Understanding Writing Problems in Young Children: Contributions of Cognitive Skills to the Development of Written Expression

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ABSTRACT

Amy Childress: Understanding Writing Problems in Young Children: Contributions of Cognitive Skills to the Development of Written Expression
(Under the direction of Dr. Barbara H. Wasik and Dr. Stephen R. Hooper)

While several models of adult writing have been proposed and studied, the development of writing skills in young children has only recently garnered attention. Using measures of fine-motor, language, working memory, and attention/executive functions, the current study explored motor and cognitive skills that may contribute to writing skill in first grade.

Structural equation modeling techniques were used to examine the Not-So-Simple View of Writing. This study addressed the following questions: (a) do the cognitive variables represented in the Not-So-Simple View of Writing contribute to text generation of students in first grade; (b) do demographic variables contribute to text generation of students in first grade; and (c) is there a hierarchy of predictive power of motor and cognitive skills for text generation of children in first grade? The structural equation modeling techniques did not result in interpretable findings due to the covariance model being underidentified and nonpositive definite.

Since structural equation modeling techniques did not result in interpretable findings, analysis of variance methods were used as an alternative method to explore the contributions of motor and cognitive skills to writing skill in first grade. Alternative questions asked: (a) do students at-risk for writing problems differ from typically developing students on the motor and cognitive components of fine-motor skills, language skills, attention/executive functioning skills, and working memory skills; and (b) are fine-motor skills, language, working memory, and attention/executive functions predictive of writing skill for children in first grade?

Results showed differences on measures of fine-motor skills (dominant hand dexterity), language (rapid letter naming and orthographic processing), working memory (nonverbal and verbal), and attention/executive functions (word retrieval, planning, and inhibition of response). Results of the logistic regression analysis indicated that the motor and cognitive variables were predictive of text generation performance.

Findings from the analysis of variance methods suggested that fine-motor, language, working memory, and attention/executive functions can be used to identify children who are at-risk for writing problems. This evidence could be used to develop early writing assessments or target interventions for writing development. Limitations and suggestions for future research are discussed.

To: My Family

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ABBREVIATIONS

AR………………………	At Risk for Writing Problems
CPT……………………..	Continuous Performance Test
CREVT…………………	Comprehensive Receptive and Expressive Vocabulary Test
CTOPP…………………	Comprehensive Test of Phonological Processing
PAL……………………	Process Assessment of the Learner
PPVT…………………..	Peabody Picture Vocabulary Test
RAN…………………...	Rapid Automatized Naming
SEM……………………	Structural Equation Modeling
TD……………………..	Typically Developing Writing Skills
WASI………………….	Wechsler Abbreviated Scale of Intelligence
WIAT…………………	Wechsler Individual Achievement Test
WISC…………………	Wechsler Intelligence Scale for Children
WJ-III Cog………………	Woodcock Johnson: Third Edition of Cognitive Abilities

CHAPTER I

INTRODUCTION

As humans have evolved, so has the complexity of their writing systems. Early writing systems were ideographic, using pictures and easily recognizable symbols. Then logographic systems using written signs to represent each actual spoken word evolved. The next evolution was syllabic systems, using written signs to represent syllable units. The most recent evolution was the alphabetic system, the one most languages use today (Leonard, 2001). In the United States, our system of written expression, an alphabetic system, is based on a phonological code of sound symbol relationships and is governed by rules and principles that allow us to communicate effectively with each other. As in Mesopotamia and nearly all civilizations since then, writing is an essential tool used to organize and manage not only monetary matters, but also our thoughts and opinions, our workday and personal lives, and even to entertain ourselves and others.

Reading education has garnered a lot of attention in the last few decades. The assurance that all children leave school with the ability to read is essential and deserves attention, but we must be able to write competently in order to respond to what is read and to demonstrate knowledge on a given subject (Hooper, 2002). Writing is incorporated into almost all subjects in school. In later grades, students are often taught specifics of how to write for different academic areas, such as scientific writing. College and scholarship applications require essays that often weigh significantly in acceptance or awarding of scholarships.

Lerner (1976) proposed that writing difficulties were the most prevalent communication disability. Data from both research and national statistics suggest that writing problems in early elementary education are pervasive. Berninger and Hart (1992) reported that of the 300 primary school children included in their study 1.3% to 2.7% had problems with handwriting, 3.7% to 4% had problems with spelling, and 1% to 3% had problems with written narratives. Hooper et al. (1993) found significantly higher rates of text generation problems in a large epidemiological sample of middle school students, with rates ranging from 6% to 22% depending on region of the country, gender, and ethnic status. The National Center for Education Statistics reported that only about 28% of fourth graders write at a proficient level or above, 58% write at a basic level, and 14% write below basic level (NCES, 2003). Over the past few years writing research has shown that children have trouble with the writing process from the time they begin writing in early elementary school to later in their academic careers. Having identified this problem, the question becomes how to solve it. The first step in solving the problem is having an understanding of the writing process and what factors affect writing.

Research on the writing process has revealed that, quite frankly, learning to write is hard. It is a complex process incorporating many different cognitive skills working simultaneously and in a coordinated effort to produce understandable written output. Skills ranging from those needed for low level transcription skills, higher level composing abilities (Gregg & Mather, 2002), and the overall organization and regulation of all of these skills are needed to produce a written product. Even at the beginning stages of writing a lot of cognitive demands are placed on children. They have to be able to generate ideas, organize ideas, and translate those ideas onto paper using the conventions of English writing. Given the great complexity of writing, it is, as Singer and Bashir (2004) observed, perhaps more surprising that there are children who do not have problems with writing.

Early writing research focused on the method of adult skilled writing (Berninger, 1996). Several theoretical models have been proposed to explain and organize the cognitive functions involved in writing (Ellis, 1983; Kellogg, 1996; Roeltgen, 1985). One of the most recognized and influential models was developed by Hayes and Flower (1986) and then later revised by Hayes (1996, 2000). The Hayes and Flower cognitive model of writing has been influential in the field of written expression; however, little work has been done to see how the model works for elementary students who are just beginning to develop writing skills.

In the last few decades research interests have moved to questions of the normal process of writing acquisition. The initial focus on adult skilled writing has begun to shift to the developmental processes involved in learning to write (Berninger, 1996). The increased demands of educational accountability and increased funding to research efforts in literacy skills have contributed to this increase in interest. This shift is new and our understanding of the development of written expression in the early elementary school years is in its infancy (Edwards, 2003; Graham & Harris, 2005). Berninger and colleagues (2003, 2006) have developed a contemporary model of written expression based on the research they have conducted with elementary age children. They have expanded Juel, Griffith, and Gough's (1986) Simple View of Writing model (Berninger & Amtmann, 2003; Berninger & Winn, 2006).

The three major components of the model are transcription, executive functions, and text generation. Transcription encompasses handwriting or letter production and spelling or word production. Executive functions necessary for writing include planning, monitoring, and revising. Text generation refers to the main writing goal of the beginning writer; which occurs at the word, sentence, and text levels. The Simple View of Writing suggests that transcription skills and executive functions support text generation in an environment of working memory (Berninger & Amtmann, 2003).

In 2006, Berninger and Winn made modifications to the Simple View of Writing resulting in the Not-So-Simple View of Writing. Findings from the application of brain scanning technology to the study of adult and developing writers contributed to the changes made in the model. The structure of the model remained the same; however, additions were made to the concepts of working memory and attention reflecting a deeper understanding of these concepts and their role in written expression. In the Not-So-Simple View of Writing, working memory activates long-term memory during planning, composing, reviewing, and revising. Short-term memory is activated by working memory only during reviewing and revising. The Not-So-Simple View of Writing does more to define the role of supervisory attention as a system that focuses attention to allow writers to stay on task and switch between mental states as they write.

These models of writing provide a framework in which to think about the developing writer. Each model represents an evolution in our understanding of the process of writing. The structure and the elements within the writing models can be used as a starting point in understanding how a good writer is able to produce writing and exploring where weaknesses in the structure or elements contribute to problems with writing. During the initial stages of writing development, children will be constrained by factors related to graphomotor output (the physical act of letter formation), memory for letters and words, emergent working memory capacities, and linguistic capabilities (Berninger & Winn, 2006; Berninger et al., 1992). In order to become efficient writers, children must first master transcription skills so that lower level abilities; such as, forming letters and using correct spelling and structural forms become automatic. Automaticity with these skills frees up working memory and cognitive energy for the more demanding executive function tasks (Bruning et al., 2004). In order to develop automaticity, children need repetition and practice. For the majority of children, sufficient transcription skills will have developed by the middle of elementary school from which point writing development progresses with increased focus on text generation and attention to executive functions.

Current Study

The current study examined the early stages of writing development by assessing and evaluating the motor and cognitive skills contained in the Not-So-Simple View of Writing that contribute to the written expression of children in first grade. Data were collected from a sample of first graders enrolled in a single school district in North Carolina. A battery of standardized cognitive and achievement tests was administered to the participants during their first grade year. The data were analyzed to explore the differential contribution of the motor and cognitive variables represented in the Not-So-Simple View of Writing to written expression in first grade.

Statement of Purpose

This study looked closely at the process of writing during early development. The motor and cognitive skills that have been shown to contribute to writing development were examined within a developmental model of writing, the Not-So-Simple View of Writing. The study served to both further understanding of what motor and cognitive skills contribute to the writing process at the beginning of writing (first grade) and how those skills differentially contribute to the process.

Questions and Hypotheses

Question 1

Do the motor and cognitive variables represented in the Not-So-Simple View of Writing contribute to text generation of students in first grade?

Hypothesis 1-1: It is hypothesized that the fine-motor variable will contribute to text generation for children in first grade.

Hypothesis 1-2: It is hypothesized that the language variable will contribute to text generation for children in first grade.

Hypothesis 1-3: It is hypothesized that the attention/executive function variable will contribute to text generation for children in first grade.

Hypothesis 1-4: It is hypothesized that the working memory variable will contribute to text generation for children in first grade, as well as mediate the contribution of fine-motor, language, and attention/executive functions.

Question 2

Do demographic variables contribute to text generation of students in first grade?

Hypothesis 2-1: It is hypothesized that gender will contribute to text generation for children in first grade (Berninger & Fuller, 1992; Hooper et al., 1993; NCES, 2003).

Hypothesis 2-2: It is hypothesized that race will contribute to text generation for children in first grade (Berninger & Fuller, 1992; Hooper et al., 1993; NCES, 2003).

Hypothesis 2-3: It is hypothesized that socioeconomic status (SES), represented by mother's education, will contribute to text generation for children in first grade.

Question 3

Is there a hierarchy of predictive power of motor and cognitive skills for text generation of children in first grade?

Hypothesis 3-1: It is hypothesized that the fine-motor variable will contribute more to text generation than the attention/executive function variable.

Hypothesis 3-2: It is hypothesized that the language variable will contribute more to text generation than the attention/executive function variable.

CHAPTER II

LITERATURE REVIEW

Introduction

The study of the cognitive processes of writing does not have a long history, with interest from researchers, clinicians, and school personnel arising only in the last two to three decades (Hooper, 2002). The development of writing skills in elementary school has an even shorter timeline with our understanding of the factors contributing to written expression in young children still in its infancy (Edwards, 2003; Graham & Harris, 2005). To extend our knowledge in this area, this study has focused on understanding written expression in early elementary school children. The Not-So-Simple View of Writing (Berninger & Winn, 2006) provided a structure to explore the cognitive factors that contribute to writing skills of first grade students. In the following literature review models that contributed to the formulation of the Not-So-Simple View of Writing are examined as well as research on the cognitive components in the Not-So-Simple View of Writing and their link to written expression. Previous research on the characteristics of poor writers is also reviewed.

Models

Hayes and Flower (1980)

During the 1970s the assessment of writing began to change from analysis of the products of writing to analysis of the process of writing. Prior to the process movement, writing was judged solely on the correctness of the completed text. The process movement, grounded in cognitive research, suggested that writing should be looked at as a process from the point of assignment to final draft (Hayes & Flower, 1986; Hayes & Flower, 1987). A cognitive based process approach to writing research focuses on the connections among thinking, learning, and writing (Hayes & Flower, 1986; Hayes & Flower, 1987) and attempts to construct a model of how these elements work together as a person writes.

In 1980, Hayes and Flower proposed a conceptual model of writing as a problem-solving process, based on their cognitive approach to writing research. Their model became the most recognized model of writing. This model was developed using protocol analysis with skilled adult writers. Protocol analysis had previously been used to identify processes in problem solving tasks (Hayes & Flower, 1980). In the Hayes and Flower study, adult writers were asked to describe the activities they engaged in as they completed an expository writing task. The writers' descriptions were analyzed to see if the process the writers used matched the proposed model. The model was a product of two years of analyzing a number of writing protocols (Hayes & Flower, 1980).

The Hayes-Flower Model, (Figure 1), identified the writing process as goal directed and recursive. They proposed three elements to the writing process: task environment, writer's long term memory, and the writing process. Task environment includes all of the pieces of the writing process that are external to the writer; such as, the framework of the task, the topic and the intended audience, and resources for the writer; such as, notes and previous drafts. The writer's long term memory provides information for content and for discourse processes. Writers must have sufficient knowledge about the topic they are writing about (content knowledge) in order to generate ideas. Long-term memory also holds discourse process knowledge. Discourse process knowledge is information about the process of writing; such as, audience design, mechanics of writing, and structures of different forms of written text. Procedural and declarative knowledge are also held in long-term memory and are essential to writing. Procedural knowledge is information about how to write: how to form letters and words, how to construct sentences and paragraphs, how to edit, etc. Declarative knowledge is information about what to write; i.e., the factual knowledge about a subject. The task environment and writer's long term memory are the context in which the model works (Hayes & Flower, 1980).

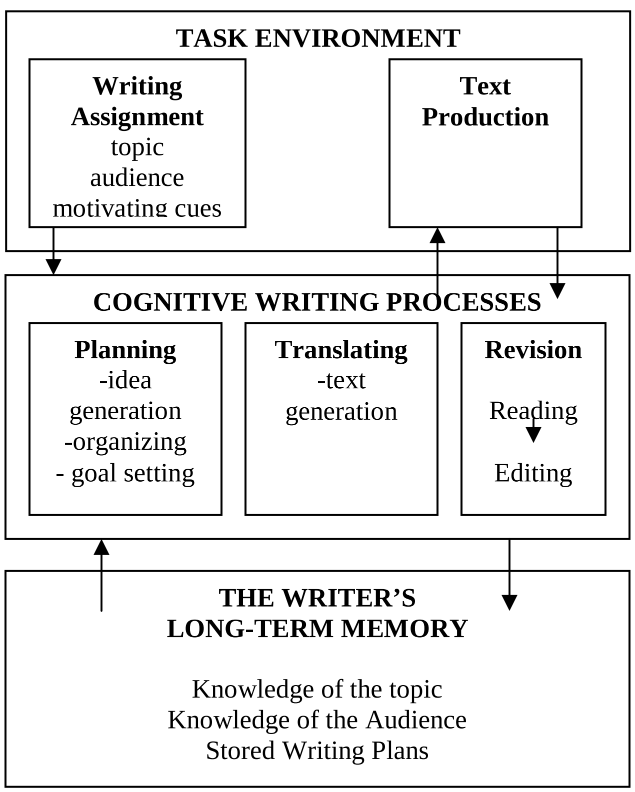

Figure 1. The Hayes-Flower Model (Hayes & Flower, 1980)

The writing process consists of three major processes: planning, translating, and reviewing. Planning includes generating ideas, organizing, and goal setting. The translating process uses the writing plan to generate text that corresponds with information in the writer's memory. Reviewing includes reading and editing. Editing is an automatic process that can interrupt other processes as the writer recognizes potential errors or unclear writing. Reviewing only happens when a writer decides to systematically evaluate their written product (Hayes & Flower, 1980).

Hayes Model (1996)

The model Hayes presented in 1996 was a reaction to research findings that had accumulated over the years since the Hayes-Flower Model had been presented. He suggested that this model was just another step in finding a model that explained writing, and intended for the model to continue to be adapted as new discoveries were made (Hayes, 1996). The Hayes Model can be described as an individual-environmental model rather than a social-cognitive model as all the elements that effect and support writing can be placed in the realm of the task environment or the individual (Hayes, 1996).

The Hayes Model (Figure 2) varies in four major ways from the Hayes-Flower Model. First, the inclusion of and emphasis on working memory as a key player in the individual's writing process. Second, the model recognized the importance of visual-spatial representations in writing (i.e., graphs, tables, and diagrams) to help the writer convey meaning to the reader. Third, the model included the writer's motivation and affect among the elements that support the individual in the writing process. Finally, the revised model reorganized the cognitive process section to align with new research. In the cognitive process section planning and translation were included under more general labels of reflection and text production, respectively; and revision was replaced entirely by text interpretation (Hayes, 1996). These changes in cognitive processes create more general categories that have more flexibility to define the complex processes that support writing.

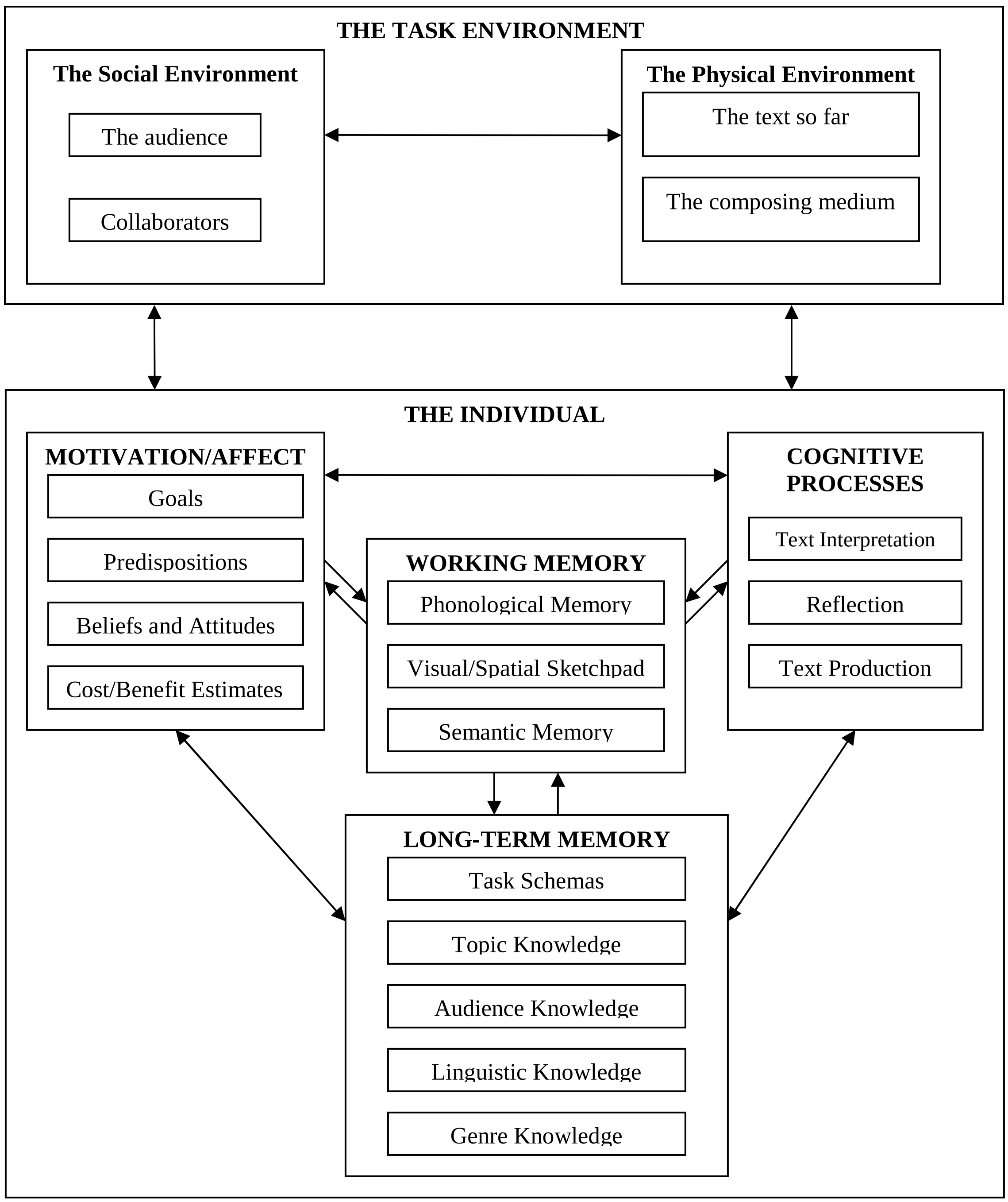

Figure 2. The Hayes Model (Hayes, 1996)

Working memory is where the major cognitive activity of writing takes place. This is where all the elements from long-term memory (content knowledge and discourse process knowledge), external information about the writing assignment, and new content knowledge that has not yet made its way into long-term memory, come together and are integrated to produce the physical product of the written text. Working memory has a limited capacity; only so much information can be held and manipulated in working memory at one time. Creating automaticity through repetition frees up “cognitive space” for more complex processes in working memory. In writing, the automaticity with which we form letters and words makes room in working memory for consideration of content, organization, and the recursive aspects of producing a written product.

A major revision in the Hayes Model is the revamping of the cognitive processes section. The section now includes text interpretation, reflection, and text production. Text interpretation includes cognitive processes such as reading, listening, and interpreting graphs or diagrams to create internal representations of the linguistic and graphic inputs (Hayes, 1996). Reflection encompasses the cognitive processes of problem solving, decision making, and making inferences to use the internal representation from text interpretation and produce other internal representations through integration and analysis (Hayes, 1996). Text production is the process by which the internal representations created in text interpretation and reflection are turned into written, spoken, or graphic output (Hayes, 1996).

The revision of the Hayes-Flower Model by Hayes expanded the model and aligned it with research findings from the sixteen years since the original model was proposed. The revised model continues the focus on adult expert writing. While it is important to understand the final result of developing writing skills in the form of adult writing, the process of development of writing skills can not be understood as simply a less complex version of adult writing (Berninger, 1996).

Juel, Griffith, and Gough Simple View of Writing

In the late 1980s, Juel, Griffith, and Gough proposed the "simple view of reading and writing" to explain the development of these skills in elementary school children. They conducted a longitudinal study with children in first through fourth grades to test the model. The researchers suggested as simple a model as they felt could explain the processes of reading and writing in an effort to see how far it would take them. They also suggested that simple models have the advantage of being easy to break apart to see what elements work and what elements are incorrect or should be modified (Juel, Griffith, & Gough, 1986).

Their simple view of writing proposed that writing is composed of spelling and ideation. While they acknowledge that each of these processes is complex, they felt that the two processes encapsulated what it takes to write. The model suggested that cipher knowledge, which they use to refer to the set of spelling-sound correspondence rules of the language, and lexical knowledge contribute to spelling ability. Phonemic awareness, which is influenced by ethnicity and oral language ability, contributes to cipher knowledge. Exposure to print also contributes to cipher and lexical knowledge. Ideation is not outlined further in this model and is an area that is open to further investigation (Juel, Griffith, & Gough, 1986).

Results from their longitudinal study suggested that spelling had the most influence over writing in first grade. As the children got older, ideation became a bigger factor. Word-level skills such as decoding and spelling were influential in first grade writing, but as these skills became more automatic in later grades higher order processes, such as idea generation, held more influence over writing success. An additional finding of interest was that idea generation contributed to successful writing over and above the influence of IQ and oral language proficiency (e.g., listening comprehension) (Juel, Griffith, & Gough, 1986; Juel, 1988).

Berninger and Colleagues Simple View of Writing

In 1996, Berninger and colleagues proposed seven modifications to the Hayes-Flower Model of the writing process that would allow the model to address beginning and developing writing. The modifications included: (1) translation is comprised of the two separable components of text generation and transcription which may develop at different rates; (2) translation is affected by individual differences in oral language and levels of written language; (3) planning and reviewing have temporal and spatial dimensions; (4) the skills of planning, translating, and revising emerge systematically during the development of writing skills; (5) developing writers' metacognitions about writing are not organized around the three processes in the Hayes-Flower Model; (6) working memory should be included in the model; and (7) gender differences in writing affect transcription more than translation (Berninger, 1996; Berninger et al., 1996; Swanson & Berninger, 1996). The addition of working memory was part of the Hayes Model; however, other suggested modifications were not incorporated as they apply only to the development of writing skills and not adult writing skills.

The proposed modifications fall into two main categories that help to summarize the differences between adult writing and the process of developing writing skills. One category is that the cognitive processes necessary for writing do not all emerge or develop at the same rate. Planning, translating, and revising develop along their own trajectories and are not always balanced at a given time in development. The second category is that there are additional cognitive processes and sub-processes not outlined in the Hayes-Flower Model that affect developing writing. An important addition is the distinction between text generation and transcription under the heading of translation. Text generation is the ability to translate ideas into a linguistic representation in memory. Transcription is the ability to create written symbols to signify the linguistic representation in memory. As with planning, translating, and revising, these subprocesses of translation may develop at different rates. This results in children who have good ideas, but lack the ability to effectively convey them in writing, or children who have good transcription skills, but have trouble coming up with things to write (Swanson & Berninger, 1996).

In order to fully encapsulate the development of writing skills in children, Berninger and colleagues (2002) proposed the revision of the Simple View of Writing (Figure 3) which incorporates research from the fields of education, cognition, linguistics, child development, and neuropsychology. The three major components of the model are: transcription, executive functions, and text generation. Transcription encompasses handwriting or letter production and spelling or word production. Executive functions necessary for writing include planning, monitoring, and revising. Text generation refers to the main writing goal of the beginning writer; which occurs at the word, sentence, and text levels. The Simple View of Writing suggests that transcription skills and executive functions support text generation in an environment of working memory, which coordinates the contributions of short-term and long-term memory. In early stages of development, transcription plays a larger role in text generation. As children get older, many transcription skills become automatic and executive functions begin to take a larger role in the writing process (Berninger & Amtmann, 2003).

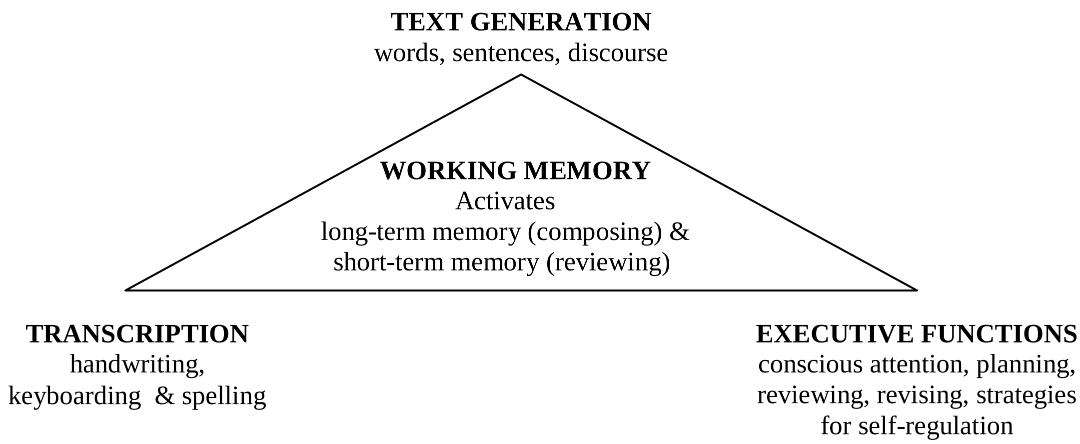

Figure 3. The Simple View of Writing Model (Berninger & Amtmann, 2003)

Berninger and Winn (2006) Not-So-Simple View of Writing

The development of brain scanning technology starting in the 1980s has contributed to writing research by being applied to the study of adult writers and, to a lesser extent, developing writers. An accumulation of findings from brain imaging technology led to Berninger and Winn’s (2006) additions to the Simple View of Writing, resulting in the Not-So-Simple View of Writing (Figure 4). The modifications reflect a deeper understanding of the role of working memory and the role of attention within the executive functions domain.

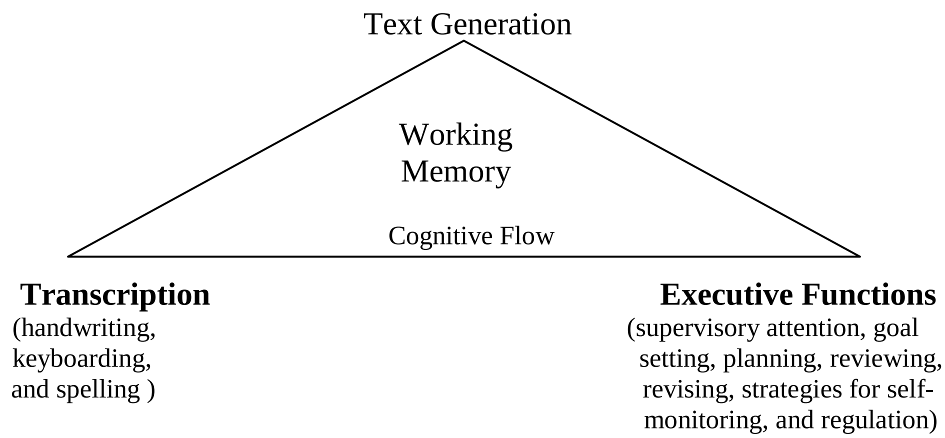

Figure 4. The Not-So-Simple View of Writing Model (Berninger & Winn 2006)

Two additions were made in the relationship of working memory to other segments of written expression. The first outlines the differences between short-term and long-term memory and their contribution to the writing process. Working memory activates long-term memory during the processes of planning, composing, reviewing, and revising; whereas, short-term memory is activated only during reviewing and revising. The second addition to working memory is the breakdown of the components of working memory. These components include "… (1) orthographic, phonological, and morphological storage units for verbal information, (2) a phonological loop for learning words and maintaining verbal information actively in working memory, and (3) executive supports that link verbal working memory with the general executive system (a distributed network of many executive functions) and with nonverbal working memory (which stores information in visual-spatial sketchpad)" (Berninger & Winn, 2006, pg. 97). The addition to executive functions is a more defined role of the complex system of supervisory attention. Supervisory attention focuses attention on what is deemed relevant, and inhibits non-relevant information. This component allows the writers to stay on task and switch between mental states as they engage in the act of writing (Berninger & Winn, 2006).

Summary of Writing Models

The writing models discussed use a cognitive based approach to studying writing that focuses on the connections among thinking, learning, and writing. The Hayes-Flower Model and the Hayes Model provide a framework for thinking about how expert adult writers take in, process and out-put information during the process of writing. In the more recent Hayes Model, the cognitive processes include text interpretation, reflection, and text production. Working memory and long-term memory are also included in the model, and working memory is recognized as where the major cognitive activity takes place (Hayes, 1996).

Juel, Griffith, and Gough introduced a Simple View of Writing to help explain what cognitive processes children who are developing writing skills use to produce written text. Their goal was to explain writing in a simple model which was easy to break apart and adjust as new research was done (Juel, Griffith, & Gough, 1986; Juel, 1988). Berninger and her colleagues expanded on this idea and introduced their Simple View of Writing. The development of brain scanning technology and its use with adult and developing writers led to the revision of the Simple View of Writing into the Not-So-Simple View of Writing (Berninger & Winn, 2006). The Not-So-Simple View of Writing incorporated research from education, cognition, linguistics, development, and neuropsychology. The model provides a framework in which to think about developing writers and what cognitive skills they need to be successful. The components of the Not-So-Simple View of Writing are further described in the following sections.

Text Generation in First Grade

Text generation is typically thought of as functioning on three levels: word, sentence, and text. Writers differ in their strengths and weaknesses across these levels of text generation (Berninger, 2000). First grade writers are just beginning to develop the skills necessary to generate text at the word, sentence, and text levels, and these skills are developing at different rates. Even within the broad areas of transcription and executive functions, sub-processes have differential developmental trajectories. Within transcription, handwriting skills tend to develop quicker than the linguistic skills necessary for spelling (Berninger, 2000). Executive functions are in their infancy in first grade student and require a great deal of scaffolding from adults (Berninger, 2000). Working memory is a limited capacity system that may not have reached its full capacity at this young age, particularly in at-risk writers (McCutchen, 1996). For these reasons, compositions in first grade generally consist of a single clause, a complex sentence, or a few related sentences and clauses (Berninger, 2000; Traweek & Berninger, 1997). According to the Not-So-Simple View of Writing, as skills in the areas of transcription, working memory, and executive functions develop, text generation will become more fluent and better organized.

Cognitive Processes Supporting Text Generation

Transcription

Transcription is the act of turning ideas into linguistic representations in the mind and subsequently turning those representations into the symbols of writing that can be read and understood by others. Transcription is the first of the writing skills to emerge and is vital to the ability to showcase other writing skills. The performance of this component of writing requires skills in two areas: graphomotor and linguistics. Graphomotor skills, including fine-motor skills, indirectly affect transcription. Linguistic skills, including orthographic and phonological skills, directly affect transcription (Abbott & Berninger, 1993; Swanson & Berninger, 1996).

Graphomotor skills are the skills that allow us to create the ultimate goal of the writing process; i.e., written output. Without the development of these low-level motor skills, it is impossible to demonstrate the higher-order skill of writing. The development of graphomotor skills applied to writing begins with a child's discovery that he or she can leave a mark with a writing instrument. From there, skills develop through a predictable course: random scribbling, zigzag lines, letter-like marks, true letters, single words, clauses, and sentences (Gibson & Levin, 1975; Traweek & Berninger, 1997, Berninger, 2000). Initially children learn to form letters accurately, and then automatically. The automaticity of letter production allows writing to take place with little cognitive energy spent on forming letters. This allows more energy to be spent on higher-order cognitive processes (Berninger et al., 1991, Berninger, 2002).

Linguistic skills include phonology, orthography, and semantics. Phonology and orthography skills are critical to spelling and word recognition. Semantic skills allow children to decipher meaning from words. These skills have a longer growth trajectory than graphomotor skills (Berninger, 2000). While some evidence of the basics of phonology, orthography, and semantics may appear as early as pre-school, these skills and the resulting abilities to read and spell words will continue to develop throughout the school years.

Working Memory

In both the Not-So-Simple View of Writing and the Hayes Model of adult writing, working memory is identified as a critical component of the writing process. The Not-So-Simple View of Writing places working memory in the center of the triangle to represent its central role as the environment in which the coordination of the other cognitive skills takes place. Working memory develops during the elementary school years (Berninger et al., 1994; Berninger, 2000). Short-term memory and long-term memory are accessed via working memory for processing during text generation (Berninger, 2000; McCutchen, 1996; Swanson & Berninger, 1996).

Both the adult model and the developmental model use Baddeley's (1990) model of working memory to conceptualize the process. This model is comprised of a controlling central executive system with two sub-systems: the articulatory loop and the visuospatial sketch pad. Baddeley (2003) recently suggested the addition of an episodic buffer to the model. The episodic buffer binds together information from different sources into a single multi-faceted unit. The central executive element regulates the flow of information, retrieves information from other memory systems, and processes and stores information. The articulatory loop is comprised of a capacity limited phonological short-term store and an articulatory control process that refreshes and maintains speech material in store for brief periods. The visuospatial sketch pad is a temporary storage for visual information that is being used to solve a specific problem. The episodic buffer is dependent on executive functions dealing with the storage and retrieval of information (Baddeley, 2003).

Working memory draws information from short-term memory and long-term memory to be processed and used in writing. Short-term memory briefly stores incoming information including word recognition and transcription during the reviewing and revising processes (Berninger et al., 1991; Swanson & Berninger, 1996). Long-term memory includes content knowledge, which is a source for domain-specific idea generation and discourse structure knowledge, which provides a mechanism for schemas for different genres of writing (Berninger, 2000).

Executive Functions

In the Not-So-Simple View of Writing, executive functions include supervisory attention, goal setting, planning, reviewing, revising, strategies for self-monitoring, and the overall regulation of writing (Berninger & Winn, 2006). These components are the higher-order skills that help a writer compose an organized, cohesive, and understandable written output. Evidence from adult writers indicate that expert writers are goal directed and move recursively through the Hayes and Flower's steps of planning, translating, and revising. They are able to continuously evaluate their output for its relevance in meeting proximal and distal goals. Poor writers produce unorganized text at both sentence and paragraph levels, and are not as likely to revise (Hooper et al., 2002).

Relatively little research has looked into the role of executive functions in the developing writer. Graham and colleagues have used their empirically-based findings to develop an intervention targeting self-regulation, Self-Regulated Strategy Development (SRSD). Their model has aided students in the development of reflective writing strategies and positive attitudes about their writing abilities (Graham et al., 1998). Hooper and colleagues (2002) studied executive functions and writing in fourth and fifth grade students using Denckla's (1996) four-factor model of executive functions. In this model executive functions included initiating behavior, sustaining behavior, inhibiting/stopping behavior, and set-shifting. Initiating includes organizing and planning activities. Sustaining behavior relies on regulating attention to continue a task. Inhibiting/stopping behavior is the ability to refrain from inappropriate or distracting behavior. Set-shifting is related to cognitive flexibility and self-monitoring. Findings from this study suggested that the executive functions of initiation, set-shifting, and sustaining behavior separate good from poor writers in elementary school (Hooper et al., 2002).

Executive functions are a higher-order set of cognitive skills, and are likely to be less influential to writing during the early years. Most studies of executive functions and writing, including those mentioned above, have used children in upper elementary school or above. Hooper and colleagues (2002) reported moderate effect sizes and this may be, in part, because of the age of the children. Executive functions are expected to be present in early elementary school students; however, they are just developing and require a great deal of scaffolding from adults (Berninger, 2002).

Other Factors Influencing Writing

As the Hayes Model demonstrates, writing is an interaction between the individual and the environment. Although the model is intended to describe adult writers, the influence of environment on writing extends to developing writers. There are influences outside of the internal cognitive environment of children that affect writing. These outside influences result in reported group differences in writing development. Differences in writing performance have been reported for gender, race/ethnicity, and socioeconomic status. Some gains have been reported in the past few years, but trends continue to show males as less proficient than females (Berninger & Fuller, 1992; Hooper et al., 1993) and Caucasian students more proficient than African American and Hispanic peers (Hooper et al., 1993; NCES, 2003).

In general, children from higher socioeconomic strata or with parents who are highly educated are more likely to perform better in school (Duncan & Brooks-Gunn, 1997; Perez-Johnson & Maynard, 2007). These general findings have not been applied directly to written expression performance; however, it may be that the influence of socioeconomic factors can be explained by exposure to prewriting skills. Children in homes or preschools where prewriting skills such as letter formations and exposure to print are stressed enter school in a better position to move forward with writing skill development. Students who enter school without these advantages begin building literacy skills later than children who have had prewriting experience.

There is evidence that academic performance in school is also affected by the relationship between students and teachers. Teacher's perception of their relationship with students has been shown to be an important factor in early academic progress (Burchinal et al., 2002). The teacher-student relationship's effect on writing skill development has not been explored. The pursuit of an explanation for the influence of gender, race/ethnicity, socioeconomic status, and teacher-student relationship to the development of writing skills is important, but little data are available for this part of the model.

Characteristics of Children At-Risk for Writing Problems

Even at a young age, the coordination of the cognitive processes outlined in this chapter is necessary for the creation of written products. Gregg and Mather (2002) noted several constraints that can limit writing development including limited instruction, poor oral language abilities, cognitive deficits, limited cultural experiences, delayed neural or motor development, and poor motivation. Some research has been done to look at delays or deficits in cognitive skills that are characteristic of poor writers at different developmental stages. Early in writing development (early elementary school) neurodevelopmental constraints in orthographic coding, fine-motor function and orthographic-motor integration are likely to interfere with rapid and automatic production of written language. In the intermediate grades, writing is constrained by verbal working memory and the ability to generate word, sentence, or text-level structures. At the junior-high school level, problems with planning, translating, and revising constrain writing (Berninger & Rutberg, 1992).

In the first grade, it is expected that fine-motor skills and orthography skills will constrain writing. Higher-order cognitive skills have not developed in children this young and; therefore, are not expected to be used in developmentally appropriate writing assignments. The absence or delay of fine-motor skills that allow a child to hold a pencil and write affects current writing performance and constrains the acquisition of writing skills (Berninger & Rutberg, 1992). If a child has to devote a lot of cognitive energy to the task of manipulating the pencil, he or she is less likely to be able to attend to what is being written. This can delay the development of letter writing automaticity and recognition of letter-sound relationships. Later in school, the inability to rapidly produce letters and quickly spell words through automatic orthographic knowledge constrains writing through working memory. If these basic processes are not automatic, they take up cognitive space in working memory, which has a limited capacity (McCutchen, 2000).

Conclusions

The study of the cognitive processes that are necessary for writing and how they are coordinated has led to the development of several models of writing. Each model builds on new research to further our understanding of writing. These models can be used as a framework to study the development of writing. The Not-So-Simple View of Writing is a model that strives to explain how children generate text through the coordination of transcription skills and executive functions in an environment of working memory. Some evidence has been found to support these elements as the primary processes at work in developing writers. Research has suggested that deficits in fine-motor skills and orthographic skills constrain early writing, deficits in memory constrain writing in the intermediate years, and deficits in executive functions, such as planning, constrain later writing (Berninger & Rutberg, 1992). This study adds to the, as yet small, body of research on how young writers' skills in the areas of transcription (fine-motor and language skills), working memory, and attention/executive functions contribute to writing skill. How these skills can be used to identify children at-risk for writing problems in early elementary school was also explored.

CHAPTER III

METHODS

Participants

Participants were recruited from a single suburban-rural public school district. The sample was drawn from a single school district to prevent potential differences that may arise from implementation of curriculum and instructional practices in different school districts. All seven elementary schools in the school district participated in the study resulting in the initial screening of 950 first-graders in 54 classes. The Written Expression subtest of the Wechsler Individual Achievement Test – Second Edition (WIAT-II; Wechsler, 2002) was used as a screening tool to identify students at-risk for written expression problems. In accordance with the IRB proposal (Appendix A), a letter describing the study, two consent forms, and a flyer were sent home via the backpack to families whose children met at-risk criteria from the screening. In compliance with the school district administration, students receiving the lowest scores on the WIAT-II Written Expression subtest were recruited first for the study. In total 545 students, including all students meeting at-risk criteria during screening, were recruited and 223 of the 545 had parents sign consent forms. Scheduling conflicts resulted in dropping 17 students from the study.

The final sample consisted of 206 students from seven elementary schools in a single suburban-rural public school district. All of the students had their primary placement in a regular education setting, completed kindergarten, and spoke English as their primary language. The sample included 118 (57%) males and 88 (43%) females. Information on race and maternal education was gathered through parent reports. Maternal education was used as a measure of socioeconomic status.

Measures

Criterion Measure

The Wechsler Individual Achievement Test – Second Edition form A (WIAT-II; Wechsler, 2002) Written Expression Grade-Based Composite score was used as the criterion measure to identify students as at-risk for written expression problems or typically developing in the area of written expression. The WIAT-II Written Expression Composite measures individual achievement skills in the areas of handwriting, timed alphabet writing, written word fluency, and sentence combining. Reported inter-item reliability is strong (grade 1 $r = 0.91$; Wechsler, 2002). Content validity was monitored through the participation of subject area expert judges during the development of the WIAT-II. Item Response Theory methods were also used to document empirical consistency among items. As part of this process, item-total correlations were calculated and any item with a correlation less than .20 was evaluated for removal or revision (Wechsler, 2002). Criterion related validity is documented with correlations with other tests of achievement. The correlation between the Wide Range Achievement Test – 3rd edition (WRAT3) Reading subtest and the WIAT-II Word Reading subtest was .73. The correlation between the WRAT3 Spelling subtest and the WIAT-II Spelling subtest was .78 (Wechsler, 2002).

Fine-Motor Measures

The Process Assessment of the Learner: Test Battery for Reading and Writing (PAL; Berninger, 2001) Finger Sense-Finger Succession subtest was used as a measure of fine-motor control. Students were asked to hold their hands up by their ears (out of their line of vision) and touch each finger to their thumb. A raw score was generated by recording the time it took for the students to complete five rounds of touching each finger to their thumb. Scores were obtained for their dominant hand (the hand they wrote with) and their nondominant hand. These raw scores were converted into decile scores from the published normative data. This measure has been found to be a strong predictor of handwriting, spelling, and writing skills acquisition for elementary school children (Berninger et al., 1992). Reported reliability coefficients for this measure are strong (dominant hand $r = 0.89$, nondominant hand $r = 0.87$; Berninger, 2001). The validity of the Finger Succession subtest as a measure of writing ability was supported by a study of 300 primary-grade students. The results of the study showed that Finger Succession correlated significantly with both handwriting (dominant hand $r = -0.32$, nondominant hand $r = -0.33$) and narrative compositional fluency (dominant hand $r = -0.31$, nondominant hand $r = -.30$; Berninger & Rutberg, 1992).

Language Measures

The assessment of language ability included measures of basic phonological awareness, receptive vocabulary skills, orthographic processing, and orthographic-phonological coordination. The Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotle, 1999) Elision subtest asks the child to segment spoken words into smaller parts in order to measure basic phonological awareness. Raw scores were translated into scaled scores in accordance with the test manual. Reported content sampling alpha coefficients are strong (age 6 $r = 0.92$, age 7 $r = 0.91$, age 8 $r = 0.89$; Wagner et al., 1999). Validity studies during test development used item discrimination and difficulty statistics, parameters in Item Response Theory models, and examination of item and test information to identify unsatisfactory items, which were removed from the test. Criterion validity studies included comparison studies with other measures of language ability. The correlation between the CTOPP Elision subtest and the Woodcock Reading Mastery Tests-Revised (WRMT-R) Word Analysis subtest was .74, and between the CTOPP Elision subtest and the WRMT-R Word Identification subtest was .73. The correlation between the CTOPP Elision subtest and the Test of Word Reading Efficiency (TOWRE) Sight Word Efficiency subtest was .67, and between the CTOPP Elision subtest and the TOWRE Phonetic Decoding Efficiency subtest was .68 (Wagner et al., 1999).

After the first year of assessment, the CTOPP Elision subtest was removed from the test battery at the request of the school district because of its use by school psychologists. The Process Assessment of the Learner: Test Battery for Reading and Writing (PAL; Berninger, 2001) Syllable and Phoneme subtest was selected to replace the CTOPP Elision due to its similarity in methods and items. The PAL Syllable and Phoneme subtest demonstrates the students' ability to segment words into syllables and phonemes by asking participants to repeat words and then repeat them again, this time removing a syllable or phoneme as instructed. Reliability estimates for the subtests in grade 1 are strong (syllable $r = .80$, phoneme $r = .92$; Berninger, 2001). During the development of the PAL expert judgments and empirical item analysis were used to ensure content validity. Construct validity was examined with comparison studies with tests that measure similar constructs. One study compared the PAL subtests with WIAT-II subtests. The correlation between the PAL Syllable subtest and the WIAT-II Written Expression subtest was .30, and the correlation between the Syllable subtest and the WIAT-II Pseudoword Decoding subtest was .49. The correlation between the PAL Phoneme subtest and the WIAT-II Written Expression subtest was .50, and the correlation between the Phoneme subtest and the WIAT-II Pseudoword Decoding subtest was .56 (Berninger, 2001).

The Peabody Picture Vocabulary Test – Forth Edition (PPVT-IV; Dunn & Dunn, 2007) was administered to measure the participants' receptive vocabulary skills. Participants are shown a sheet with several pictures and asked to point to the picture that matches the word the examiner says. Standard scores were generated from the raw scores according to the test's published normative tables. Reported alpha coefficients indicate strong reliability of the test (age 6:0-6:5 α = 0.97, age 6:6-6:11 α = 0.94, age 7 α = 0.94, age 8 α = 0.99; Dunn & Dunn, 2007). Convergent evidence of construct validity was reported through the results of correlation studies with other tests of expressive vocabulary and language ability, and reading achievement. The correlation between the PPVT-IV and the Expressive Vocabulary Test, 2nd edition (EVT-2) is .84 for ages 5-6 and .80 for ages 7-10. The correlation between the PPVT-IV and the Clinical Evaluation of Language Fundamentals, 4th edition (CELF-4) is .67 for receptive language in the age range 5-8 (Dunn & Dunn, 2007).

The Comprehensive Receptive and Expressive Vocabulary Test – Second Edition (CREVT-2; Wallace & Hammill, 2002) Receptive Vocabulary subtest was added to the battery of tests in the second year of the study to replace the PPVT-IV. The PPVT-IV was removed at the request of the school district because of its use by school psychologists. The CREVT-2 was chosen to replace the PPVT-IV because it measures receptive vocabulary using a similar method. Participants are presented with different plates of several pictures from different categories (i.e., animals) and asked to point to the picture that goes with stimulus words. Reported reliability alpha coefficients are strong (age 6 α = .88, age 7 α = .91, age 8 α = .91). Evidence of validity includes correlation studies with other language measures. The CREVT-2 has a reported correlation of .59 with the PPVT-IV, .66 with the Wechsler Intelligence Scale for Children – 3rd edition (WISC-III) Vocabulary test, and .74 with the Clinical Evaluations of Language Fundamentals (CELF-R) (Wallace & Hammill, 2002).

The PAL Word Choice subtest measures orthographic processing by evaluating a child's ability to access word-specific representations from long-term memory both accurately and quickly. Participants are asked to choose the correctly spelled word from three choices. Decile scores are generated from raw scores using the published normative tables. The reported internal consistency alpha coefficient for grade 1 is moderate (r = 0.66; Berninger, 2001). Expert judges and empirical item analysis were used during the development of the PAL to ensure content validity. Construct validity was examined with comparison studies with tests that measure similar constructs. One study compared the PAL subtests with WIAT-II subtests. The correlation between the PAL Word Choice subtest and the WIAT-II Written Expression subtest was .75. The correlation between the PAL Word Choice subtest and the WIAT-II Pseudoword Decoding subtest was .80 (Berninger, 2001).

The PAL Rapid Automatized Naming (RAN) Letters or Digits subtest measures orthographic-phonological coordination through the rapid automatized naming of letters or digits. Decile scores were generated from raw scores using the test's published normative tables. Reported stability coefficients for this task's scores were strong (letters $r = 0.92$, digits $r = 0.84$; Berninger, 2001). To demonstrate content validity expert judges and empirical item analysis were used during the development of the PAL. Construct validity was examined with comparison studies with tests that measure similar constructs. One study compared the PAL subtests with WIAT-II subtests. The correlation between the PAL RAN subtest and the WIAT-II Written Expression subtest was -0.78. The correlation between the PAL RAN subtest and the WIAT-II Pseudoword Decoding subtest was -0.72 (Berninger, 2001).

Working Memory Measures

Working memory in the visual and auditory mode was assessed. The Wechsler Intelligence Scale for Children – Fourth Edition Integrated (WISC-IV-I; Wechsler, Kaplan, Fein, Kramer, Morris, Delis, & Maerlender, 2004) Spatial Span subtest measures visual-spatial working memory. After assessors tapped blocks in a certain order, participants were asked to repeat the order (Forward) or reverse the order (Backward). Standard scores were generated from the raw scores according to the test's published tables. Internal consistency reliability coefficients were moderate (age 6 SSpF $r = 0.76$, SSpB $r = 0.81$, age 7 SSpF $r = 0.70$, SSpB $r = 0.74$, age 8 SSpF $r = 0.79$, SSpB $r = 0.77$; Wechsler et al., 2004). During the development of the WISC-IV-I, research studies, review of theoretical literature, and expert reviews were utilized to support the validity of the measure. After development, a comparison study with the Clinical Evaluation of

Language Fundamentals, 4th edition (CELF-4) was conducted with children with language disorders. The result of the Working Memory Index (including Spatial Span) comparison was a correlation of .69 (WISC-IV-I; Wechsler et al., 2004).

The Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotle, 1999) Nonword Repetition subtest measures auditory memory. Participants were asked to repeat fictitious words after hearing them from a recording. Scaled scores were generated from the raw scores according to the measure's published standardization tables. Content sampling reliability alpha coefficients were strong for CTOPP Nonword Repetition (age6 α = 0.80, age 7 α = 0.80, age 8 α = 0.80; Wagner et. al., 1999). During the development of the test, content validity was evaluated using item discrimination and difficulty statistics, parameters in Item Response Theory models, and examination of item and test information to identify unsatisfactory items, which were removed from the test. Results of a confirmatory factor analysis of the CTOPP showed that the Nonword Repetition subtest loaded on the same factor as the Memory for Digits subtest, which created the Phonological Memory factor. The result of the confirmatory factor analysis provided evidence for the validity of using the Nonword Repetition subtest as a measure of auditory memory (Wagner et al., 1999).

At the request of the school district, the CTOPP Nonword Repetition measure was removed from the battery of tests because of its use by school psychologists. The WISC-IV-I Digit Span subtest, which also measures auditory memory through verbal repetition, was used in the second year of the study with cohort 2. Participants were asked to repeat sequences of numbers. Standard scores were generated from the raw scores according to the test's published tables. Internal consistency reliability coefficients were good to moderate (age 6 DSpF $r = 0.83$, DSpB $r = 0.83$, age 7 DSpF $r = 0.79$, DSpB $r = 0.69$, age 8 DSpF $r = 0.82$, DSpB $r = 0.68$; Wechsler et al., 2004). Research studies, review of theoretical literature, and expert reviews were utilized during the development of the test to support the validity of the measure. The results of a comparison study with the Clinical Evaluation of Language Fundamentals, 4th edition (CELF-4) included a Working Memory Index (including Digit Span) comparison, and a correlation of .69 was found (WISC-IV-I; Wechsler, Kaplan, Fein, Kramer, Morris, Delis, & Maerlender, 2004).

Attention/Executive Functions Measures

The Woodcock Johnson: Third Edition of Cognitive Abilities (WJ III Cog; Woodcock, McGrew, & Mather, 2001) Planning subtest measures spatial scanning, general sequential reasoning, and problem solving abilities. Participants trace over line drawings without lifting their pencils or re-drawing lines. Age-based standard scores were generated from raw scores using the test's computer scoring system. Reported reliability coefficients were moderate (age 6 $r = 0.67$, age 7 $r = 0.75$, age 8 $r = 0.69$; Woodcock et al., 2001). The WJ III Cog (Woodcock, McGrew, & Mather, 2001) Retrieval Fluency assesses long-term verbal retrieval and fluency. Participants were given a minute to name as many things as they could in different categories. Reported reliability coefficients were moderate (age 6 $r = 0.79$, age 7 $r = 0.80$, age 8 $r = 0.78$; Woodcock et al., 2001). The WJ III Cog was developed based on the Cattell-Horn-Carroll theory of cognitive abilities. Outside experts were used in development to help insure the validity of test items and the content of the test is similar to other well-established cognitive measures (Woodcock, McGrew, & Mather, 2001).

Sustained attention, speed and consistency of responding, and response inhibition in the visual mode were examined using the Vigil Continuous Performance Test (Vigil CPT; Psychological Corporation, 1998). Using a laptop computer, the test showed a series of letters in which participants were asked to press the spacebar in response to seeing a certain sequence of letters (AK). Age-based standard scores were generated by the computer scoring program. The reported reliability estimates for errors of omission, errors of commission, and reaction time were good (omissions $\alpha = .91$, commissions, $\alpha = .956$, reaction time $\alpha = .896$; Psychological Corporation, 1998). A comparison study with other tests of attention was performed to provide evidence of validity. In one study, the Vigil CPT and the Stop Signal Task (SST) had a correlation coefficient of .648 for errors of omission and a .337 for errors of commission.

Intellectual Ability Measures

The Wechsler Abbreviated Scale of Intelligence (WASI) Vocabulary and Matrix Reasoning subtests were used to obtain an IQ score (FSIQ-2). Reliability estimates for the FSIQ-2 are strong (age 6 $r = .94$, age 7 $r = .93$, age 8 $r = .92$; Wechsler et al., 2004). The results of comparison studies with other ability measures and achievement provide evidence of the validity of this test. Comparison studies with the Wechsler Intelligence Scale for Children – 3rd edition (WISC-III) and the Wechsler Adult Intelligence Scale - 3rd edition (WAIS-III) suggested that the WASI FSIQ-2 measures constructs similar to those in the other ability measures ($r = .81$ with WISC-III, $r = .87$ with WAIS-III). A comparison study with the Wechsler Individual Achievement Test (WIAT) composite scores showed moderate to high correlations with the WASI FSIQ-2 ($r = .69$ with

Reading, $r = .66$ with Math, $r = .63$ with Language, $r = .72$ with Writing; Wechsler et al., 2004).

Procedures

The parents of all first grade students in a single school district in North Carolina were invited to have their child participate in a fifteen minute group screening assessment of written expression skills. All of the first graders who participated in the initial screening (950) were tested within their class groups (20-25 students per group). The WIAT-II Written Expression subtest was used as the screening assessment. The results of the screening were used to tentatively place students in at-risk and typically developing groups for written expression. After receiving parent consent for the study, the children were assessed during their first grade year with the administration of a battery of neuropsychological and cognitive assessments. All measures in the battery were administered, scored, and standardized according to their published test manuals. Trained researchers and graduate students administered and scored the measures. The measures were also second scored by a researcher or graduate student that had not originally administered the measure. The Frank Porter Graham Child Development Institute (FPG) Data Management and Analysis Center double-entered the raw scores and standardized the scores (e.g., standard score, scaled score) according to each measure's published norms.

The battery was administered in two blocks of measures, with the blocks being administered in counterbalanced fashion to control for order effects. The battery contains some measures that were not included in this study, but were administered as part of a larger study. Block A consisted of the Wechsler Abbreviated Scale of Intelligence

(WASI) Vocabulary and Matrix Reasoning subtests; the Wechsler Individual Achievement Test – Second Edition, form A (WIAT-II) Reading and Written Expression subtests; the Process Assessment of the Learner: Test Battery for Reading and Writing (PAL) RAN, Finger Succession, and Word Choice subtests, the Peabody Picture Vocabulary Test – Fourth Edition (PPVT-IV), and the Wechsler Intelligence Scale for Children - Fourth Edition Integrated (WISC-IV-I) Spatial Span. Block B consisted of the Wide Range Assessment of Memory and Learning – Second Edition (WRAML-2) Picture Memory Immediate and Delayed Recognition and Story Memory Immediate and Delayed Recognition subtests, the Woodcock Johnson III Tests of Cognitive Abilities (WJ-III Cog) Planning and Retrieval Fluency subtests, the Comprehensive Test of Phonological Processing (CTOPP) Elision and Nonword Repetition subtests, and the Vigil Continuous Performance Test (Vigil CPT). After the first year of data collection, The CTOPP Elision subtest was replaced by the PAL Syllable and Phoneme subtests. The PPVT-IV was replaced by the Comprehensive Receptive and Expressive Vocabulary Test – Second Edition (CREVT-2) Receptive Vocabulary subtest. The CTOPP Nonword Repetition subtest was replaced by the WISC-IV-I Digit Span subtest. This new battery of assessments was used to collect data from the cohort 2 first graders in the second year of the study. The list of measures separated in blocks and listed in the order presented is in Tables 1 and 2.

Data Analysis

Structural Equation Modeling (SEM) methods were used to address the research questions. The analysis was run using the Mplus version 6 (Muthen & Muthen, 2010) software program. SEM methods allowed for the assessment of the contribution of the measures given as well as the latent variables that underlie those measures. An outline of the proposed model is displayed in Figure 5. The latent variables are enclosed in circles and the tests used to measure them are in rectangles. The relationship between the latent variables in the proposed model and the Not-So-Simple View of Writing is explained in Figure 6.

Table 1

List of Measures: Block A

Cohort 1	**Cohort 2**
BLOCK A Can be administered in any order	BLOCK A Can be administered in any order
WASI Vocabulary	WASI Vocabulary
WASI Matrix Reasoning	WASI Matrix Reasoning
WIAT-II Reading*	WIAT-IIA Reading*
WIAT-II Written Expression (Alphabet, Fluency, Sentences)	WIAT-II Written Expression (Alphabet, Fluency, Sentences)
PAL RAN – Letters or Digits	PAL RAN – Letters or Digits
PAL Finger Sense – Finger Succession	PAL Finger Sense – Finger Succession
PAL Word Choice	PAL Word Choice
PPVT-IV	PAL Syllables
WISC-IV Spatial Span	PAL Phonemes
	CREVT-2

*measure not used in the current study

Table 2

List of Measures: Block B

Cohort 1	**Cohort 2**
BLOCK B – FIXED ORDER due to timing for memory items	BLOCK B – FIXED ORDER due to timing for memory items
WRAML-2 Picture Memory Immediate*	WRAML-2 Picture Memory Immediate*
CTOPP Elision	WISC-IV Spatial Span (forward/backward)
WJ-III Cog Planning Subtest	WJ-III Cog Planning Subtest
WJ-III Cog Retrieval Fluency Subtest	WJ-III Cog Retrieval Fluency Subtest
WRAML-2 Picture Memory Recognition*	WRAML-2 Picture Memory Recognition*
WRAML-2 Story Memory Immediate*	WRAML-2 Story Memory Immediate*
Vigil CPT	Vigil CPT
CTOPP Nonword Repetition	WISC Digit Span (forward/backward)
WRAML-2 Story Memory Recognition*	WRAML-2 Story Memory Recognition*

*measure not used in the current study

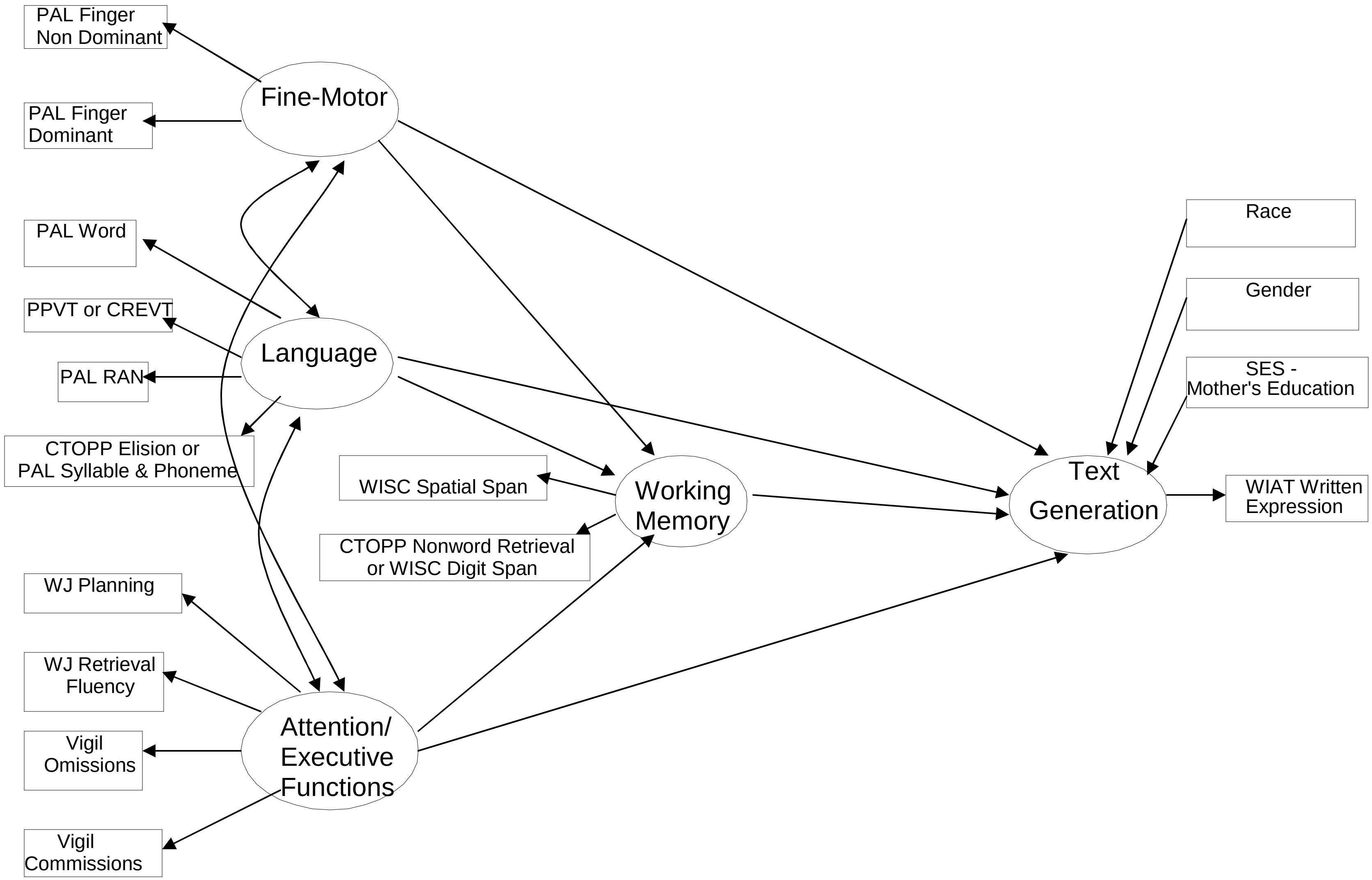

Figure 5. Structural Equation Model

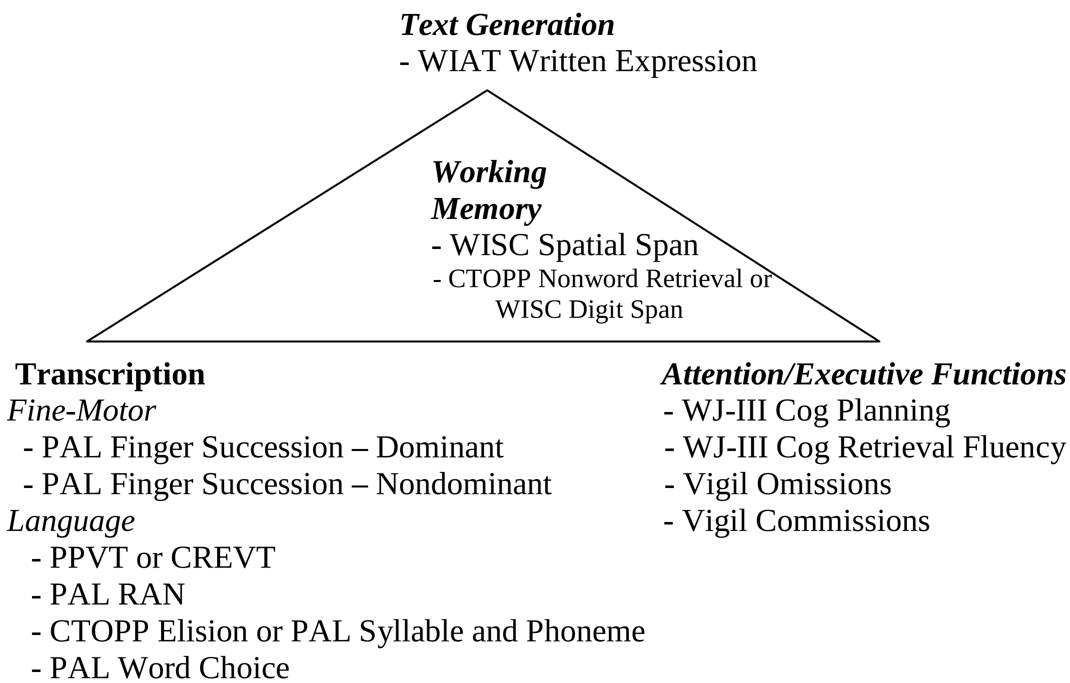

Figure 6. Measures' Alignment with Not-So-Simple View of Writing Model (Berninger & Winn 2006) with latent variables italicized and measures bulleted.

Data Screening

Initially, the data were screened to ensure that they met the criteria necessary for a Confirmatory Factor Analysis using structural equation modeling methods to be interpreted. The data was analyzed to check the assumptions of univariate and multivariate normality based on measures of skewness and kurtosis, and the Mahalanobis D test was conducted to check for possible outliers. The measurement model was then run to check for fit and modified as necessary.

Analyzing the Model

A valid measurement model is necessary before the evaluation of the structural component of the hybrid model (Kline, 2005). In order to estimate the measurement model the latent variables text generation, transcription, attention/executive functions, language, and working memory were allowed to co-vary. This allowed the paths from the latent variables to their indicator variables (the administered tests) to be estimated to explore if the indicator variables were supporting the latent variables as the proposed model suggests. The chi-square statistic (χ^2), standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) were assessed to judge measurement model fit. Modification indices were requested so that any potential beneficial adjustments to the model could be made. Decisions to modify the model were based on theory and the results of the measurement model analysis.

Application of Data Analysis to Research Questions

Review of Questions

Question 1. Do motor and cognitive variables represented in the Not-So-Simple View of Writing contribute to text generation of students in first grade?

Hypothesis 1-1: It is hypothesized that the fine-motor variable will significantly contribute to text generation for children in first grade.

Hypothesis 1-2: It is hypothesized that the language variable will significantly contribute to text generation for children in first grade.

Hypothesis 1-3: It is hypothesized that the attention/executive function variable will significantly contribute to text generation for children in first grade.

Hypothesis 1-4: It is hypothesized that the working memory variable will significantly contribute to text generation for children in first grade, as well as mediate the contribution of fine-motor, language, and attention/executive functions.

Question 2. Do demographic variables contribute to text generation of students in first grade?

Hypothesis 2-1: It is hypothesized that gender will significantly contribute to text generation for children in first grade (Berninger & Fuller, 1992; Hooper et al., 1993; NCES, 2003).

Hypothesis 2-2: It is hypothesized that race will significantly contribute to text generation for children in first grade (Berninger & Fuller, 1992; Hooper et al., 1993; NCES, 2003).

Hypothesis 2-3: It is hypothesized that socioeconomic status (SES), represented by mother's education, will significantly contribute to text generation for children in first grade.

Question 3. Is there a hierarchy of predictive power of motor and cognitive skills for text generation of children in first grade?

Hypothesis 3-1: It is hypothesized that the fine-motor variable will contribute more to text generation than the attention/executive function variable.

Hypothesis 3-2: It is hypothesized that the language variable will contribute more to text generation than the attention/executive function variable.

Data Analysis

In order to establish a valid measurement model before the evaluation of the structural component of the hybrid model (Kline, 2005), the latent variables of Fine-Motor, Language, Attention/Executive Functions, Working Memory, and Text Generation were allowed to co-vary. The analysis did not result in convergence of a non-identified model; therefore, the analysis of the measurement model could not be completed. After exploration of the model, it was determined that attempts to modify the model enough for it to be analyzed would result in a model that was not reflective of the

Not-So-Simple View of Writing and any results could not be meaningfully applied to answer the research questions.

CHAPTER IV

RESULTS

Data Screening

To conduct the analyses for this study, the data were first entered into PASW Statistics 18.0 statistical software for data screening. The structural equation model was analyzed with the Mplus version 6 (Muthen & Muthen, 2010) software program. An examination of the data was conducted to assess for missing information and the results of this examination showed that two variables had considerable missing data. The SES-Mother's education variable was missing in 27 cases (13.1%), resulting in a decision to exclude this variable from the model because the missing data was too high to impute values and retain interpretable results. Other variables with missing data included PAL Word Choice (1 case, 0.5%), PAL RAN (4 cases, 2%), PAL Finger Succession-Dominant (3 cases, 1.5%), PAL Finger Succession-Nondominant (4 cases, 2%), WJ-III Cog Retrieval Fluency (1 case, 0.5%), Vigil Omissions (3 cases, 1.5%), and Vigil Commissions (3 cases, 1.5%). From a visual inspection of the missing data for the existence of patterns, results showed data were scattered across cases and no pattern was evident. PASW Statistics 18.0 was used to impute missing values using the regression-based method of linear trend at point (Kline, 2005).

In examining the data for univariate and multivariate normality, assumptions of univariate and multivariate normality were upheld based on measures of skewness and kurtosis (Table 3). A Mahalanobis D test was run to assess the presence of any outliers and none were detected.

Table 3

Measures of Normality

Variable	Skew	Kurtosis
WIAT Written Expression	0.650	0.286
PAL Finger Non Dominant	-0.878	0.817
PAL Finger Dominant	-0.780	0.831
PAL Word	0.298	-1.034
Receptive Language (PPVT or CREVT)	0.178	0.237
PAL RAN	-1.452	3.027
Phonemic Awareness (CTOPP Elision or PAL Syllable and Phoneme)	-0.058	1.369
WJ-III Cog Planning	-0.394	-0.451
WJ-III Cog Retrieval Fluency	-1.048	2.380
Vigil Omissions	0.965	0.554
Vigil Commissions	1.035	0.347
WISC Spatial Span	0.096	0.458
Auditory Working Memory (CTOPP Nonword Retrieval or WISC Digit Span)	0.267	0.106

Measurement Model

The measurement model (Figure 7) was fit first because establishment of a valid measurement model is necessary before the evaluation of the structural component of the hybrid model (Kline, 2005). To analyze the measurement model, the latent variables, Fine-Motor, Language, Attention/Executive Functions, Working Memory, and Text Generation, were allowed to co-vary. Modification indices were requested so that any potential beneficial adjustments to the model could be made. The covariance matrix of the analyzed data can be found in Appendix C. Since the analysis did not result in convergence of a non-identified model, the analysis of the measurement model could not be completed.

Inspection of the model revealed that the model was underidentified and the covariance matrix was nonpositive definite. In order for a model to be identified it must have as many or more observations as free model parameters, which can be determined by assessing if the degrees of freedom are more than or equal to zero. In the measurement model analyzed, the degrees of freedom equaled 69. Another potential problem with identification is the presence of multicollinearity of the data which can also be a cause of nonpositive definite matrices. Examination of the correlation matrix did not reveal any correlations above .90; however, multicollinearity may lie in the multivariate correlations. Linear dependency among the observed variables is another possible cause of the problems with analyzing the measurement model. These problems could be addressed by fixing additional parameters or removing paths from the model (Schumacker & Lomax, 2010). Attempts were made to estimate additional model parameters based on theory and standardized measures' reliability statistics. After exploration it was determined that to estimate the number of parameters necessary to analyze the model would lead to a model that was not reflective of the Not-So-Simple View of Writing model and the results would not be interpretable for the present research questions.

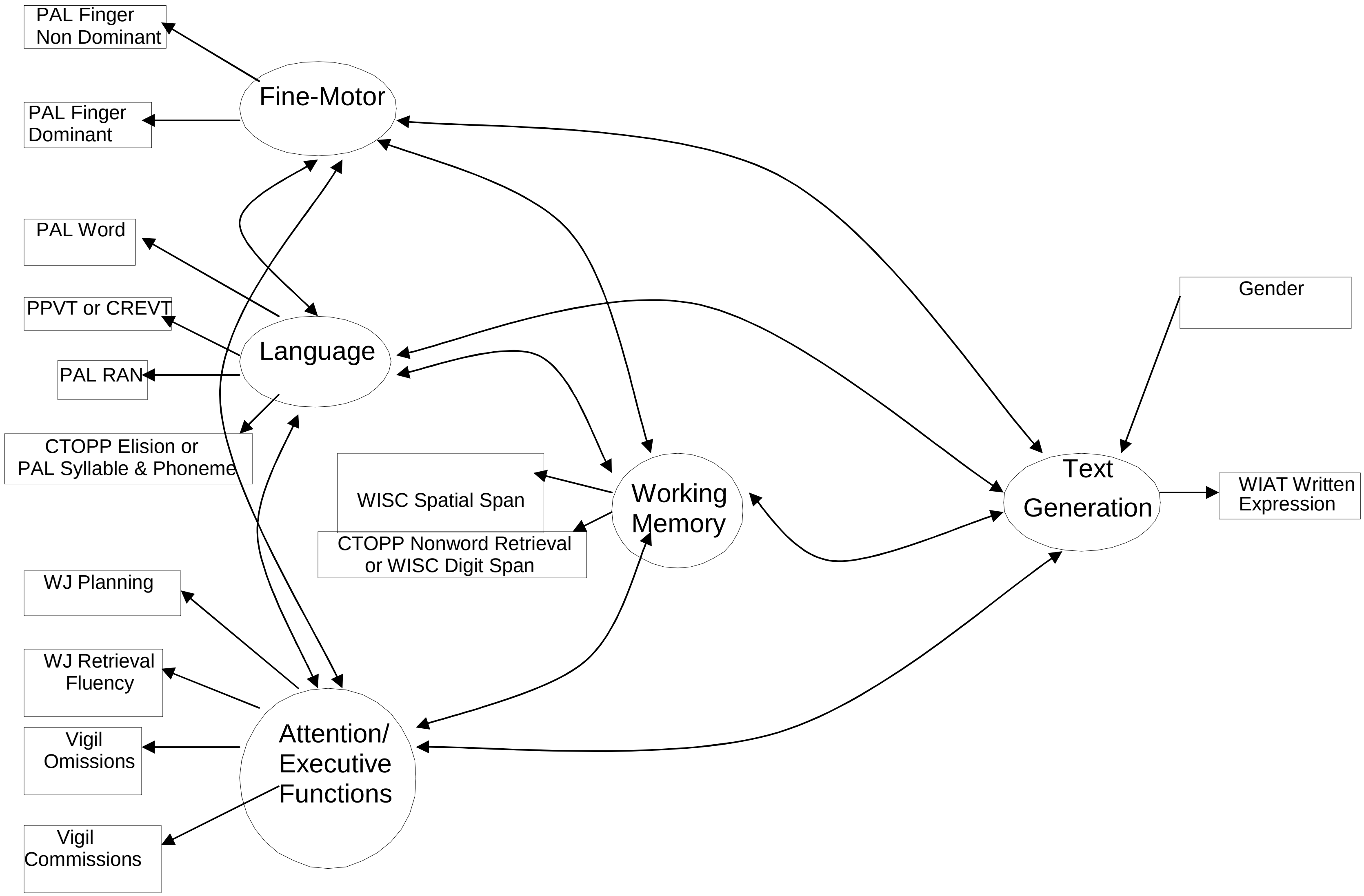

Figure 7. Measurement Model

Additional Exploratory Analysis of the Model

Individual path models

The full structural equation model that was designed to explore the Not-So-Simple View of Writing could not be analyzed with the current data. In an effort to explore the model further, identify areas of multicollinearity, and identify any other problems in the model design that may inform future research, the variables were analyzed separately.

The proposed path models for each variable are in Figures 8 - 11. The path models for the Fine-Motor and Working Memory variables could not be analyzed due to negative degrees of freedom. The path models for the Language and Attention/Executive Functions models resulted in non-positive definite matrices. The Language variable output indicated a problem with the PPVT or CREVT indicator. This variable was negatively correlated with the PAL RAN indicator. Also, this variable is one of the indicators that had to be created from two different subtests which may have caused problems with the analysis. For the Attention/Executive Functions variable, there was a problem with the indicator WJ-III Cog Retrieval Fluency. This indicator was negatively correlated with the Vigil Omissions indicator.

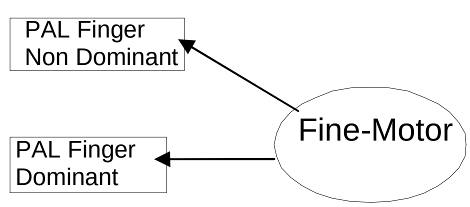

Figure 8. Fine-Motor Skills Path Model

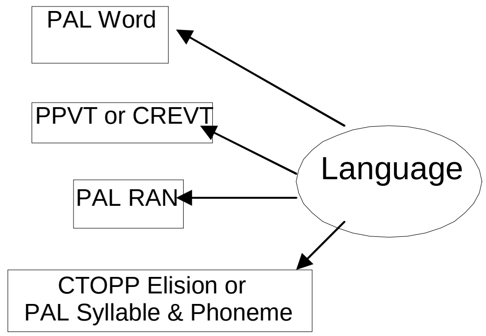

Figure 9. Language Path Model

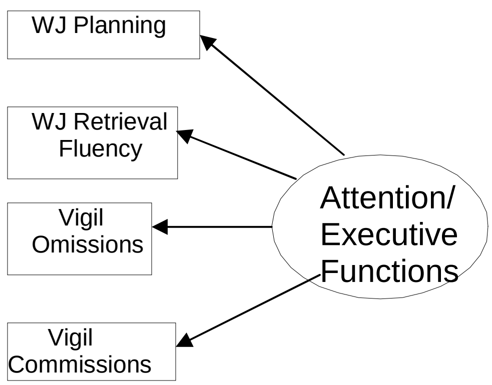

Figure 10. Attention/Executive Functions Path Model

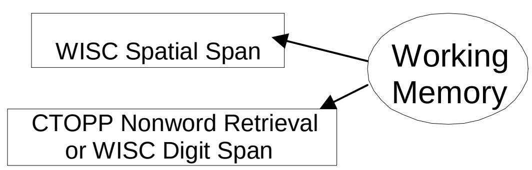

Figure 11. Working Memory Path Model

Analysis of Variance Method

Path analysis of the individual variables identified problems with the structural equation model, but did not allow for any analysis of the data to address the research questions. In an effort to further explore the data, analysis of variance methods were used to look at the individual variables in more depth. The analysis of variance methods allowed for separate examination of each of the measures within the fine-motor, language, working memory, and attention/executive functions variables. The sample was divided into two groups based on the WIAT Written Expression score obtained as part of the full assessment battery presented to all study participants. The standard score 85; which is one standard deviation below the mean, was used as a cut score to create the groups. The Typically Developing (TD) group had scores higher then 85 and the At-Risk (AR) group had scores of 85 or below. These groups were compared on each of the demographic, motor, and cognitive variables. While this method does not address the research questions in the same way Structural Equation Modeling methods would have, it does allow us to look at the relationship between motor and cognitive variables and writing ability in first grade students. Instead of exploring a full model of writing, the relationship between text generation and the motor and cognitive variables of fine-motor skills, language, attention/executive functions, and working memory were looked at separately in question 1a. For each variable it is hypothesized that the TD group will demonstrate higher scores than the AR group. This would demonstrate that the variable is related to text generation and could be used as a way to identify children at-risk for difficulties with text generation; which was the overall intention of this study.

The third proposed research question addressed the predictive power of the motor and cognitive variables. Logistic regression methods were used to address this in question 2a. A block-wise logistic regression was constructed to determine which composite variable groupings made the largest contribution to group status and; therefore, are the most predictive of group status. The variable groups were entered in the following order: fine-motor, language, working memory, and attention/executive functions. The alternative research questions and hypotheses are as follows:

Question 1a: Do students at-risk for writing problems differ from typically developing students on the motor and cognitive components of fine-motor skills, language skills, attention/executive functioning skills, and working memory skills?

Hypothesis 1a-1: It is hypothesized that the TD group will perform significantly better on measures of fine-motor skills.

Hypothesis 1a-2: It is hypothesized that the TD group will perform significantly better on measures of language skills.

Hypothesis 1a-3: It is hypothesized that the TD group will perform significantly better on measures of attention/executive functioning skills.

Hypothesis 1a-4: It is hypothesized that the TD group will perform significantly better on measures of working memory skills.

Question 2a: Are fine-motor skills, language, working memory, and attention/executive functions predictive of writing skill for children in first grade?

Hypothesis 2a-1: It is hypothesized that the fine-motor variable will be more predictive of group status than the attention/executive function variable.

Hypothesis 2a-2: It is hypothesized that the language variable will be more predictive of group status than the attention/executive function variable.

Hypothesis 2a-3: It is hypothesized that the working memory variable will be more predictive of group status than the attention/executive function variable.

Hypothesis 2a-4: It is hypothesized that the language variable will be more predictive of group status than the working memory variable.

Preliminary analysis. A series of Multivariate Analysis of Covariances (MANCOVA) were run on each of the variable groupings (fine-motor measures, language measures, attention/executive function measures, and working memory measures) by groups (at-risk and typically developing). This analysis provided a preliminary probe into any significant differences between groups on each of the variable groupings. Significant MANCOVAs were followed-up with univariate Analysis of Variances (ANOVA) giving further information about group separation on variable measures.

The at-risk (AR) group consisted of 102 (49.5%) students and the typically developing (TD) group consisted of 104 (50.5%) students. To examine the necessity to include demographic variables as covariates to reduce within-cell variability, correlation coefficients were obtained for the variables of age and IQ with the dependent variable of WIAT-II Written Expression scores. For the categorical demographic variables of gender, race, and mother's education, ANOVAs were analyzed with the WIAT-II Written Expression scores.

The AR group's ages ranged from 6 years, 1 month to 8 years, 4 months with an average of 6 years, 10 months. The TD group's ages ranged from 6 years, 0 months to 8 years, 4 months with an average of 6 years, 10 months. The correlation was not significant (*r* = -0.018, n = 206, *p*=0.797). Therefore, age was not entered as a covariate in the data analysis.

The AR group included 63 (62%) males and 39 (38%) females, while the TD group contained 55 (53%) males and 49 (47%) females. Results of the ANOVA was not significant ($F(1, 204) = 3.530$, $p = .062$).and gender was not included as a covariate in the data analysis.

The AR group contained 72 (70.6%) European American participants, 25 (24.5%) African-American participants, and 5 (4.9%) multi-racial participants. The TD group was comprised of 82 (78.8%) European American participants, 15 (14.4%) African-America participants, 2 (1.9%) Asian American participant, 2 (1.9%) Native American participants, and 3 (2.9%) multi-racial participants. The ANOVA was significant ($F(4, 201) = 3.445$, $p=.010$), so race was entered as a covariate in the data analysis.

The mother's education variable was missing data for 27 (13.1%) cases, 15 of these were from the AR group and 12 were from the TD group. Of the cases in the AR group that included information about mother's education, 12 (11.8%) had not received a high school diploma, 14 (13.7%) obtained a high school diploma or GED, 28 (27.4%) completed technical training or some college, and 33 (32.3%) had a college degree. In the TD group, 6 (5.8%) had not received a high school diploma, 14 (13.5%) obtained a high school diploma or GED, 21 (20.2%) completed technical training or some college, and 51 (49.1%) had a college degree. As a result of the ANOVA not being significant ($F(8, 170) = 1.890$, $p=.064$), mother's education was not included as a covariate in the data analysis.

The AR group's IQ scores ranged from 66 to 131 with an average of 93.06. The TD group's IQ scores ranged from 76 to 134 with an average of 100.41. The correlation was significant(r = 0.439, n = 206, p<.0001). The possibility of using IQ as a covariate was considered; however, there is recent research to suggest that the use of IQ as a covariate in cognitive studies is not appropriate. Dennis et al. (2009) found that the use of IQ as a covariate has resulted in overcorrected findings in neurocognitive studies due to IQ being an attribute of a childhood disability or disorder and therefore not meeting the requirements of a covariate. Based on this research IQ was not included as a covariate in the analysis.

Question 1a. Do students at-risk for writing problems differ from typically developing students on the motor and cognitive components of fine-motor skills, language skills, attention/executive functioning skills, and working memory skills?

Fine-Motor skills. It was hypothesized that the TD group would perform better on measures of fine-motor skills than the AR group. A MANCOVA was run to determine whether the TD and AR groups differed on the measures of fine-motor skills. The MANCOVA of the fine-motor variable revealed significant group differences, Wilks' Lambda = 0.971, $F(2, 202) = 2.972$, p=.053, with a small effect size of $\eta^2 = .029$. The follow up ANOVAs showed a significant difference in group scores for the PAL Finger Succession – Dominant, $F(1, 203) = 5.965$, p=.015, with a small effect size $\eta^2 = .029$. The typically developing group had a higher mean score on the PAL Finger Succession-Dominant test than the at-risk group. The PAL Finger Succession – Nondominant test, $F(1, 203) = 2.550$, p=.112, $\eta^2 = .012$ did not reveal significant differences for the groups.

Table 4

Univariate Analysis of Fine Motor Skills

	At-Risk Group (n=102)		Typically Developing Group (n=104)			
Measures	*M*	*SD*	*M*	*SD*	*F*	η^2
PAL Finger Succession Dominant	-0.273	0.48	-0.120	0.41	5.96*	.029
PAL Finger Succession Nondominant	-0.252	0.49	-0.148	0.41	2.55	.112

* $p \leq .05$.
** $p \leq .01$

Language skills. It was hypothesized that the TD group would perform better on the language measures than the AR group. Before analyzing the language skills measures, a receptive language variable and phonemic awareness variable were created because the two cohorts had been given different tests for these areas of functioning. The receptive language variable was created using cohort 1's PPVT receptive vocabulary score and cohort 2's CREVT receptive vocabulary scores. The phoneme variable was created using cohort 1's CTOPP Elision score and cohort 2's PAL Phoneme and Syllable scores.

Results of the MANCOVA found a significant difference between the AR and TD group for language skills, Wilks' Lambda=.875 $F(4, 200) = 7.132$, $p<.0001$, with a medium effect size $\eta^2 = .125$. Follow-up ANOVAs showed significant differences between groups for the PAL RAN measure, $F(1, 203) = 12.250$, $p=.001$, and PAL Word Choice measure $F(1, 203) = 21.243$, $p<.0001$. There was a small effect size for the PAL RAN measure, $\eta^2 = .057$, and the PAL Word Choice measure, $\eta^2 = .095$. The TD group had a higher mean score then the AR group on the PAL RAN and PAL Word Choice tests. The phoneme, $F(1, 203) = 1.555$, $p=.214$, $\eta^2 = .008$ and receptive language variables, $F(1, 203) = 2.544$, $p=.112$, $\eta^2 = .012$ did not show significant differences between the AR and TD groups.

Table 5

Univariate Analysis of Language Skills

	At-Risk Group (n=102)		Typically Developing Group (n=104)			
Measures	*M*	*SD*	*M*	*SD*	*F*	η^2
PAL RAN	0.016	0.81	0.365	0.60	12.25**	.057
PAL Word Choice	-0.439	1.19	0.390	1.38	21.24**	.095
Phonemes	0.017	0.91	0.173	0.82	1.56	.008
Receptive Language	-0.101	1.05	0.124	0.94	2.54	.012

* $p \leq .05$.
** $p \leq .01$

Attention/Executive Functioning skills. It was hypothesized that the TD group would demonstrate better attention/executive functioning skills than the AR group. The MANCOVA for attention/executive functioning skills was significant, Wilks' Lambda=.888 $F(4, 200) = 6.325$, $p<.0001$, with a small effect size, $\eta^2 = .112$. The follow-up ANOVAs showed that the WJ-III Cog Retrieval Fluency measure, $F(1, 203) = 16.536$, $p<.0001$ was significantly different for the AR and TD groups. The effect size was small, $\eta^2 = .075$. The WJ-III Cog Planning measure, $F(1, 203) = 5.798$, $p=.017$, showed a significant difference between the groups with a small effect size, $\eta^2 = .028$. The Vigil Commissions measure was significantly different for the AR and TD groups, $F(1, 203) = 5.827$, $p=.017$, with a small effect size, $\eta^2 = 0.028$. For the WJ-III Cog Retrieval Fluency and WJ-III Cog Planning measure the TD group had a higher mean score than the AR group. On the Vigil Commissions measure the AR group had a higher mean score than the TD group. The Vigil Omissions measure, $F(1, 203) = 1.277$, $p=.260$, $\eta^2 = .006$ was not significant.

Table 6

Univariate Analysis of Attention/Executive Functioning Skills

	At-Risk Group (n=102)		Typically Developing Group (n=104)			
Measures	*M*	*SD*	*M*	*SD*	*F*	η^2
WJ-III Cog Retrieval Fluency	91.74	17.31	100.09	11.84	16.54**	.075
WJ-III Cog Planning	104.64	8.41	107.61	8.99	5.80*	.028
Vigil Omissions	57.82	26.36	62.50	34.10	1.28	.006
Vigil Commissions	94.06	66.37	73.18	59.19	5.83*	.028

* $p \leq .05$.
** $p \leq .01$

Working Memory. It was hypothesized the TD group would perform better on the working memory measures than the AR group. Before analyzing the working memory variable, a verbal working memory variable was created because the two cohorts had been given different tests for verbal working memory. Cohort 1's CTOPP Nonword Repetition score and cohort 2's WISC Digit Span score were used to create this variable. The MANCOVA for working memory was significant, Wilks' Lambda=0.877 $F(2, 202) = 14.19$, $p<.0001$, with a medium effect size $\eta^2 = .12$). The follow-up ANOVAs showed that both the verbal working memory variable, $F(1, 203) = 12.197$, $p=.001$, and WISC Spatial Span measure, $F(1, 203) = 24.040$, $p<.0001$, were significantly different for the AR and TD groups. The effect size was small for both the verbal working memory variable, $\eta^2= .057$, and the WISC Spatial Span measure $\eta^2=.106$. The TD group had higher mean scores than the AR group on both working memory variables.

Table 7

Univariate Analysis of Working Memory

	At-Risk Group (n=102)		Typically Developing Group (n=104)			
Measures	*M*	*SD*	*M*	*SD*	*F*	η^2
Verbal Working Memory	-0.218	0.84	0.214	0.94	12.20**	.057
WISC Spatial Span	-0.282	0.79	0.277	0.84	24.04**	.106

* $p \leq .05$.
** $p \leq .01$

Question 2a. Are fine-motor skills, language, working memory, and attention/executive functions predictive of writing skill for children in first grade?

Since structural equation modeling methods could not be utilized to address this research question, logistic regression methods were used. The variables were entered into the block wise logistic regression model in the following order: fine-motor, language, working memory and attention/executive functions. This order was used based on previous research which suggests that deficits in fine-motor skills and language skills constrain early writing, deficits in memory constrain writing in the intermediate years, and deficits in executive functions, such as planning, constrain later writing (Berninger & Rutberg, 1992).

When the fine motor measures (PAL Finger Succession – Dominant and PAL Finger Succession – Nondominant) were entered into the regression analysis the model was statistically significant, χ^2 (2, *N* = 206) = 6.02, *p* = .049. The next step added the language measures (PAL RAN, PAL Word Choice, phonemes, and receptive language) and the step was statistically significant, χ^2 (4, *N* = 206) = 26.84, $p < .0001$. The working memory measures (verbal working memory and WISC Spatial Span) were added next and this step was also significant, χ^2 (2, *N* = 206) = 13.68, *p* = .001. Finally, the attention/executive functions measures (WJ-III Cog Retrieval Fluency, WJ-III Cog Planning, Vigil Omissions, and Vigil Commissions) were added and this step was significant as well, χ^2 (4, *N* = 206) = 10.98, *p* = .027. The fine-motor variable was able to predict 58.3% of the cases. The language variable correctly classified 64.1% of the cases; whereas, the working memory variable predicted 67.0% of the cases. Finally, 71.4% of the cases were correctly classified by the attention/executive function variable. The classification rates and Nagelkerke R^2 of the variables as entered into the model are in Table 8.

Table 8

Logistic Regression

	Nagelkerke R^2	χ^2	Classification Rate of AR Group	Classification Rate of TD group	Overall Classification Rate
Fine-Motor	.038	6.02*	50%	66.3%	58.3%
Language	.191	25.84**	64.7%	63.5%	64.1%
Working Memory	.264	13.68**	66.7%	67.3%	67%
Attention/ Executive Functions	.320	10.98*	65.7%	76.9%	71.4%

* $p \leq .05$.
** $p \leq .01$

CHAPTER V

DISCUSSION

The intent of this paper was to look at the process of writing during early development to further understanding of what cognitive skills contribute to the writing process at an early age and how those skills differently contribute to the writing process. In an effort to examine the process as a whole, structural equation modeling methods were attempted to examine a proposed developmental model of writing, the Not-So-Simple View of Writing. However, structural equation modeling techniques were unsuccessful in producing interpretable results due to a covariance matrix that was underidentified and nonpositive definite.

Measures

The tests used to measure the latent variables of Fine-Motor, Language, Attention/Executive Functions, Working Memory, and Text Generation in the structural equation model were all standardized, researched-based measures showing good reliability and validity for measuring the traits they represented. However, when placed in the model, problems with their relationship to each other and their ability to fully represent the latent variables arose.

It should be noted that a potential problem with some measures may have been the combination of two tests used to represent a cognitive skill. The total sample was made up of two different cohorts of students who attended first grade during two consecutive years and each participant was assessed during the year he or she was in first grade. After the first cohort was assessed, the school system requested that some of the tests be changed because they were used by the school system as part of assessments for special education classifications. Due to this request, receptive language was measured by the PPVT and the CREVT, phonemic awareness was measured by the CTOPP Elision subtest and the PAL Syllable and Phoneme subtest, and verbal working memory was measured by the CTOPP Nonword Retrieval subtest and the WISC Digit Span subtest. While the tests chosen to replace the original measures were based on their similarity in methods and items with the original measures, this does introduce some possible systematic differences in the data. Though the methods and items were similar, they were not identical and it is possible that the instruments were not assessing the same skills, or were not at the same level of difficulty.

For some latent variables in the model, positive results may have been obtained if the measures had been more varied. The Fine-Motor variable was represented by two subtests of the PAL: Finger Succession – Dominant and Finger Succession – Nondominant. For these subtests the participants were asked to touch each of their fingers to their thumb five times in rapid succession. This measure has been found to be a strong predictor of handwriting, spelling, and writing skills acquisition for elementary school children (Berninger et al., 1992). The use of only these two closely related measures for the Fine-Motor variable may have caused problems in analysis of the model. The addition of a measure of handwriting ability may have added useful information to the model. The difficulty in adding a handwriting sample is the lack of standardized protocols for assessing handwriting skills.

The Working Memory variable was also represented by only two indicator measures. One of these indicators, verbal working memory, was among the ones that used two different subtests for different cohorts as described previously. It may have been more in line with the model to have measures of long-term and short-term memory included, but these were not included in the proposed model due to concerns that there would not be enough data to support analyzing a larger model.

The Language variable was represented by a variety of indicators that aligned well with the Not-So-Simple View of Writing model. Receptive language, phonemic awareness, orthographic processing, and rapid automatized naming were included. Two of these indicators; receptive language and phonemic awareness, were represented by two different subtests for different cohorts as discussed previously. Examination of the correlations of these indicators revealed several negative correlations. In fact, only the orthographic processing (PAL Word Choice) and receptive language (PPVT or CREVT) were positively correlated. The model was designed so that the indicator variables should all represent skills that work together to promote higher overall language scores. The fact that the tests were negatively correlated suggests that there are problems with using these tests together to measure the Language variable.

The Attention/Executive Functions latent variable included measures of sustained attention, response inhibition, problem solving abilities, and fluency. This variable also contained problems with negative correlations. Only the WJ-III Cog Planning and WJ-III Cog Retrieval Fluency measures were positively correlated. The model was designed so that the indicator variables represented skills that were part of the latent trait of

Attention/Executive Functions; however, the presence of negative correlations among the indicator measures suggests that the measures were not aligned as expected.

Finally, the Text Generation variable was represented by only one indicator measure, the WIAT Written Expression score. Ideally, the variable would be represented by at least two indicators in a structural equation model (Kline, 2005). The lack of standardized writing skills tests that have empirical evidence to support them resulted in only one measure being used in this study. The addition of more indicator measures to represent this latent variable may have described the variable better and allowed the model to be analyzed.

Additional Analysis

Additional analysis was conducted due to the inability to glean any results related to the research questions from the original analysis. Analysis of variance methods were utilized to investigate the research questions by dividing the original sample into two groups, an at-risk group and a typically developing group. For this study the standard score of 85, which is one standard deviation below the mean, on the WIAT Written Expression subtest was used to separate the sample into the typically developing and at-risk for writing problems groups. The use of one standard deviation below the mean was selected based on the young age of the participants in the current study. Reading research suggests that the identification of risk is not stable in the early elementary school years and that when children who are identified as at risk (below the mean) in first grade are re-tested in later grades they may have developed skills that place them in the average range (Phillips, Norris, Osmond, & Maynard, 2002). The use of one standard deviation below the mean as the differentiating score may create an at-risk group that contains children that are more likely to develop later writing impairments.

Question 1a

Do students at-risk for writing problems differ from typically developing students on the motor and cognitive components of fine-motor skills, language skills, attention/executive functioning skills, and working memory skills? It was hypothesized that the typically developing group would perform better on measures of fine-motor skills, language, attention/executive functions, and working memory. A significant difference was found in the overall fine-motor variable. The fine-motor variable consisted of two measures, one for the dominant hand and one for the non-dominant hand. The typically developing group did perform better on the measure for the dominant hand, but there was no significant difference for the nondominant hand. The fine-motor skills of the dominant hand may be more pertinent to writing skills since the dominant hand is the hand used for writing.

There was also a significant difference between the typically developing group and the at-risk group for the overall language variable. Within this variable, the typically developing group performed better on the rapid automatized naming task which looks at orthographic-phonological coordination. The typically developing group also performed better on the word choice task which measures orthographic processing by assessing a child's accuracy and rate of access to word-specific representations in long-term memory. The phoneme and receptive language tasks did not result in a significant difference. These results suggests that at the first grade level the ability to rapidly recall and name letters contributes to typical writing skills; as does the ability to rapidly access familiar word representations from long term memory. Phonemic awareness and receptive language do not differentiate typical from at-risk writers. These skills may better differentiate typical from at-risk writers later in development.

There was a significant difference between the typically developing and at-risk groups for the attention/executive functions variable for the measures of retrieval fluency, planning, and commissions on a continuous performance test. The omissions measure on a continuous performance test did not reveal a significant difference. Based on these results, the ability to quickly and fluently access long-term memory and planning skills contribute to writing ability. Sustained attention as measured on the continuous performance test had variable results. The omissions measure, which counts the number of times a target letter appeared and the participant did not hit the proper key, did not result in a significant difference between groups. However, the commission measure, which counts the number of times the participant hit a key for a letter that was not the target letter, resulted in a significant difference with the at-risk group having a higher mean. These findings suggest that difficulty inhibiting a response is the element of sustained attention that is a factor in writing skill development in the first grade year. Previous research suggested that deficits in executive functions constrain later writing as opposed to early writing development (Berninger & Rutberg, 1992). However, the results of this study suggest that attention/executive functioning skills may be useful in identifying children with writing skill problems in early elementary school. Sustained attention may contribute more to later writing, when individuals are expected to create longer, cohesive written passages. However, at the first grade level, the ability to quickly retrieve information, plan, and inhibit responses may mark a divide between typical and at-risk writers.

As hypothesized, the working memory variable did show a significant difference between the typical and at-risk writers. The typical group had better results on both verbal and nonverbal working memory measures. According to these results, the ability to retain and manipulate information does appear to contribute to writing skills in the first grade.

Overall, the results suggest that fine-motor skills, language, attention/executive functions, and working memory contributed to text generation skills in first grade. When looking at discrete skills within these areas, it appears that dexterity of the dominant hand, orthographic-phonological coordination and orthographic processing, long term verbal retrieval and fluency, planning, the ability to inhibit responses, and verbal and nonverbal working memory, are the skills that differentiate typical from at-risk writers in first grade. These findings support current writing models in that the areas of fine motor skills, language, attention/executive functions, and working memory were found to differentiate between at-risk and typical writers. However, previous writing development research suggests that attention/executive functioning skills do not constrain writing until the junior high school level and verbal working memory does not constrain writing until the intermediate grades (Berninger & Rutberg, 1992). While working memory and attention/executive functioning skills may not constrain writing in class or have an influence on grades in writing, these cognitive skills may be early indicators of writing problems.

The results of this study suggest that the profile of a first-grade student with a writing problem is one who has difficulty with writing hand dexterity, letter naming, rapid recognition of familiar words, verbal retrieval of words, organizational skills, inhibiting responses, and retaining and using information. A child with dexterity problems may have difficulty manipulating a pencil to form legible passages and have a slow, labored handwriting which results in tiring easily or difficulty retaining what he or she wants to write as they are writing. As previous research suggests, the ability to accurately and automatically form letters conserves cognitive energy that can be spent on higher-order cognitive processes necessary for writing (Berninger et al., 1991, Berninger, 2002). The rapid naming of letters demonstrates an ability to automatically and accurately recall the letters of the alphabet which allows children to write words without having to use cognitive energy to remember what a letter looks like or how it is formed. If a child is expending memory and attention on letter recall, it may be more difficult to remember the whole word or sentence they are attempting to construct. The ability to rapidly identify visual representations of frequently used words also conserves cognitive energy for other tasks. The attention/executive functioning skills that, according to this study identify at-risk writers include verbal retrieval of words, organizational skills, and inhibiting responses. Similarly to the language skill of rapid letter naming and word identification, the ability to quickly retrieve words reduces the cognitive energy needed to find words to construct a sentence and this energy can be used for higher-order skills such as organization. Children who have trouble with retrieving words from long term memory may take longer to form sentences and their sentences may use simple, repetitive language. Difficulties with organization skills would inhibit a child's ability to form coherent sentences and paragraphs and make writing longer passages a laborious task. The ability to inhibit responses allows a writer to control his or her attention while writing and write methodically and deliberately; therefore, difficulty with inhibition may result in poor organization and trouble with revision. Finally, children with poor working memory skills have difficulty retaining and manipulating information, which interferes with the ability to coordinate other cognitive skills. Writing is a complex process that requires the coordination of cognitive skills, and writing models have identified working memory as the process where this coordination takes place (Berninger & Winn, 2006, Hayes, 1996). The findings of this study suggest that the fine motor skill of writing hand dexterity; the language skill of letter naming and rapid recognition of familiar words; the attention/executive functioning skills of verbal retrieval of words, organization, and inhibiting responses; and working memory skills may be productive areas to target for writing skill development assessment and intervention in the early school years. If we can provide early identification and intervention for these skills, we may be able to improve later writing.

Question 2a

Are fine-motor skills, language, working memory, and attention/executive functions predictive of writing skill for children in first grade? Based on the results of the logistic regression, the fine motor variable correctly predicted 58.3% of the cases. The language, working memory, and attention/executive functions variables were able to predict additional cases (64.1%, 67%, and 71.4% respectively) and all of the steps entered into the logistic regression were significant. It appears that all the variables contribute to the prediction of text generation performance in first grade, as the addition of the language variable, working memory variable, and the attention/executive functions variable added predictive power to the model. The addition of the language variable resulted in a 5.8% increase in cases correctly identified; however, the working memory variable only increased this percentage by 2.9% and the attention/executive functions variable increased this percentage by 4.4%. These results suggest that the full model, containing all cognitive variables, is predictive of text generation performance in first grade. The order the cognitive skills were entered into the model resulted in progressively more children being identified correctly. The model was proposed based on writing development models; such as Juel, Griffith, and Gough's (1986) Simple View of Writing and the Not-So-Simple View of Writing (Berninger & Winn, 2006) which suggest that transcription and language skills contribute to early writing skills and higher order cognitive skills like working memory and attention/executive functioning skills contribute to later writing. The current findings support these models in that the majority of the correctly classified cases were classified with just the fine motor and language variables in the model. However, the addition of the working memory and attention/executive functions variables did increase the percentage of correctly identified cases. The proposed contributing motor and cognitive factors may be useful as predictors of writing skill problems in first grade children, which suggests this model as a possible blueprint for assessment of writing skills in early elementary school.

Limitations

The present study used data that were collected as part of a larger longitudinal study of the development of writing skills. Therefore, the measures were not selected, and the methods were not designed with the intention of using structural equation modeling to investigate the Not-So-Simple View of Writing. When the data was entered into a structural equation model, the covariance matrix was underidentified and nonpositive definite. After exploration of the problems it was determined that attempts to modify the model would result in output that was not interpretable.

If structural equation modeling methods had produced interpretable results, there would still be limitations to the research outcomes. The purpose of the study was to look at the process of early writing development. This study looked at only one model of writing development and only provided information on the constructs that were part of the proposed model. There may be other contributors to writing skill development that were not addressed in this model. In addition, several environmental factors that have been shown to have an effect on school achievement, namely teacher-student relationships (Burchinal et al., 2002), limited instruction, limited cultural experiences, and poor motivation (Gregg & Mather, 2002) were not explored.

Future Directions

Although the current model could not be run, the testing of a complete model of writing development would add to the research. Future studies that are designed from the data collection stage to use structural equation modeling would give researchers the opportunity to look at how all the proposed factors of a writing model work to support writing skill development. Initial exploratory factor analysis with measures of cognitive functioning may help to inform the design of structural equation modeling studies. The exploration of a complete theoretical model has the advantage of looking at the model as a whole instead of in parts, which could shed additional light on how the factors in a model interact with each other, and how they support writing development.

Longitudinal studies would be beneficial in showing how the model may change over time. Previous research has suggested that deficits in fine-motor skills constrain early writing, deficits in memory constrain writing in the intermediate years, and deficits in executive functions constrain later writing (Berninger & Rutberg, 1992); however, this study found that measures of working memory and attention/executive functions did significantly differentiate between typically developing writers and those at-risk for writing problems. Longitudinal studies of writing development models would add to this research. A foundation of understanding the development of writing over time would help inform instruction and intervention in writing for children. In addition, a better understanding of the traits that contribute to writing skill as children age would help in the identification of writing skill deficits.

This study was proposed to explore the Not-So-Simple View of Writing, but research into other models of writing skill development would add to the literature. Comparative studies of different models of writing skill development would also be a valuable addition to the current writing research. Research of different models may help to focus the conceptualization of writing skill development and also inform better writing instruction. In general, there is a lack of research on writing skill development in the early elementary school years in the literature (Edwards, 2003; Graham & Harris, 2005). Recently writing research has shifted from a focus on competent adult writing to writing development in children (Berninger, 1996). However, there is still much that could be added to the literature to help us increase our understanding of how children become competent writers.

Appendix A: IRB approval letter

THE UNIVERSITY
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To: Stephen Hooper
Psychiatry, School Of Education, Developmental
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From: Biomedical IRB

Authorized signature on behalf of IRB

Approval Date: 6/20/2008
Expiration Date of Approval: 6/15/2009

RE: Notice of IRB Approval by Expedited Review (under 45 CFR 46.110)
Submission Type: Modification
Expedited Category: Minor Change to Previously Reviewed Research
Study #: 05-2755 (Former IRB Number 05-CDL-1325)

Study Title: Attention, Memory, and Executive Functions in Written Language Expression in Elementary School Children
Sponsors: Dept of Education Institute
This letter serves as revision to the approval letter dated 6/20/08.

This submission has been approved by the above IRB for the period indicated. It has been determined that the risk involved in this modification is no more than minimal. Unless otherwise noted, regulatory and other findings made previously for this study continue to be applicable.

Investigator's Responsibilities:
When applicable, enclosed are stamped copies of approved consent documents and other recruitment materials. You must copy the stamped consent forms for use with subjects unless you have approval to do otherwise.

This study was reviewed in accordance with federal regulations governing human subjects research, including those found at 45 CFR 46 (Common Rule), 45 CFR 164 (HIPAA), 21 CFR 50 & 56 (FDA), and 40 CFR 26 (EPA), where applicable.

CC: Kathleen Anderson, Developmental & Learning Ctr

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Appendix B: Reliability and Validity of Measures

Test	Reliability	Summary of Validity
Wechsler Individual Achievement Test – Second Edition (WIAT-II)	r = 0.91	Expert judges, Item Response Theory methods (item-total correlations <20 removed), correlations with other tests of achievement (0.73 with WRAT3 Reading, 0.78 with WRAT3 Spelling)
Process Assessment of the Learner (PAL) Finger Succession	dominant hand r=0.89, non-dominant hand r=0.87	Study conducted with 300 primary-grade children showed significant correlation with handwriting and narrative compositional fluency
Comprehensive Test of Phonological Processing (CTOPP) Elision	age 6 r=0.92, age 7 r=0.91, age 8 r=0.89	Item discrimination and difficulty statistics, parameters in Item Response Theory models, correlations with other tests of language (0.74 with WRMT-R Word Analysis, 0.73 with WRMT-R Word Identification, 0.67 with TOWRE Sight Word Efficiency, 0.68 with TOWRE Phonetic Decoding)
Process Assessment of the Learner (PAL) Syllables and Phonemes	syllable r = .80, phoneme r = .92	Expert judges, empirical item analysis, correlations with other tests (Syllables correlated 0.49 with WIAT-II Pseudoword Decoding, Phonemes correlated 0.56 with WIAT-II Pseudoword Decoding)
Peabody Picture Vocabulary Test-4 (PPVT-4)	age 6:0-6:5 α=0.97, age 6:6-6:11 α=0.94, age 7 α = 0.94, age 8 α= 0.99	Correlations with other tests of language (0.84 with EVT-2 for ages 5-6, 0.80 with EVT-2 for ages 7-10, 0.67 with CELF-4 for ages 5-8
The Comprehensive Receptive and Expressive Vocabulary Test – Second Edition (CREVT-2)	age 6 α = .88, age 7 α = .91, age 8 α = .91	Correlations with other tests of language (0.59 with PPVT-IV, 0.66 with WISC-III Vocabulary, 0.74 with CELF-R

Test	**Reliability**	**Summary of Validity**
Process Assessment of the Learner (PAL) Word Choice	r=0.66	Expert judges, empirical item analysis, correlations with other tests (0.80 with WIAT-II Pseudoword Decoding)
Process Assessment of the Learner (PAL) Rapid Automatized Naming	letters r = 0.92, digits r = 0.84	Expert judges, empirical item analysis, correlations with other tests (-0.72 with WIAT-II Pseudoword Decoding)
Wechsler Intelligence Scale for Children-IV-Integrated (WISC-IV-I) Spatial Span	age 6 SSpF r = 0.76, SSpB r = 0.81, age 7 SSpF r = 0.70, SSpB r = 0.74, age 8 SSpF r = 0.79, SSpB r = 0.77	Research studies, review of theortical literature, expert reviews, correlations with other tests (Working Memory scale including Spatial Span correlated 0.69 with CELF-4)
CTOPP Nonword Repetition	age6 α = 0.80, age 7 α = 0.80, age 8 α = 0.80	Item discrimination and difficulty statistics, parameters in Item Response Theory models, confirmatory factor analysis of CTOPP shows Nonword Repetition loads o the Phonological Memory factor
Wechsler Intelligence Scale for Children-IV-Integrated (WISC-IV-I) Digit Span	age 6 DSpF r = 0.83, DSpB r = 0.83, age 7 DSpF r = 0.79, DSpB r = 0.69, age 8 DSpF r = 0.82, DSpB r = 0.68	Research studies, review of theortical literature, expert reviews, correlations with other tests (Working Memory scale including Digit Span correlated 0.69 with CELF-4)
Woodcock-Johnson Tests of Cognitive Abilities-III (WJ-III COG-Cog) Planning	age 6 r = 0.67, age 7 r = 0.75, age 8 r = 0.69	Developed based on the Cattell-Horn-Carroll theory of cognitive abilities, outside experts used, content of test similar to other well-established cognitive measures
WJ-III COG-Cog Retrieval Fluency	age 6 r = 0.79, age 7 r = 0.80, age 8 r = 0.78	Developed based on the Cattell-Horn-Carroll theory of cognitive abilities, outside experts used, content of test similar to other well-established cognitive measures

Test	**Reliability**	**Summary of Validity**
Vigil Continuous Performance Test	omissions α=.91, commissions, α=.956, reaction time α=.896	Correlations with other tests of attention (0.648 with Stop Signal Task for errors of omission, 0.337 with Stop Signal Task for errors of commission)
Wechsler Abbreviated Scales of Intelligence (WASI)Full Scale-2	age 6 r = .94, age 7 r = .93, age 8 r = .92	Correlations with other tests (0.81 with WISC-III, 0.87 with WAIS-III)

Appendix C: Covariance matrix of the data

	Fine-Motor		**Language**				**Attention/Executive Functions**				**Working Memory**		**Text Generation**
	PAL Finger Succession Non Dominant	PAL Finger Succession Dominant	PAL Word Choice	PPVT or CREVT	PAL RAN	CTOPP Elision or PAL Syllable and Phoneme	WJ Planning	WJ Retrieval Fluency	Vigil Omissions	Vigil Commissions	WISC Spatial Span	CTOPP Nonword Retrieval or WISC Digit Span	WIAT Written Expression
PAL Finger Succession Non Dominant	0.159												
PAL Finger Succession Dominant	0.103	0.165											
PAL Word Choice	0.001	-0.020	1.061										
PPVT or CREVT	0.026	0.032	0.054	0.989									
PAL RAN	0.019	0.039	-0.235	-0.046	0.533								
CTOPP Elision or PAL Syllable and Phoneme	0.001	0.032	-0.019	-0.017	-0.022	0.755							
WJ Planning	0.117	0.160	-1.563	-0.555	1.395	0.277	77.321						
WJ Retrieval Fluency	0.376	0.926	-1.896	0.789	3.299	-0.296	33.001	234.487					
Vigil Omissions	-0.394	-0.343	2.215	2.184	-3.707	0.393	-15.835	-38.667	927.302				
Vigil Commissions	-0.326	-0.872	9.392	3.855	-5.750	-4.586	-39.128	-42.488	-545.034	4020.513			
WISC Spatial Span	0.055	0.069	-0.151	0.071	0.162	0.027	2.621	3.489	-2.056	-11.690	0.734		
CTOPP Nonword Retrieval or WISC Digit Span	0.006	0.018	-0.288	0.068	0.208	-0.026	2.149	4.773	0.720	-11.283	0.270	0.835	
WIAT Written Expression	0.342	0.704	-4.546	-0.057	3.059	0.933	23.736	61.601	-8.193	-193.334	4.359	3.400	155.483
Means	-0.177	-0.173	-0.365	0.000	0.186	0.096	106.136	95.975	60.198	83.320	0.000	-0.001	86.481

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