paths are in the expected direction (Blunch, 2008; Norman & Streiner, 2003). Then the significance of the path coefficients for the latent variable associations is used to verify or disprove the hypothesis. The signs and the significance of the path coefficients provide information about the individual components of the model. Kline (2005) suggests that the magnitude of the path coefficients can be interpreted similar to an effect size. Standardized path coefficients with absolute values $< .10$ may suggest a small effect; absolute values around $.30$ suggest a medium effect; and absolute values $\geq .50$ suggest a large effect (Kline, 2005). Additionally, the degree of significance as a p value is also provided for path coefficients.

Structural equation modeling analyses calculates a squared multiple correlation coefficient that, like R^2 in multiple regression, represents the proportion of variance explained by the predictors (Weston & Gore, 2006). The estimated parameters will be examined for each identified path between the independent latent variables and the dependent variable in order to determine whether or not the Executive Function latent variable has a direct effect on the writing achievement outcome. For the purposes of this dissertation study, the squared multiple correlation (R^2) represents the proportion of variance in the writing achievement of first-grade students explained by the observed and

latent variables.

Model respecification. If the hypothesized model does not fit the data well according to the goodness-of-fit statistics or high correlations between observed or latent variables, then a model can be respecified to improve the fit (Blunch, 2008; Hoyle, 2012; Tabachnik & Fidell, 2007). However, respecification of a model should be theoretically based (Norman & Streiner, 2003). Improvement of the model fit is typically done by adding parameters, fixing parameters, or deleting parameters (Blunch, 2008). Two types of information can be useful for respecification: residuals and modification indices (Kline, 2005; Tabachnick & Fidell, 2007). The residuals should be small and centered around zero (Tabachnick & Fidell, 2007). Modification indices are statistics that signify how much model fit could be improved. Specifically, modification indices indicate possible parameters to add to a model to improve fit (Bowen & Guo, 2012).

Hypothesized Full Structural Model

The hypothesized measurement model path diagram for this study is presented in Figure 3.1. In the hypothesized measurement model, the transcription latent factor includes Alphabet Copy and WJ-III Spelling. The oral vocabulary latent factor includes PPVT-4 and EOWPVT-4. The reading factor includes WJ-III Letter-Word Identification, Word Attack, and Passage Comprehension. The Executive Function latent factor includes CEFS and PAL-II Verbal Working Memory. Upon confirmation of the hypothesized measurement model, the hypothesized full structural equation model is analyzed. Adding the outcome, WJ-III Written Expression, to the hypothesized measurement model results in the hypothesized full structural model.

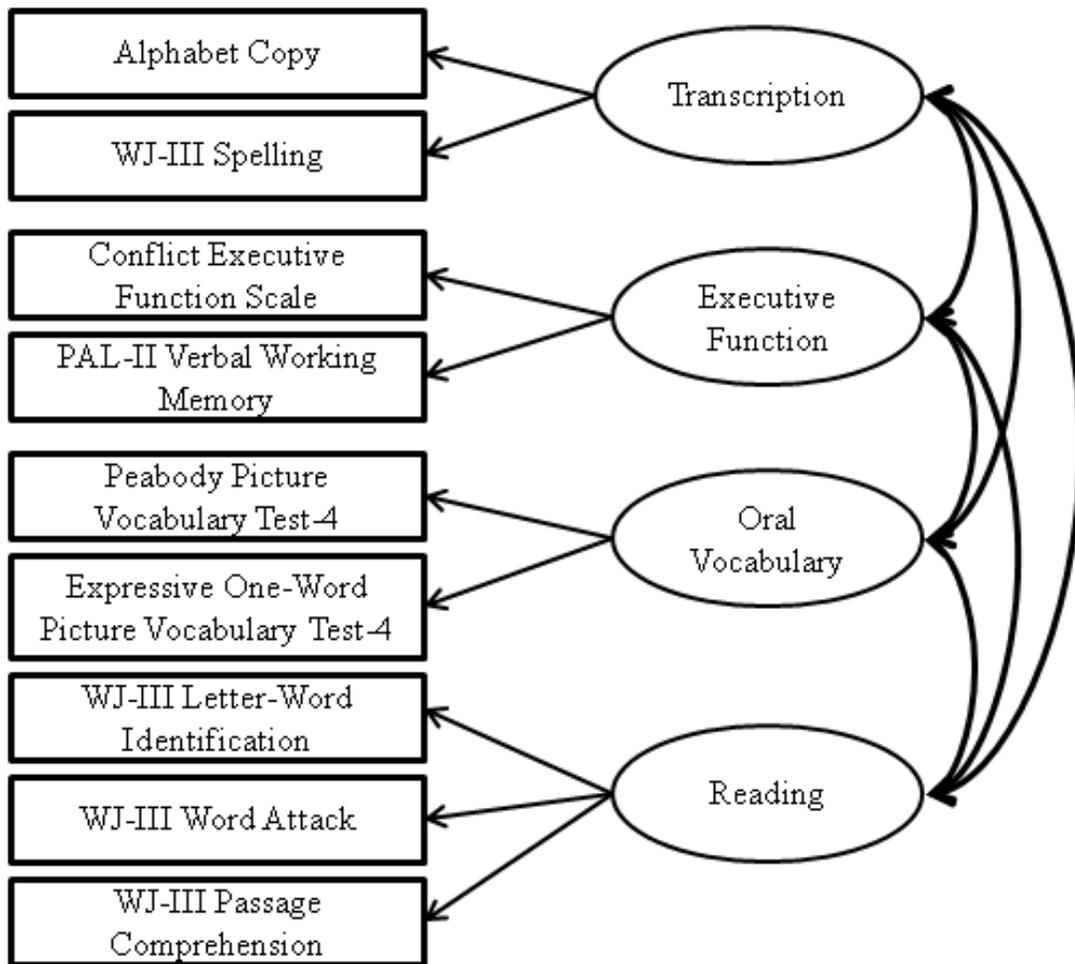


Figure 3.1. Hypothesized measurement model.

Additionally, the hypothesized relationships are identified by adding paths between the latent constructs and the outcome. The hypothesized full structural equation model is presented in Figure 3.2.

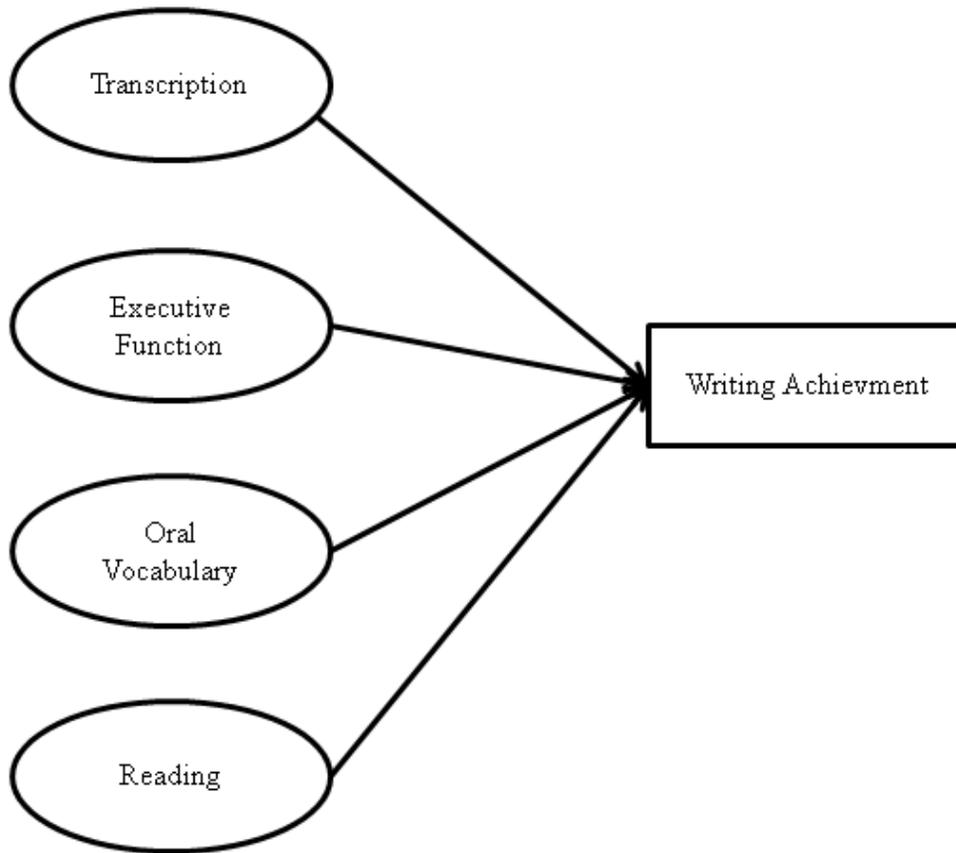


Figure 3.2. Hypothesized full structural model.

Hypothesized Study Outcomes

The following hypotheses are proposed. It is hypothesized that executive function would have a direct effect on writing. Previous research (Hooper et al., 2011; Kent et al., 2014) found that executive function had a significant direct effect on writing achievement. This result is also expected based on the theoretical framework guiding this study. It is hypothesized that other variables (transcription, oral vocabulary, and reading)

will also have a direct effect on writing. These variables have consistently predicted beginning writing (Abbott & Berninger, 1993; Coker, 2006; Jones & Christensen, 1999; Kim et al., 2011; Kim et al., 2013; Puranik & Al Otaiba, 2012; Wagner et al., 2011). The hypotheses will be confirmed if the standardized regression coefficient for the direct paths for each latent variable is positive and statistically significantly.

Chapter 4

RESULTS

This dissertation study examined the relation between executive function and beginning writing achievement for first-grade students. This chapter will discuss data screening, descriptive statistics, handling of missing data, results of the confirmatory factor analysis, structural equation modeling analysis, and a summary of the results.

Data Screening of Observed Variables

Data screening was conducted using SPSS version 22. Univariate outliers were evaluated by examining the frequency distributions of z scores. Four scores with a z score above ± 3.29 were identified as possible univariate outliers. Further examination of these four scores determined that two of the outliers were due to extremely low scores. The other two outliers were data entry errors and were corrected. The two low scores were retained based on recommended procedures (Tabachnick & Fidell, 2007). Multivariate outliers were evaluated by examining the Mahalanobis distance statistic. All outliers had a p value less than .001 with the exception of three cases. However, the Mahalanobis distance for each case were below the critical value ($\chi^2(9) = 27.88$) and were retained.

Normality of the variables was evaluated by examining the skewness and kurtosis statistics for each variable. Table 4.1 summarizes the normality and collinearity statistics. The absolute values of the skewness indices ranged from -.14 to 1.07, and kurtosis

Table 4.1
Univariate Normality and Multicollinearity

	Normality Statistics		Collinearity Statistics	
	Skewness	Kurtosis	Tolerance	Variance Inflation Factor
Alphabet Copy	0.254	-0.357	0.716	1.392
CEFS	-0.536	0.953	0.757	1.263
PPVT-4	-0.315	0.530	0.323	3.055
EOWPVT-4	-0.051	-0.223	0.303	3.274
PAL-II Verbal Working Memory	1.08	1.17	0.531	2.214
WJ-III Spelling	0.599	0.385	0.762	4.331
WJ-III L-W Id	0.425	-0.202	0.360	4.113
WJ-III Word Attack	0.394	-0.197	0.289	3.561

Note. Dependent variable is WJ-III Written Expression. CEFS = Conflict Executive Function Scale; PPVT-4 = Peabody Picture Vocabulary Test-4th Edition; EOWPVT-4 = Expressive One-Word Picture Vocabulary Test-4th Edition; PAL-II = Process Assessment of the Learner-Second Edition: Diagnostics for Reading and Writing; WJ-III = Woodcock-Johnson Test of Achievement Letter-Word Identification.

indices ranged from -.11 to 1.35. These indices suggest no critical deviation from normality. Multivariate collinearity was evaluated by examining tolerance values and variance inflation factors (VIF). Tolerance values ranged from .278 to .792 and VIF values ranged from 1.263 to 4.331, suggesting no multivariate collinearity.

Descriptive Statistics

Descriptive statistics were conducted using SPSS version 22. Descriptive statistics for observed variables are presented in Table 4.2 and include raw scores and standard scores when appropriate. Bivariate correlations among all variables are presented in Table 4.3. Raw scores and *W* scores were used for data analysis. The

Table 4.2
Descriptive Statistics

	<i>N</i>	<i>M</i>	<i>SD</i>	Min-Max
Transcription				
Alphabet Copy	233	5.14	2.54	0–12
WJ-III Spelling	232	105.94	13.8	65–147
Oral Vocabulary				
PPVT-4	227	110.21	20.32	36–161
EOWPVT-4	230	76.41	15.93	29–113
Executive Function				
CEFS	228	52.12	6.64	34–70
PAL-II Verbal Working Memory	231	9.77	1.94	6–16
Reading				
WJ-III L-W Id	233	119.39	13.39	67–153
WJ-III Word Attack	231	109.68	9.67	82–134
WJ-III Passage Comprehension	233	101.14	15.15	57–136
Writing Achievement				
WJ-III Written Expression	219	112.6	14.67	56–142

Note. PPVT-4 = Peabody Picture Vocabulary Test-4; EOWPVT-4 = Expressive One-Word Picture Vocabulary Test-4; CEFS = Conflict Executive Function Scale; PAL-II = Process Assessment of the Learner-Second Edition: Diagnostics for Reading and Writing; WJ-III = Woodcock-Johnson Test of Achievement Letter-Word Identification.

magnitude of the relations varied from small ($r = .26$ between PPVT-4 and Alphabet Copy) to strong ($r = .91$ between WJ-III Passage Comprehension and WJ-III Letter-Word Identification). Correlations between all variables were significantly correlated ($ps < .01$). The high correlation between WJ-III Letter-Word Identification and WJ-III Passage Comprehension ($r = .91$) suggests possible multicollinearity. Therefore, WJ-III Passage

Table 4.3
Bivariate Correlations Between Observed Variables

	1	2	3	4	5	6	7	8	9	10
Transcription										
1. Alphabet Copy	1									
2. WJ-III Spelling	0.49	1								
Oral Vocabulary										
3. PPVT-4	0.26	0.44	1							
4. EOWPVT-4	0.32	0.43	0.81	1						
Executive Function										
5. CEFS	0.28	0.32	0.36	0.39	1					
6. PAL-II Verbal Working Memory	0.43	0.70	0.43	0.45	0.39	1				
Reading										
7. WJ-III L-W Id	0.46	0.84	0.46	0.50	0.33	0.65	1			
8. WJ-III Word Attack	0.40	0.79	0.43	0.46	0.28	0.63	0.84	1		
9. WJ-III Passage Comprehension	0.47	0.77	0.53	0.56	0.44	0.62	0.91	0.76	1	
Writing Achievement										
10. WJ-III Written Expression	0.48	0.69	0.53	0.50	0.40	0.64	0.71	0.67	0.72	1

Note. PPVT-4 = Peabody Picture Vocabulary Test-4th Edition; EOWPVT-4 = Expressive One-Word Picture Vocabulary Test-4th Edition; CEFS = Conflict Executive Function Scale; PAL-II = Process Assessment of the Learner-Second Edition: Diagnostics for Reading and Writing; WJ-III = Woodcock-Johnson III Test of Achievement Letter-Word Identification.

Comprehension was excluded from further analyses. This measure was chosen for exclusion because the WJ-III Letter-Word Identification and WJ-III Word Attack represent basic reading skills and WJ-III Written Expression composite represents basic writing skills.

Treatment of Missing Data

Missing data was analyzed using the SPSS Missing Value Analysis (MVA) to detect patterns of missing data (Tabachnick & Fidell, 2007). Data were found to be missing at random (MAR), and all missing data were imputed using the SPSS MVA Expectation maximization (EM) algorithm (Tabachnick & Fidell, 2007). After completing these preliminary analyses, confirmatory factor analysis was conducted to confirm the hypothesized measurement model.

Measurement Model

Confirmatory factor analysis indicated that the hypothesized measurement model fit the data well: $\chi^2(21) = 43.877, p = .002$; CFI = .98; RMSEA = .069 (CI [.04, .09]) and SRMR = .03. Figure 4.1 presents the factor loadings for each latent construct in the hypothesized measurement model. As shown in Figure 4.1, all of the observed variables loaded on to the hypothesized latent constructs.

Correlations among the latent constructs are presented in Table 4.3. All latent constructs were significantly and positively related to one another ($.53 \leq r \leq .91$). Although the hypothesized measurement model indicated a good fit, there was a high level of intercorrelation. Intercorrelations greater than .85 may result in statistical problems such as multicollinearity (Kline, 2005; Tabachnick & Fidel, 2007). Specifically,

the latent constructs for this study may not be distinct variables as hypothesized. As shown in Table 4.4, the correlation between the Executive Function latent construct and the Transcription latent construct was .89. The correlation between the Transcription latent construct and the Reading latent construct was .95. These correlations suggest an issue with multicollinearity.

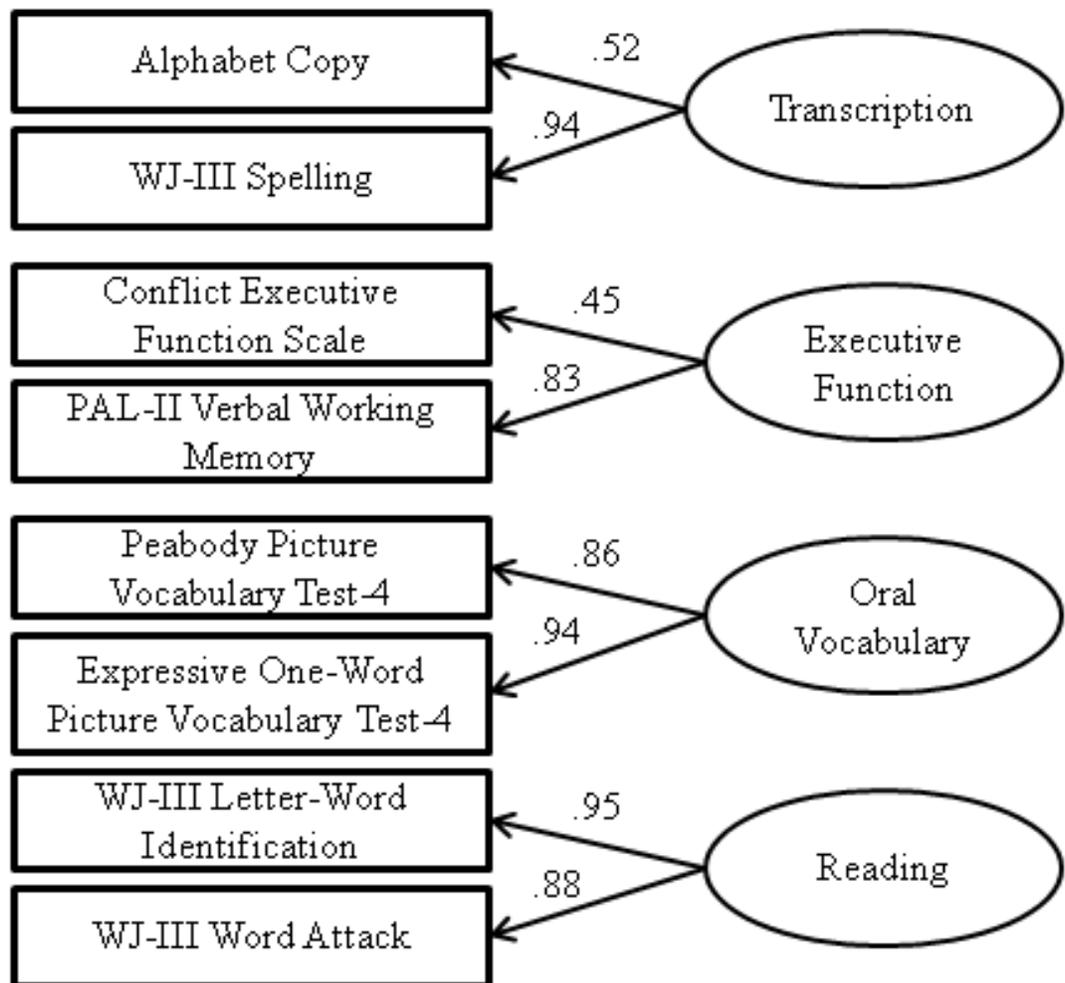


Figure 4.1. Factor loadings for hypothesized measurement model

Table 4.4
*Hypothesized Measurement Model Correlations Among
 Transcription, Oral Vocabulary, Executive Function, and Reading*

	Transcription	Oral Vocabulary	Executive Function	Reading
Transcription	1			
Oral Vocabulary	.50	1		
Executive Function	.89	.62	1	
Reading	.95	.56	.83	1

Note. All coefficients are statistically significant at the .001 level

One proposed solution for addressing multicollinearity among latent constructs is to conduct exploratory factor analysis (Field, 2009; Tabachnick & Fidel, 2007). Whereas confirmatory factor analysis is used to confirm a stated hypothesis, exploratory factor analysis is an exploratory technique used to combine variables. Specifically, exploratory factor analysis is not guided by an expected hypothesis (Bowen & Guo, 2012).

Exploratory factor analysis was conducted to create factors using principal components analysis with varimax rotation. After varimax rotation, a five factor solution resulted in two latent factors and three single item factors. The factor loadings are presented in Table 4.5. WJ-III Letter-Word Identification, WJ-III Word Attack, and WJ-III Spelling loaded on the first factor and were labeled Early Literacy. Early Literacy accounted for 29.85% of the variance. PPVT-4 and EOWPVT-4 loaded on the second factor and were labeled Oral Vocabulary. Oral Vocabulary accounted for 23.82% of the variance. The original executive function latent factor was split into two single item factors. The first single item factor was the Conflict Executive Function Scale measure, now labeled Executive Function, and accounted for 13.81% of the variance. The second single item factor

Table 4.5
Factor Loadings from Principal Components Analysis

Measure	Early Literacy	Oral Vocabulary	Executive Function	Handwriting Fluency	Verbal Working Memory
WJ-III L-W Id	0.887				
WJ-III Word Attack	0.875				
WJ-III Spelling	0.874				
PPVT-4		0.907			
EOWPVT- 4		0.889			
CEFS			0.953		
Alphabet Copy				0.938	
PAL-II Verbal Working Memory					.884

Note; WJ-III L-W Id = Woodcock-Johnson Letter-Word Identification; PPVT-4 = Peabody Picture Vocabulary Test-4th Edition; EOWPVT-4 = Expressive One Word Vocabulary Test-4th Edition; CEFS = Conflict Executive Function Scale; PAL-II VWM = Process Assessment of the Learner-Second Edition: Diagnostics for Reading and Writing Verbal Working Memory.

is the Alphabet Copy measure, now labeled Handwriting Fluency, and accounted for 12.80% of the variance. The third single item factor is the PAL-II Verbal Working Memory measure, now labeled Verbal Working Memory, and accounted for 12.28% of the variance. These five factors accounted for 92.56% of the total variance. The revised measurement model was evaluated using confirmatory factor analysis. The revised measurement model fit the data well: $\chi^2(13) = 25.798, p = .018$; CFI = .989; RMSEA = .065 (CI [.026, .102]) and SRMR = .0163. Unlike in the hypothesized measurement model, multicollinearity was not evident for this revised measurement

model. The correlations for the revised measurement model are presented in Table 4.6. Factor loadings for the two latent constructs (i.e., Early Literacy and Oral Vocabulary) are presented in Figure 4.2.

Table 4.6
Revised Measurement Model Correlations Among Handwriting Fluency, Executive Function, Verbal Working Memory, Oral Vocabulary, and Early Literacy

	Handwriting Fluency	EF	Verbal Working Memory	Oral Vocabulary	Early Literacy
Handwriting Fluency	1				
Executive Function	.28	1			
Verbal Working Memory	.43	.37	1		
Oral Vocabulary	.33	.42	.49	1	
Early Literacy	.51	.36	.72	.56	1

Note. HF = Handwriting Fluency; EF = Executive Function; VWM = Verbal Working Memory. All coefficients are statistically significant at the .001 level.

Structural Models

Structural equation modeling was used to examine the shared and unique relations of Executive Function, Handwriting Fluency, Oral Vocabulary, and Early Literacy to Writing Achievement assessed at the end of first grade. First, a full revised structural model (Model 1) with only direct effects was examined (Figure 4.3). Model 1 included direct paths from Handwriting Fluency, Executive Function, Verbal Working Memory, Oral Vocabulary, and Early Literacy to Writing Achievement. Additionally, gender was

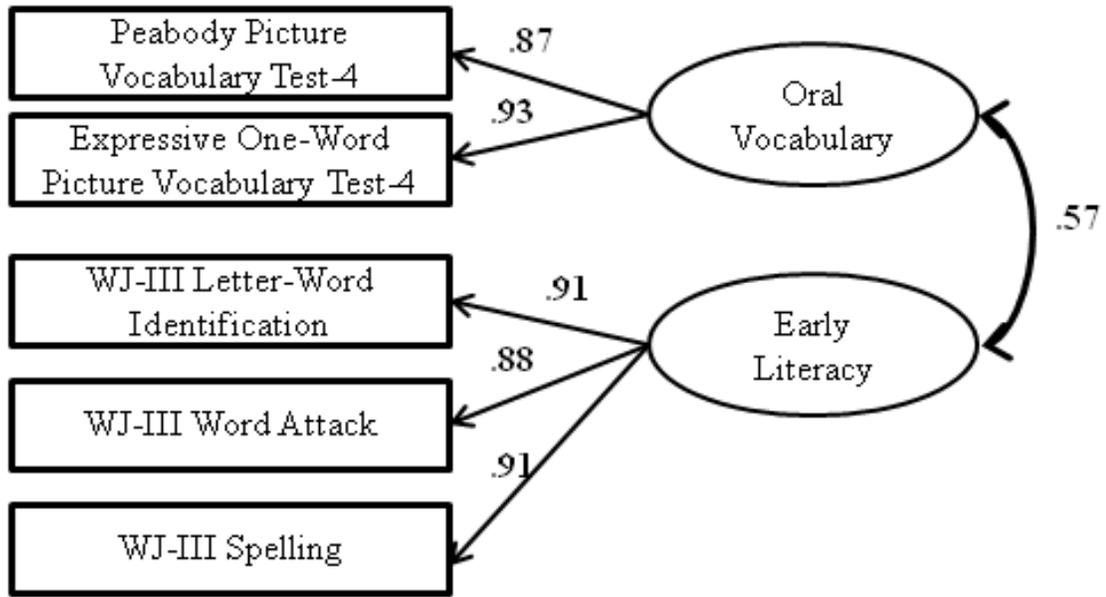


Figure 4.2. Factor loadings for Early Literacy and Oral Vocabulary.

included as a covariate. Model 1 demonstrated good fit: $\chi^2(24) = 47.51, p = .003$; CFI = .983; RMSEA = .065 (CI [.038, .092]) and SRMR = .031. Handwriting Fluency ($\gamma = .11, p = .02$), Oral Vocabulary ($\gamma = .18, p = .001$), and Early Literacy ($\gamma = .50, p = .001$) revealed unique and statistically significant relations to Writing Achievement. The magnitude of the standardized path coefficients for Handwriting Fluency ($\gamma = .11$) and Oral Vocabulary ($\gamma = .18$) were small. The magnitude of the standardized path coefficient for Early Literacy ($\gamma = .58$) was large.

The direct paths from Executive Function and Verbal Working Memory to Writing Achievement at the end of first grade were not statistically significant ($\gamma = .07, p = .13$; $\gamma = .11, p = .07$, respectively) nor did either path uniquely contribute to Model 1.

The standardized path coefficient for gender was negative but statistically significant suggesting that girls performed better than boys on writing at the end of first-grade.

Model 1 accounted for 64% of the variance in Writing Achievement.

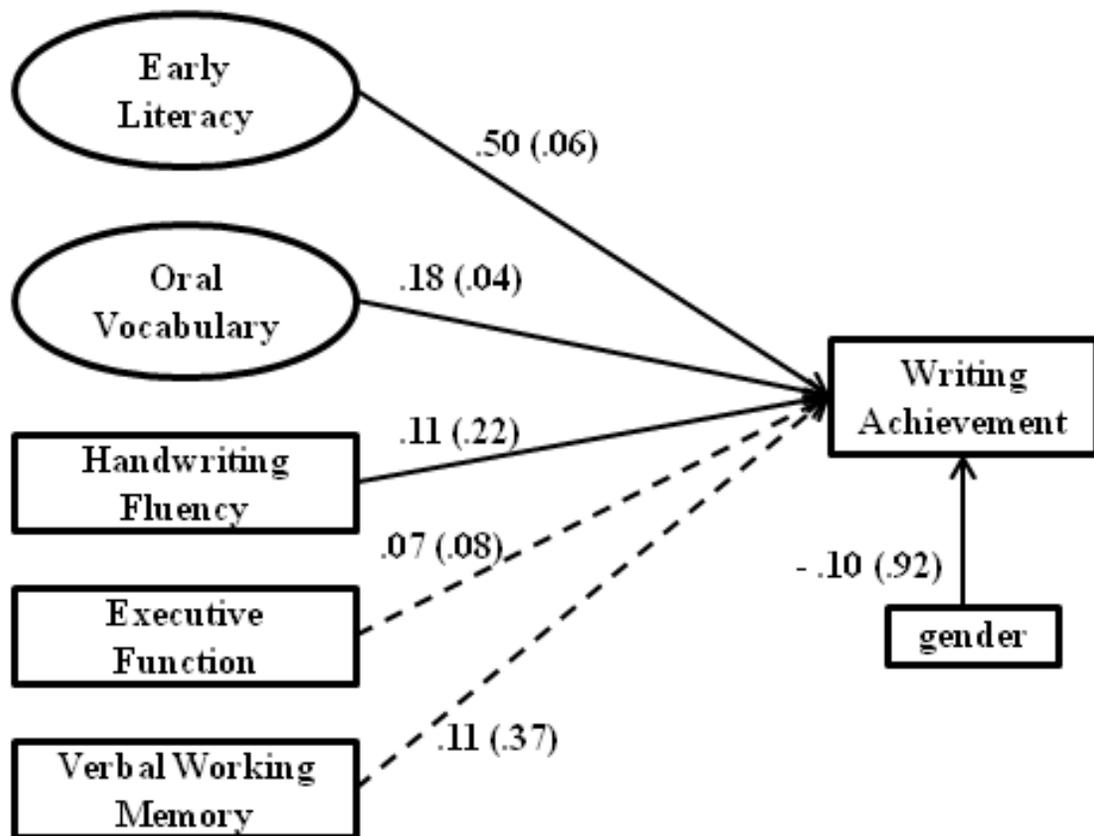


Figure 4.3. Standardized structural regression weights (standard errors in parentheses) for Model 1. Nonsignificant ($p > .05$) paths are indicated by a dashed line.

Although Executive Function and Verbal Working Memory did not directly contribute to Writing Achievement at the end of first grade, a second model (Model 2) was analyzed to examine if either factor indirectly contributed to Writing Achievement (see Figure 4.4). Specifically, Model 2 included additional paths between Executive Function and Early Literacy, Executive Function and Oral Vocabulary, and Executive Function and Handwriting Fluency. Additional paths between Verbal Working Memory and Early Literacy, Verbal Working Memory and Oral Vocabulary, and Verbal Working Memory and Handwriting Fluency were included. The nonsignificant paths from Executive Function and Verbal Working Memory to Writing Achievement were deleted. Model 2 demonstrated an adequate fit: $\chi^2(29) = 87.34, p = .001$; CFI = .959; RMSEA = .094 (CI [.071, .118]) and SRMR = .071. Handwriting Fluency ($\gamma = .14, p = .002$), Oral Vocabulary ($\gamma = .24, p = .001$), and Early Literacy ($\gamma = .59, p = .001$) revealed unique and statistically significant relations to Writing Achievement. The magnitude of the standardized path coefficient for Handwriting Fluency ($\gamma = .14$) was small. The magnitude of the path coefficient for Oral Vocabulary ($\gamma = .24$) was medium. The magnitude of the standardized path coefficient for Early Literacy ($\gamma = .59$) was large.

Executive Function indirectly contributed to Writing Achievement through Handwriting Fluency ($\gamma = .14, p = .03$) and Oral Vocabulary ($\gamma = .28, p = .001$). The magnitude of the indirect path through Handwriting Fluency ($\gamma = .14$) was small; however, the magnitude of the indirect path through Oral Vocabulary ($\gamma = .28$) was medium. Executive Function did not indirectly contribute to Writing Achievement

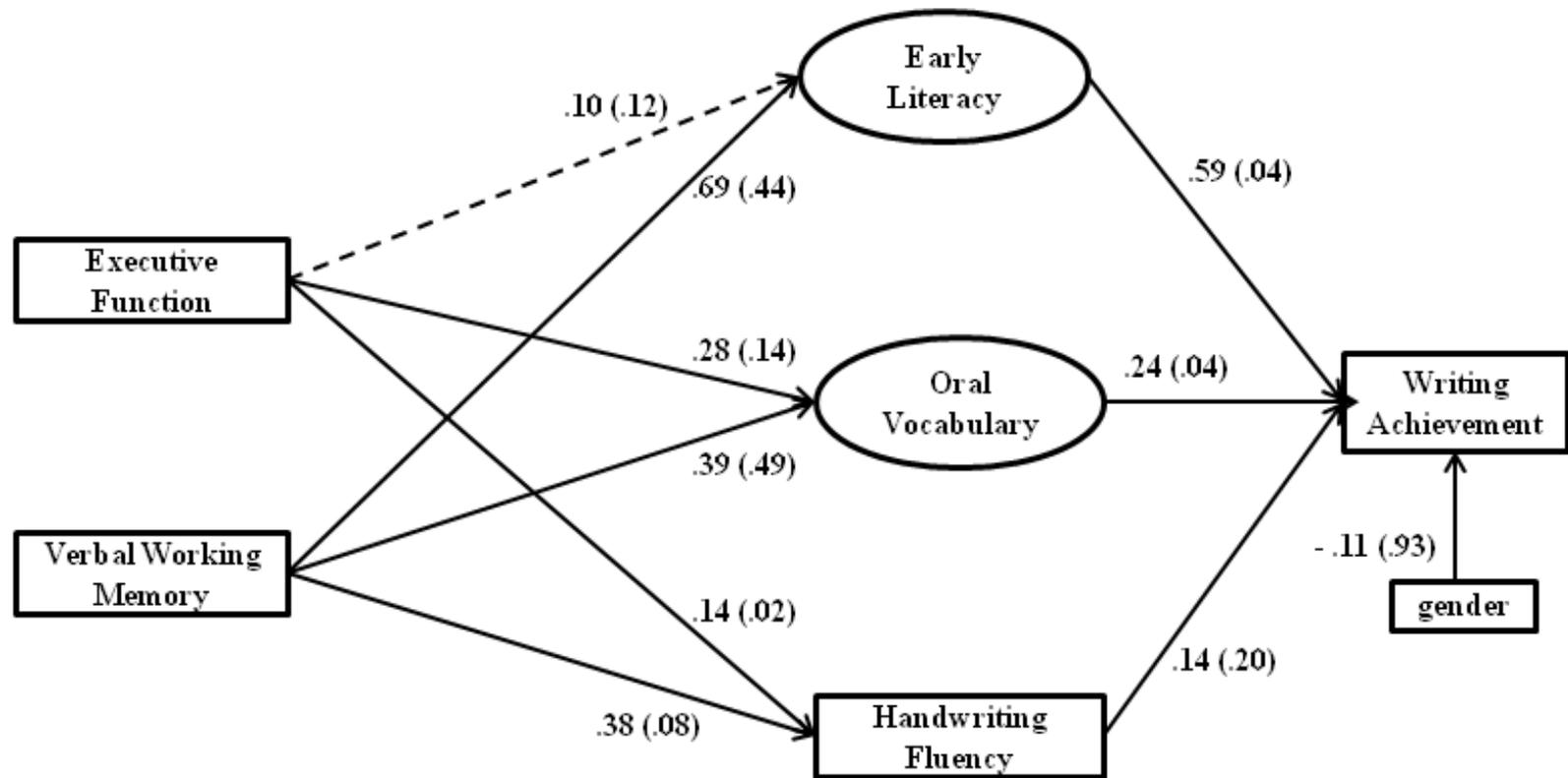


Figure 4.4. Standardized structural regression weights (standard errors in parentheses) for Model 2. Nonsignificant ($p > .05$) paths are indicated by a dashed line.

through Early Literacy ($\gamma = .09, p = .07$). Verbal Working Memory indirectly contributed to Writing Achievement through Handwriting Fluency ($\gamma = .38, p = .001$) and Oral Vocabulary ($\gamma = .39, p = .001$) and Early Literacy ($\gamma = .69, p = .001$). The magnitude of the indirect paths through Handwriting Fluency ($\gamma = .38$) and Oral Vocabulary ($\gamma = .39$) were medium. The magnitude of the indirect path through Early Literacy ($\gamma = .69$) was large. The standardized path coefficient for gender was negative but statistically significant suggesting that girls performed better than boys on writing at the end of first grade. Model 2 accounted for 62% of the variance in Writing Achievement.

Post hoc model modifications were performed to determine if an alternative model would fit the data better than Model 2. Respecification of the model was guided by modification indices and a third model (Model 3) was analyzed (see Figure 4.5). Model 3 was the same as Model 2; however, an indirect path between Handwriting Fluency and Early Literacy and an indirect path between Oral Vocabulary and Early Literacy were added to the model. The nonsignificant path from Executive Function to Early Literacy was deleted. This final model demonstrated good fit: $\chi^2 (29) = 55.82, p = .001$; CFI = .980; RMSEA = .068 (CI [.042, .093]) and SRMR = .036. Handwriting Fluency ($\gamma = .12, p = .01$), Oral Vocabulary ($\gamma = .22, p = .001$), and Early Literacy ($\gamma = .58, p = .001$) continued to demonstrate unique and statistically significant relations to Writing Achievement. The magnitude of the standardized path coefficients remained small for Handwriting Fluency ($\gamma = .12$) and Oral Vocabulary ($\gamma = .22$). The magnitude of the standardized path coefficient remained large for Early Literacy ($\gamma = .58$).

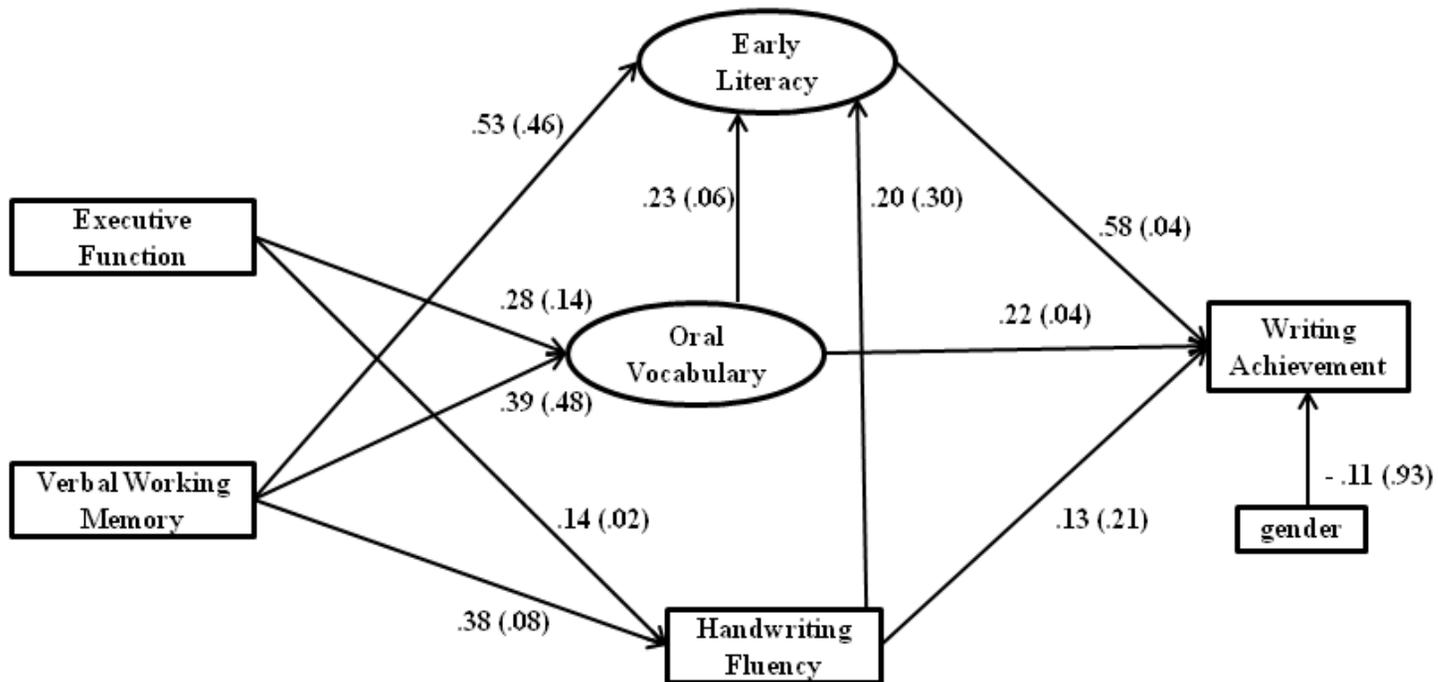


Figure 4.5. Standardized structural regression weights (standard errors in parentheses) for Model 3.

Executive Function indirectly contributed to Writing Achievement through Handwriting Fluency ($\gamma = .14, p = .03$) and Oral Vocabulary ($\gamma = .28, p = .001$). The magnitude of the indirect path through Handwriting Fluency was small; however, the magnitude of the indirect path through Oral Vocabulary was medium. Verbal Working Memory indirectly contributed to Writing Achievement through Handwriting Fluency ($\gamma = .38, p = .001$), Oral Vocabulary ($\gamma = .39, p = .001$), and Early Literacy ($\gamma = .53, p = .001$). The magnitude of the indirect effects of Verbal Working Memory through Handwriting Fluency ($\gamma = .38$), Oral Vocabulary ($\gamma = .39$), and Early Literacy ($\gamma = .53$) were medium to large.

Handwriting Fluency ($\gamma = .20, p = .001$) and Oral Vocabulary ($\gamma = .23, p = .001$) indirectly contributed to Writing Achievement through Early Literacy. The magnitude of the indirect paths through Handwriting Fluency and Oral Vocabulary were medium. The standardized path coefficient for gender continued to suggest that girls performed better than boys on Writing Achievement. The standardized indirect, direct, and total effects estimated in Model 3 are presented in Table 4.7. Model 3 accounted for 64% of the variance in Writing Achievement at the end of first grade. Model fit indices and statistics for the hypothesized measurement model, revised measurement model, and the full structural models are presented in Table 4.8.

Summary

Confirmatory factor analysis results suggested that the hypothesized measurement model fit the data; however, there was multicollinearity among the latent constructs. Because multicollinearity suggests the hypothesized latent constructs were not distinct,

Table 4.7
Standardized Indirect, Direct, and Total Effects on First-grade Writing

Mediated Paths	Indirect Effect	Direct Effect	Total Effect
EF → HF → Writing Achievement	0.141*	-	0.141*
EF → OV → Writing Achievement	0.276*	-	0.276*
VWM → HF → Writing Achievement	0.381*	-	0.381*
VWM → OV → Writing Achievement	0.389*	-	0.389*
VWM → EL → Writing Achievement	0.532*	-	0.532*
HF → EL → Writing Achievement	0.218*	0.120*	0.338*
OV → EL → Writing Achievement	0.230*	0.223*	0.453*

Note. EF = Executive Function; HF = Handwriting Fluency; OV = Oral Vocabulary; VWM = Verbal Working Memory; EL = Early Literacy.
 * $p < .05$.

Table 4.8
Model Fit Indices and Statistics

Model	χ^2 (df)	<i>P</i> value	CFI	RMSEA (CI)	SRMR
Hypothesized Measurement Model	27.12 (14)	.019	.989	.064 (.026, .100)	.039
Revised Measurement Model	25.80 (13)	.018	.989	.065 (.026, .102)	.016
SEM					
Model 1	47.51 (24)	.003	.983	.065 (.037, .092)	.031
Model 2	82.41 (27)	.001	.961	.094 (.072, .118)	.072
Model 3	55.83 (28)	.001	.980	.066 (.040, .091)	.036

Note. df = degree of freedom; CFI = comparative fit index; RMSEA = root mean square of approximations; CI = confidence interval; SRMR = standardized root mean square; SEM = Structural equation modeling.

exploratory factor analysis was conducted to identify a revised measurement model. The revised model included two latent factors (Early Literacy and Oral Vocabulary) and three single item factors (Executive Function, Handwriting Fluency, and Verbal Working Memory). The revised measurement model was a good fit to the data. The final structural model found unique and statistically significant direct relations between Early Literacy, Oral Vocabulary, and Handwriting Fluency to Writing Achievement at the end of first grade. Furthermore, Handwriting Fluency and Oral Vocabulary also indirectly contributed to writing achievement through Early Literacy.

Executive Function and Verbal Working Memory did not directly contribute to Writing Achievement at the end of first grade. However, Executive Function indirectly contributed to Writing Achievement through Handwriting Fluency and Oral Vocabulary. Verbal Working Memory indirectly contributed to Writing Achievement through Handwriting Fluency, Oral Vocabulary, and Early Literacy. Additionally, the gender covariate suggested that girls performed better than boys on writing at the end of first grade. These results will be discussed further in Chapter 5.

Chapter 5

DISCUSSION

The purpose of this dissertation study was to examine executive function in relation to the writing proficiency of students at the end of first grade. It was hypothesized that executive function would be directly related to writing in first grade. The results showed that executive function did not contribute directly to writing achievement at the end of first grade. However, the Executive Function factor contributed indirectly to Writing Achievement through Handwriting Fluency and Oral Vocabulary. Specifically, Handwriting Fluency and Oral Vocabulary mediated the relation between Executive Function and Writing Achievement at the end of first grade.

This chapter will discuss the findings in relation to the Not So Simple View of Writing theoretical framework. Additionally, all of the structural model factors (i.e., Early Literacy, Oral Vocabulary, Executive Function, Verbal Working Memory, Handwriting Fluency, and gender) will be discussed in relation to Writing Achievement. Limitations and recommendations for future research will be discussed.

Not So Simple View of Writing

The Not So Simple View of Writing (Berninger & Winn, 2006) was selected as the theoretical framework to guide this study. According to this model, transcription, executive function, and text generation represent cognitive components important for developing writing skills. Based on the model, four latent factors were hypothesized for

the measurement model. First, it was expected that measures for verbal working memory and executive function would represent a latent factor. However, exploratory factor analysis found that the Conflict Executive Function Scale and the PAL-II Verbal Working Memory were separate single item factors. These results align with the Not So Simple View of Writing, which presents executive function and working memory as separate components, but differ from descriptions of executive function that suggest that working memory is a component of executive function (ref). With regards to writing development, the results suggest that for first-grade students working memory is a separate component from the executive function construct as hypothesized by this study's theoretical framework. Furthermore, future research should examine these two components separately in order to further understand how each component contributes to beginning writing. These results further demonstrate how much is still not known about the development of beginning writing.

According to the Not So Simple View of Writing, transcription skills include handwriting and spelling. For this study, it was unsurprising that the handwriting and spelling measures would represent a latent factor for transcription. However, exploratory factor analysis found that Handwriting Fluency, as measured by Alphabet Copy, was a single item factor whereas the spelling measure, WJ-III Spelling, combined with the reading measures to form a factor which was labeled Early Literacy. This finding was plausible since research has demonstrated that spelling skills are related to reading (Abbott, Berninger, & Fayol, 2010; Ehri, 2000; Moats, 2005/2006). Furthermore, the correlation between WJ-III Spelling and Alphabet Copy was .41. The correlations

between WJ-III Spelling and WJ-III Letter-Word Identification and WJ-III Word Attack were .84 and .79, respectively.

Overall, the Not So Simple of Writing provides an appropriate framework for research examining executive function in relation to beginning writing. The model is a simple framework that provides guidance for examining components important for beginning writing. In the following sections, the contribution of the five factors (i.e., Early Literacy, Oral Vocabulary, Handwriting Fluency, Executive Function, and Verbal Working Memory) from the final structural model will be discussed.

Early Literacy

Of the five factors in the final model (Model 3, see Figure 4.5), Early Literacy had the largest ($\gamma = .58$) statistically significant direct contribution on Writing Achievement at the end of first grade. This construct represents important components related to early reading skills, which may also be important for beginning writing (Abbott & Berninger, 1993; Coker, 2006; Ehri, 2000; Kim et al., 2011; Puranik & Al Otaiba, 2012). This factor was similar to confirmatory factor analyses results in the Kent et al. (2014) study. In their study, spelling and reading factors were highly related and combined into a latent factor representing early literacy. As presented in Table 4.3, the correlations among the three Early Literacy measures (i.e., WJ-III Letter-Word Identification, Word Attack, and Spelling) were high. This suggests that these three tasks measured similar processes. Spelling requires phonological, orthographic, and morphological knowledge of words (Berninger et al. (2002) and this knowledge is closely linked to fluent decoding of words in relation to early reading ability (Ehri, 2000). In relation to writing, Abbott et al. (2010)

found that spelling and word reading were longitudinally related to writing. Structural equation modeling found that the path from spelling to written composition for students in first to seventh grades was significant (r 's ranged from .18 to .42). The path from word reading to writing was only significant from second to third grades ($\gamma = .16$).

Furthermore, Abbott et al. found that spelling and word reading had a reciprocal relationship (r 's ranged from .16 to .33). The path from spelling to word reading was significant from second to seventh grades (r 's ranged from .14 to .28).

The finding of this study further supports understanding of how component skills (e.g., spelling and reading) are important to beginning writing. Specifically, writing development is not a linear process involving a chronological mastery of component skills resulting in skilled writing. Learning to write is a multi-faceted process and, as such, these results highlight the importance for instruction targeting each process. Furthermore, beginning writing instruction should also be multi-faceted because these processes are interrelated as demonstrated by the previously discussed relation between spelling and reading.

Oral Vocabulary

Compared to Early Literacy, Oral Vocabulary had a small ($\gamma = .22$) but statistically significant direct contribution on Writing Achievement. This result is similar to those found by Coker (2006) and Kim et al. (2011) in which expressive and receptive vocabulary were unique predictors of writing. In contrast, Kim et al. (2014) reported that oral language (i.e., expressive vocabulary and grammatical knowledge) was not a significant predictor of writing. Producing written text involves mentally generating ideas

that are then orthographically translated into print. Oral vocabulary provides an important building block for written language (Green, McCutchen, Schwiebert, Quinlan, Eva-Wood, & Juelis, 2003). Translating the generated ideas into words and sentences has been posited to share cognitive components similar to oral language generation (McCutchen, Covill, Hoyne, & Mildes, 1994).

Although the Not So Simple View of Writing does not explicitly identify oral language as a component of beginning writing, it is an integral part of the text generation component. For example, writing a sentence requires a student to first generate ideas, and then translate those ideas into oral language, which are then transcribed into written text. Limited vocabulary and lack of knowledge of language structures may impact text quality (McCutchen, 2000; Olinghouse & Leaird, 2009). Although small ($\gamma = .23$), the relation between Oral Vocabulary and Writing Achievement was mediated (i.e., indirect effect) through Early Literacy. Given that Early Literacy consisted of measures assessing spelling, decoding, and word reading this result is not unexpected. Oral vocabulary, spelling, decoding, and word reading are important for understanding language (written and spoken). Furthermore, the development of oral language is related to the development of reading and writing. For example, knowledge of word structure (i.e., morphological awareness) is one component of spelling knowledge (Good, Lance, & Rainey, 2015; Moats, 2000). As noted by Pikulski and Templeton (2004) vocabulary development is linked to morphological awareness because “words that are related in meaning are often related in spelling, despite changes in sound” (p. 7). Furthermore, morphological awareness has been theorized to stem from a broad base of oral language

skills (Cunningham & Carroll, 2015). Given these relations it is not unexpected that Oral Vocabulary contributed directly and indirectly to Writing Achievement.

Handwriting Fluency

Handwriting Fluency had a small ($\gamma = .12$) but statistically significant direct contribution to Writing Achievement. Handwriting fluency has been shown to contribute to first-grade writing quality and fluency (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; Jones & Christensen, 1999). Similar to previous studies (Jones & Christensen, 1999; Kim et al., 2013; Wagner et al, 2011), handwriting fluency, measured by Alphabet Copy (Abbott & Berninger, 1993), had a small but statistically significant relation to writing at the end of first grade. This supports prior findings that the ability to quickly write letters is related to beginning writing (Graham & Harris, 2000). Specifically, letter writing automaticity reduces cognitive processing demands (McCutchen, 1996) so attention can then be directed to other component skills (e.g., spelling). This means that a student who automatically write letters no longer has to stop and consciously attend to aspects such as what a letter should look like or linking the letter to a sound in order to spell a word.

Although small ($\gamma = .20$), the relation between Handwriting Fluency and Writing Achievement was mediated through Early Literacy. This is not surprising since text production involves coordination of multiple skills (e.g., handwriting, spelling, decoding) which are reciprocally related. Specifically, these skills are not mutually exclusive to one another in relation to producing text.

Executive Function

The relation between Executive Function and Writing Achievement was mediated through Oral Vocabulary. The magnitude of the relation between Executive Function and Oral Vocabulary was medium ($\gamma = .28$). This suggests that for these first-grade students, stronger executive function skills were associated with stronger oral vocabulary skills which resulted in higher writing achievement at the end of first grade. Recent research has reported significant relationships between verbal ability (i.e., expressive and receptive) and executive function in early childhood (Blair & Razza, 2007; Bull, Espy, Wiebe, Sheffield, & Nelson, 2011; Espy, McDiarmid, Cwik, Stalets, Hamby, & Senn, 2004; Hongwanishkul, et al., 2005). In a longitudinal study conducted by Fuhs and Day (2011), structural equation modeling found that verbal ability (i.e., expressive and receptive) significantly predicted executive function gains in children 4 and 5 years of age. Furthermore, several studies have found that higher verbal ability (i.e., expressive, receptive, vocabulary, and verbal comprehension) among preschoolers was positively related to performance on executive function tasks (Carlson, Mandell, & Williams, 2004; Carlson, Moses, & Claxton, 2004; Hughes & Ensor, 2007). The results of the current study further suggest a link between executive function and oral vocabulary in relation to writing achievement at the end of first grade.

Executive Function was also mediated through Handwriting Fluency. The magnitude of the relation between Executive Function and Handwriting Fluency was a small ($\gamma = .14$). Research suggests that executive function influences handwriting (Berninger et al., 2006). Executive function may help integrate the multiple processes

(e.g., motor planning and orthographic-motor integration) required for handwriting automaticity. Specifically, executive function may provide the control necessary to manage the multiple components involved in physically producing text. However, for the first-grade students in this study, the contribution of the Executive Function factor and Handwriting Fluency to Writing Achievement was small.

Verbal Working Memory

The role of verbal working memory was also investigated as part of the hypothesized executive function construct. The relation between Verbal Working and Writing Achievement was mediated through Early Literacy ($\gamma = .53$), Oral Vocabulary ($\gamma = .39$) and Handwriting Fluency ($\gamma = .38$). The magnitudes of these relations were medium to large. Working memory has been shown to be related to reading (Rohl & Pratt, 1995; Swanson & Berninger, 1995) which is not unexpected since it may provide some of the resources for the skills important for reading (e.g., recall of letter knowledge). Working memory has also been shown to be related to handwriting (Berninger, 1999). Until handwriting is fluent it may constrain working memory resources which may interfere with other writing processes (McCutchen, 2006). Additionally, working memory may be related to oral vocabulary (Baddeley, Gathercole, & Papagno, 1998; Fitzpatrick & Pagani, 2012). Specifically, a student's vocabulary acquisition may be dependent on working memory capacity. Working memory has a foundational role in learning to write. The Not So Simple View of Writing posits that working memory is separate from executive function. This is not unexpected considering the importance of working memory to learning in general. For this study, working

memory was related to first-grade writing; however, its contribution was supported through Early Literacy, Oral Vocabulary, and Handwriting Fluency. One explanation for this is that working memory is a foundational component important for learning how to read, learning vocabulary, and learning to write letters. Specifically, working memory allows students to process and store information during such activities as reading.

Gender

Gender was included in the full structural model as a covariate of first-grade writing. The results suggested that girls performed better than boys on the writing outcome (i.e., WJ-III Written Expression) at the end of first grade. These results align with previous findings that girls outperform boys in writing (Malecki & Jewell, 2003; Olinghouse, 2008). Girls also scored higher on average than boys on the 2011 NAEP writing assessment. These results suggest that writing may be more challenging for boys than for girls in first grade.

Summary. This dissertation study examined the relation of Executive Function, Handwriting Fluency, Spelling, Oral Vocabulary, and Early Literacy to Writing Achievement assessed at the end of first grade. For this study, Berninger and Winn's (2006) Not So Simple View of Writing was selected as the theoretical framework. This model posits three cognitive components (i.e., transcription, executive function, and text generation) important for developing writing skills. It was expected that the transcription component, which includes handwriting and spelling, would jointly (i.e., as a latent factor) contribute to first-grade writing. Handwriting contributed independently to writing whereas spelling contributed as part of a latent factor representing early literacy.

Although this did not align with the theoretical framework, both components were still important to writing. Although executive function indirectly contributed to writing these results do not lessen its importance in the model. The model does not explicitly state whether or not the contribution of executive function to writing is direct or indirect. This lack of explanation may be because the role of executive function in relation to writing is not fully understood. Additionally, this study included oral vocabulary and reading (i.e., Early Literacy) because both have been found to be important predictors of writing as was the case for this study as well. Although oral vocabulary is not explicitly identified in the model, it is important to the text generation component. Of all of the factors, Early Literacy had the largest contribution to Writing Achievement. This component is also not explicitly identified in the model. However, changing the model to include a literacy component is not necessary because extensive research substantiates its importance to beginning writing.

Limitations and Future Research

There are limitations associated with this study. One limitation is that this dissertation study examined only one demographic factor (i.e., gender). As such, it is impossible to rule out potential effects of other demographic factors such as socioeconomic status (SES). For this study, SES was not available at the participant level; however, previous research suggest that individual SES differences are associated with executive function skills (Arán-Filippetti & de Minzi, 2012; Noble, Norman, Farah, 2005). Low SES is considered a risk factor for academic achievement and as such the executive function skills of students from low-income families may not be as developed

compared to students from high-income families (Farah et al., 2006). Therefore, future studies should examine a broader range of demographic factors, including SES.

Furthermore, additional factors such as the classroom environment and teacher characteristics are also important in relation to beginning writing (Coker, 2006; Kim et al., 2013). In addition to including other demographic factors, future research should also include school-level variables such as classroom and teacher characteristics, which have been found to contribute to beginning writing (Coker, 2006; Kim et al., 2013). Although this study focused on cognitive processes important for beginning writing, it is important to examine other components such as classroom characteristics which are important to beginning writing. This knowledge can inform instruction as well as address the challenges of implementing a writing curriculum across classrooms.

Another limitation is the methodical challenges in relation to executive function measures appropriate for young children. For this study, executive function was measured by the Conflict Executive Function Scale and the PAL-II Verbal Working Memory subtest. However, exploratory factor analysis found that each measure loaded as single item factors and did not represent a latent factor for executive function. Future research should consider including multiple measures (i.e., teacher/parent rating scales and direct student measures) targeting each component. Fuhs, Farran, and Nesbit (2015) noted that a multimethod (i.e., combination of a direct measure and teacher ratings) approach to assessing executive function in children may provide a better understanding of children's executive function. Additionally, further research using exploratory factor analysis would help identify appropriate measurement models for executive function.

This research could improve understanding of how executive function should be measured in young children. Furthermore, this research may provide better understanding of the executive function construct (i.e., unitary and diverse) in relation to young children.

Although this dissertation study studied executive function using a single measure (Brydges, Reid, Fox, & Anderson, 2012; Shing et al., 2010; Wiebe, Espy, & Charack, 2008), future research should examine the core executive function components using multiple measures. Researchers are beginning to differentiate between low-level executive function (i.e., inhibition, updating, and cognitive flexibility) and high-level executive function (i.e., planning, reviewing, and revising) in relation to beginning writing (Altemeir et al., 2008; Berninger & Chanquoy, 2012; Berninger & Winn, 2006). Altemeir and colleagues (2008) found that low-level executive function (i.e., inhibition and shifting) explained variance in spelling and written expression for students in grades 3 to 5. However, Altemeir et al. noted that it was difficult to interpret exactly how the two low-level executive functions contributed to written expression. Altemeir and colleagues suggested that different executive functions may differentiate depending on the level of language which will be discussed further in this section. For example, inhibition may only support word-level writing skills. As such, it is possible that the three widely recognized individual components (i.e., inhibition, working memory, and cognitive flexibility) of executive function are developmentally differentiated in first-grade students. Using multiple measures could address two issues: identifying whether one or all of the

components are important for beginning writing and expand understanding of the development of executive function in young children.

Another limitation concerns the measurement of writing achievement for beginning writers. First, writing measures appropriate for young children (i.e., kindergarten and first grade) are scarce. Second, many kindergarten and first-grade students may not be able to produce enough text for assessing text production at the sentence or connected text level. This limitation was also acknowledged by Kent et al. (2014), who indicated that 20% of the kindergarten writing samples could not be scored because the text produced was limited. The writing outcome for this study was the WJ-III Written Expression composite. Essentially, the WJ-III Written Expression composite score (WJ-III Writing Fluency and Writing Samples subtests) represented the students' ability to write a sentence but not connected text (i.e., multiple sentences). For Writing Fluency, the student is asked to write sentences related to a stimulus picture and include a given set of three words. For Writing Samples, the student is asked to write a phrase, sentence, or sentences in response to a variety of tasks. For this study, most of the students produced, at most, one sentence for each test item. The writing measure for the Kent et al. study and this dissertation were similar in that both writing outcomes demonstrated the student's ability to fluently produce written text but not the quality of the written text. Future research should include writing measures that examine fluency and quality of written text.

It is possible that the importance of executive function in relation to writing varies depending on the level of language (i.e., word, sentence, connected text). Future studies

should include writing measures that capture each level of language. For example, structural models could be examined with different writing outcomes representing sentence level skills (e.g., WJ-III Writing Samples) or connected text (e.g., story writing prompt). Research has recently begun to differentiate between two levels of written composition: microstructure and macrostructure (Drijbooms et al., 2015; Puranik, Lombardino, & Altmann, 2008; Wagner et al., 2011). Microstructure analysis examines word- and sentence-levels and may include measures of productivity and complexity (Drijbooms et al., 2015). Macrostructure analysis examines the text-level and may include measures of structure and content (Drijbooms et al., 2015). Given that executive function is rapidly developing during early childhood (Diamond, 2002), it is possible that its role changes in relation to the level of language in a text. Examining writing outcomes that measure different levels of language may provide a better understanding of this relation. Future research should examine the longitudinal contribution of executive function to writing achievement for students in kindergarten through second grades. This research could clarify the role of executive function in relation to beginning writing.

Conclusion

The present study examined executive function in relation to beginning writing. The research question was examined using structural equation modeling. Based on previous studies, it was hypothesized that executive function would be directly related to writing achievement at the end of first grade. Results, however, did not support this hypothesis. Instead, Executive Function indirectly contributed to Writing Achievement through Handwriting Fluency and Oral Vocabulary. These results did not support

previous studies in which executive function directly contributed to writing (Hooper et al., 2011; Kent et al., 2014). However, results did further support previous findings indicating that handwriting, oral vocabulary, and early literacy skills (e.g., word reading and spelling) are related to beginning writing (Abbot & Berninger, 1993; Coker, 2006; Kim et al., 2011; Kim et al., 2013; Jones & Christensen, 1999; Puranik & Al Otaiba, 2012; Wagner et al., 2011). Additionally, Verbal Working Memory contributed to Writing Achievement through Handwriting Fluency, Oral Vocabulary, and Early Literacy.

Findings from this dissertation partially supported the theoretical framework Not So Simple View of Writing which posits that handwriting, spelling, and executive function are components important for beginning writing. However, executive function did not directly contribute to writing at the end of first grade. The development of the executive function construct in relation to young children is not yet fully understood. Nor is the executive function construct in relation to beginning writing fully understood. With regards to first grade, the results of this study suggest that the individual components of the Not So Simple View of Writing are interrelated in the context of writing development. Specifically, Executive Function contributed to Writing Achievement indirectly through Handwriting Fluency and Oral Vocabulary.

Although executive function did not directly contribute to the writing achievement of first-grade students in this study, further research is needed in order to better understand the role of executive function and beginning writing. This research is especially important for supporting young children considered at-risk (e.g., disability or

low-income) for academic success. As research increases understanding of the role of executive function to beginning writing, instructional practices can also begin to better target the many components skills essential for skilled writing. This will be especially important for teachers, who will be responsible for ensuring that students successfully meet grade-level writing standards in accordance with the Common Core State Standards. Continued research targeting executive function and developing and struggling writers can further extend understanding of the relation between executive function and beginning writing.

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Appendix A

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER



RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE: August 25, 2014

TO: David Coker, EdD
FROM: University of Delaware IRB

STUDY TITLE: [369515-9] Year 2: Investigating the Impact of Classroom Instruction and Literacy Skills on Writing Achievement in First Grade

SUBMISSION TYPE: Continuing Review/Progress Report

ACTION: Approved for Data Analysis Only

APPROVAL DATE: August 25, 2014
EXPIRATION DATE: August 26, 2015
REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # (7)

Thank you for your submission of Continuing Review/Progress Report materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.