ABSTRACT

MERCER, JACQUELYN GORE. Relations Between Isolated Writing Skills, Executive Functions, Working Memory, and College Students' Production of Connected Text. (Under the direction of Ann C. Schulte, PhD.).

The purpose of this study was to explore potential relations between isolated writing skills, executive functions, working memory, and connected text production. The goal was to integrate concepts and measures from diverse perspectives to examine these relationships. Sixty-three students enrolled in introductory psychology completed a battery of measures, and relationships among measures were examined to test hypothesized relationships. Isolated writing skills, executive functions, and working memory measures predicted scores on a measure of unsupported production of connected text and accounted for 15% of the variance in scores on the connected text production measure. The contribution of executive function to written expression did not differ significantly from zero, and the manipulation designed to examine the role of executive function in written expression by reducing the organizational demands of the writing task did not have its predicted effect. Post hoc analyses suggested that flaws in the study's design may have accounted for the failure to find support for two of the three original hypotheses. Other possible interpretations for the findings and implications for future research and school psychology practice were discussed.

RELATIONS BETWEEN ISOLATED WRITING SKILLS, EXECUTIVE FUNCTIONS, WORKING MEMORY, AND COLLEGE STUDENTS' PRODUCTION OF CONNECTED TEXT

by

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BIOGRAPHY

Jacquelyn Marie Gore was born in Logan, West Virginia. Her family moved to North Carolina, and she grew up in the New Hanover County Public Schools. She attended North Carolina State University and earned a Bachelors of Arts degree with highest distinction and highest honors in Psychology from the University of North Carolina at Chapel Hill. She earned her Master of Science and Doctor of Philosophy degrees in School Psychology from North Carolina State University. She lives with her long-suffering husband, Joey Mercer, in Wake Forest, North Carolina and is the proud parent of three children, Joel, Andrew, and Katharine. She enjoys her work as a School Psychologist in the Wake County Public School System.

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CHAPTER ONE: INTRODUCTION

The production of connected text may be one of the most complex tasks required of students. In order to produce written words, sentences, and paragraphs, several motor, cognitive, and metacognitive skills must be deployed and managed simultaneously. Although difficulties in written expression have been observed and described for more than 100 years (Hooper et al., 1994), empirical examinations of the skills, processes, and products of written expression have typically been limited in quantity and methodology (Hooper et al., 1994; Lyon, 1996).

Theoretical and empirical models of written expression (Hayes & Flower, 1980) have identified component processes that operate in recursive interaction to produce written text. These processes include long term memory constructs (i.e., oral language skills or knowledge of writing conventions and topical content), metacognition, executive function, short term memory, and working memory, which operate via their influence on isolated basic writing skills, such as word and sentence generation, spelling and punctuation accuracy, handwriting, and text fluency as well as higher level writing skills such as planning, organizing, vocabulary use, maintaining topic relevance, and paragraph fluency. Although studies of specific components of writing processes and problems have been published (e.g., Graham & Harris, 2000), the literature includes little empirical examination of the interactions of basic and higher level writing skills or their relations to cognitive and metacognitive processes. Theoretical and methodological limitations in the writing literature have contributed to the construction of a knowledge base of writing, component skills, and writing deficits that lacks both breadth and specificity (Lyon, 1996).

The present study was conducted to address specific gaps in knowledge about writing by addressing basic and applied goals with a sample of students enrolled in introductory psychology classes at a large southeastern university. A battery of measures to assess and examine relationships between isolated writing skills, executive functions, working memory processes, and production of connected text has not been previously evaluated in the literature. One basic research goal was therefore to assemble a collection of measures to describe and assess isolated writing skills, such as spelling, handwriting, and basic writing mechanics (such as punctuation and capitalization), and their relation to other skills associated with the production of connected text, such as executive functions (planning, organizing, maintaining text that is topic-relevant), and working memory. The assessment battery therefore included measures of isolated writing skills, executive functions, and working memory so that possible relations of these constructs to the production of connected text could be examined.

This study also represented an initial attempt to evaluate the effects of providing executive function support during the writing process by comparing students' performance on writing tasks completed without and with the use of an outline that instructed students to think, plan, write, review, and revise. The students were therefore also asked to complete two samples of connected text (one without and one with the outline). This combination of basic and applied approaches sought to develop information regarding the component processes associated with the production of connected text from educational and psychological perspectives that is currently lacking in the writing literature.

Participants completed a battery of measures to assess their isolated writing, executive function, and working memory skills as well as samples of connected text. The data were analyzed to examine the relations between the three predictor constructs (isolated writing skills, executive functions, and working memory) and connected text production. Predictions of significant relationships were based on integration of diverse lines of research in education, special education, psychology, school psychology, and neuropsychology presented in the next chapter.

After defining written expression, the following section includes a brief historical summary of the study of writing, information on the developmental progression of writing skills, two writing process models, and a summary of writing research. The review of written expression concludes with a critique of current weaknesses in the writing literature. The next major section of the chapter summarizes the relevant cognitive and neuropsychological literatures that examine working memory and executive functions and their hypothesized roles in production of connected text. This integrative literature review is followed by a chapter that summarizes the issues this study sought to address and the hypotheses that were tested.

CHAPTER TWO: REVIEW OF THE LITERATURE

Written Expression

Written expression has been defined as a graphic translation of oral language (Berninger, 1999) and as a motoric production that uses a system of symbols to communicate or record an individual's thoughts, ideas, or feelings on paper (Poteet, 1980). Composing and producing written text requires the student to coordinate multiple motoric, cognitive, and metacognitive processes simultaneously (Berninger, 1999; Berninger, Abbott, Whitaker, Sylvester, & Nolen, 1995; Bradley-Johnson & Lesiak, 1989; Poteet, 1980). Several models of the components of this process and their interactions have been proposed (e.g., Berninger et al., 1995; Hayes & Flower, 1980).

Approaches to research in writing seem to have been driven by two primary influences. First, investigators have observed that although some individuals seem to learn to write well with little direct instruction, others fail to develop adequate writing skills. The study of individual differences has long been a tradition of developmental psychology, and attempts to understand problems and identify potentially associated skills (by targeting skills deficits) have served as the foundations of one approach to the study of writing (e.g., Brooks, Vaughan, & Berninger, 1999). This approach has focused on the study of writing problems as a way to understand the components of the writing process and has inherent practical value because problems that can be identified and measured may become the targets of intervention. Another influence in writing research can be historically linked to the cognitive revolution in psychology. The increasing importance of cognitive constructs in the science has paralleled the inclusion of information processing components, which include cognitive and metacognitive constructs, in writing process models (e.g., Berninger, 1999; Berninger et al., 1995). These approaches are useful because they can serve to build a comprehensive fundamental model that increases understanding, suggests potential skills deficits that may be responsive to intervention, and inspires further research. However, though empirical efforts have identified some key component reading skills and validated some successful strategies for intervention for specific reading deficits, progress in the writing research literature has been weak, particularly compared to research in other learning areas such as reading (Feifer & De Fina, 2002; Lyon, 1996).

This observation is not intended to imply that writing skills and the cognitive processes that underlie them have been ignored. Interest in writing has grown over the past 50 years, with particular emphasis during the past two decades (Hooper, 2002). Theoretical models have been discussed since the 1960s, and diagnosis and intervention for severe writing problems have been regulated by special education laws since the mid-1970s.

Since the 1980s, writing has been conceptualized as “a problem-solving process whereby authors attempt to produce visible, understandable, and legible language reflecting their declarative knowledge” (Hooper et al., 1994, p. 377). According to Gagne (1985), writing is facilitated and constrained by knowledge (of topic, the writing process, and writing strategies) and conditional knowledge (i.e., the knowledge of how and when to use other knowledge and strategies, which is clearly a metacognitive function). Despite numerous studies of writing, writing problems, and writing interventions, it has been argued that much remains unknown about neuropsychological factors that support written expression, such as attention, language, memory, neuromotor functions, and social cognition (Hooper, 2002; Hooper et al., 1994). These neuropsychological factors can be related to the constructs studied as cognitive processes, such as working memory, and executive functions, such as planning, organization, self-regulation, flexibility and inhibition, that have been found to be associated with inattention, hyperactivity, and impulsivity but not explicitly linked to writing skills and problems until Hooper's (2002) recent study of elementary children. Similar studies with college students have not been published.

Writing Problems

One approach to writing research involves the specific study of writing problems. Single participant case design and small sample studies have been prominently featured in these studies of written expression. Large sample or epidemiological research designs have not often been attempted. One exception to this trend was a study completed by Hooper and his colleagues (1994) when they used the Test of Written Language-2 to measure the writing skills of all 531 students in a middle school in Troy, Alabama. Preliminary analysis of a random sample of 30% of the data revealed that 4 - 18% of the middle school students obtained scores that were at least two standard deviations below the mean on the Handwriting (4.0%), Contextual Style (10.7%), Thematic Maturity (14.8%), Contextual Vocabulary (14.8%), Contextual Spelling (14.8%), and Syntactic Maturity (17.4%) subscales, as well as the composite Writing Quotient (18.1%), indicating marked impairment in these domains. These rates of impairment are impressive because they exceed, sometimes substantially, the widely disseminated 5% prevalence estimate (Lyon, 1996) for children with a specific learning disability in written expression. Despite results such as Hooper's, and growth in the importance of writing skills for academic success (Feifer & De Fina, 2002), written expression and written expression problems have received relatively little empirical attention, compared to reading skills (Feifer & De Fina, 2002; Hooper et al., 1994; Lyon, 1996).

Although it is broadly assumed that deficits in written expression need not be pervasive across all skills to cause significant writing problems, empirical attempts to identify and operationalize specific component skills where deficits may be found have occurred only relatively recently. Difficulties with identifying fundamental component skills, lack of agreement regarding relevant construct definitions, and use of a variety of informal evaluation scales (Gregg & Mather, 2002) may be associated with slow progress in understanding skills and processes related to the production of connected text. Moreover, although published studies of writing skill appear to include assumptions about implied executive dysfunction, validated laboratory measures of executive functions have not been included in most published studies of writing problems. The present study sought to integrate presently divergent lines of educational and psychological research to address these issues.

After reviewing the progress and sequence of normal development of writing skills, two writing process models will be described along with studies conducted for the purpose of examining writing problems. Following that summary, this chapter includes a critical evaluation of weaknesses in the current writing literature.

Development of Writing Skills

The development of writing skills is grounded in oral language development (Lu, 2000) and involves the progressive increase of knowledge, cognitive and metacognitive processing efficiency, and fine motor control. Each component writing skill develops at an individual rate and may influence the emergence of other skills differently at progressive points in time (Swanson & Berninger, 1996). The age at which specific skills emerge in individual children can vary widely within the normal range (Grose & Hupert, 1997).

Skill levels of each component can be thought of as falling on a continuum with infinitely fine gradations. Each component may be portrayed as a contributor to the characteristics of text product through quantifiable isolated writing skills and inferred executive functions and working memory performance (Table 1).

Table 1 lists the writing skills that are of interest in the production of connected text (defined as one or more paragraphs rendered in the form of a letter, essay, story, or report) and designates cognitive or metacognitive processes to which each skill may be related. Isolated skills, such as spelling, handwriting, punctuation, and capitalization, are related to, and dependent upon, the knowledge introduced into long term memory as well as the capacity and efficiency of working memory. Skills associated with the production of connected text, such as planning, organizing, maintaining topic relevance, and paragraph fluency, are also related to basic knowledge that may be activated in working memory (though they also require additional knowledge) as well as the efficiency of working memory. However, because of their relative difficulty and complexity, these higher level skills are additionally dependent upon the executive functions that are generated in the context of metacognitive knowledge.

The relationships that are depicted in Table 1 suggest that the extent to which knowledge, isolated writing skills, executive functions, and working memory are developed will influence the quality of written text produced by an individual. The infinite possible variations inherent in this conception (Farr, 1985) of the process do not suggest a clean developmental stage model. However, in an attempt to identify and clarify developmental differences, two broad general categories, labeled *less skilled writers* and *skilled writers*, may be imposed on the intricate continua of writing proficiency. It should be noted in the following sections that the writing literature does not present strong empirical evidence for developmental progression in writing skills.

Table 1

Theoretical Relationships Between Writing Skills and Underlying Cognitive and Metacognitive Constructs.

	Associated Constructs		
Skill	**Long Term Memory**[1]	**Working Memory**[2]	**Executive Functions**
Isolated Skills			
Spelling	*	*	
Handwriting	*	*	
Punctuation	*	*	
Capitalization	*	*	
Word, Sentence Fluency	*	*	*
Additional Skills Associated with the Production of Connected Text			
Planning	*	*	*
Organization	*	*	*
Vocabulary	*	*	*
Relevance to Topic	*	*	*
Paragraph Fluency	*	*	*

Notes:
[1] Long term memory for basic skills includes knowledge of letter strokes, spelling, and basic writing conventions. For higher level skills, it includes knowledge about the goals, purposes, processes, and structures of written compositions.
[2] Given the differences in their complexity, demands on executive function and working memory for isolated writing skills are assumed to be lower than for higher level skills.

Rather, the literature and school-based consumers of it seem to rely upon descriptive theoretical models that have gained broad acceptance, perhaps based on anecdotal observations of educators and replication across published sources.

Less skilled writers. Before writing, children draw and read their drawings as messages (Sulzby, 1985). They scribble, and over time, their scribbles grow to resemble writing (Gundlach, McLane, Stott, & McNamee, 1985). They shift from using a mitten grip to the typical tripod grip of writers (Grose & Hupert, 1997). Scribbles begin to resemble letter-like forms (Gundlach et al., 1985; Sulzby, 1985). The first written word is typically a child's own name. Knowledge of the letters in the name serves as the basis for further writing (Dyson, 1985; Lu, 2000), and children tend to write the same letters over and over in many ways or produce long strings of the letters in random order (Grose & Hupert, 1997; Gundlach et al., 1985). Early writing is often accompanied by talking and drawing. As children begin to face writing demands in school, they are often encouraged to invent spellings for words they have not mastered. One letter may represent an entire syllable or word at first, but with time and practice, more words are spelled correctly (Gundlach et al., 1985; Sulzby, 1985). Early words are typically labels for objects and pictures (Dyson, 1985; Sandbank, 2001). Eventually, spelling, neatness, and readability begin to resemble that of skilled writers (Sowams School, 2000).

Students begin to write single sentences and then multiple sentences. When sentence writing is attempted, requirements for correct capitalization and punctuation are introduced, along with knowledge of parts of speech and rules about conventions such as subject-verb agreement (School District of Philadelphia, 1999). As knowledge increases, it is not used consistently. For example, young unskilled writers may forget to allow correct space between words, have inconsistent handwriting, may use punctuation incorrectly, or sometimes misspell words (Grose & Hupert, 1997; Sandbank, 2001). Unskilled writers approach writing as a process of simply getting ideas down on paper, and each sentence may seem only to be elicited by the previous one (McCutchen, 2000).

Less skilled writers' knowledge is comprised of emergent awareness of letter forms and spacing as well as growing familiarity with writing conventions (i.e., spelling, capitalization, and punctuation rules). Their cognitive processing, which involves retrieval from long term memory and working memory functioning, is predominantly applied to the basic writing skills that Berninger (1994) refers to as low-level transcription, primarily spelling and handwriting. Motor skills include appropriate grip and control of one's pencil on paper. The goal of writing tasks at this stage is the construction of correctly formed letters and words that may be arranged to express simple ideas in a mechanically correct product.

Skilled writers. Over time, and with the benefit of experience, less skilled writers may become skilled writers. They add understanding of the goals and purposes of writing in its different forms to their previous basic writing skills knowledge base (Dyson, 1985; Gundlach et al., 1985). They learn information on the topics about which they write, and they develop the cognitive knowledge of strategies for planning, organizing, monitoring, and revising, as well as the metacognitive knowledge for when to deploy these strategies for optimal effect. It is often assumed that the automatization of basic skills reduces their demands on working memory and frees up resources for application to these higher level tasks. This *resource allocation model* for working memory is sometimes used to help explain differences in less skilled and skilled writers (e.g., Graham, Schwartz, & MacArthur, 1993).

The goal of writing at this stage is the construction of text that communicates ideas in a clear, organized, complete product. Written text grows in length and complexity over time (Lu, 2000; Sulzby, 1985). Students begin to use varied sentence structures and combine sentences into paragraphs (School District of Philadelphia, 1999). They use correct spelling and punctuation more frequently and elaborate on their ideas. They learn to use a process of drafting, editing, and revising (Grose & Hupert, 1997). As was the case with their earlier knowledge acquisition, these skills emerge at an irregular pace and are applied to the writing task occasionally at first, but with increasing frequency and regularity over time and with experience. By the time they reach college age, most individuals are thought to have developed at least average writing skills. In his commentary on instruction in first-year writing classes, Bernard-Donals (2004) noted changes in complexity in writing tasks as students' progress from producing general texts to domain-specific reports and essays.

In their review of the knowledge and abilities of unskilled and skilled writers, Graham and Harris (2000) described several findings. Similar to Berninger (1994), they defined transcription as primarily involving spelling and handwriting skills, and they noted that the transcription behaviors of skilled writers are generally faster and more accurate than those of unskilled writers. This association is stronger among young, developing writers, a finding that may be attributable to the allocation of working memory resources. Transcription skills generally improve with age and schooling. Graham and Harris found that this trend is strong for spelling, but it varies for handwriting. Handwriting fluency increases approximately ten letters per minute per grade through elementary and middle school, but it levels off at an approximately adult level around ninth grade. Handwriting legibility increases in elementary school, but it levels off or even regresses past fourth grade. In their study, Graham and Harris (2000) found that spelling skills were moderately correlated with writing quality and had a low to moderate correlation with the quantity of writing output. Handwriting fluency was moderately correlated with writing performance measures, but handwriting neatness was not correlated with writing performance. Ignoring or eliminating spelling, handwriting, and mechanics demands had weak to moderate effects on text quality, and teaching these skills improved writing in the primary grades. However, in a later study conducted with college students, Gregg, Coleman, Stennett, and Davis (2002) found that variations in handwriting and spelling skills could not account for differences in the complexity of expository writing samples.

Regarding skills associated with the production of connected text, to which they referred as self-regulation, Graham and Harris (2000) found that skilled writers used self-regulation strategies more frequently than unskilled writers. The quality and quantity of writers’ plans were associated with writing performance. Skilled writers spent more time planning their text, made more revisions, and demonstrated more knowledge about the processes involved with composing. Graham and Harris noted that although longitudinal investigation has not been published, cross-sectional studies have suggested that developing writers become increasingly self-regulated with age and schooling.

Differences in self-regulation behaviors predict individual differences in writing. Young children fail to revise at all. Developing writers revise sparingly and limit their revisions to proof-reading and minor word changes. Skilled writers revise extensively. Graham and Harris (2000) argued that teaching self-regulatory strategies led to improved writing, and they have supported this claim with intervention studies that taught students to use single strategies (Graham, 1997) or combinations of strategies (Danoff, Harris, & Graham, 1993).

The emergence and development of writing skills is highly idiosyncratic. By middle school, a sample of writers may include the entire range from very deficient to highly skilled. Indeed, a wide variety of skill was found by De La Paz (1999) in her study of students in regular education settings. In her sample of 22 seventh and eighth grade students, baseline writing standard scores (obtained on the Written Expression subtest of the Wechsler Individual Achievement Test) ranged from 77 (6^{th} percentile rank) to 123 (94^{th} percentile rank).

Researchers have sought to understand why some students struggle to master the isolated and higher level skills required for writing effectively. The following sections will include a review of models of writing processes, as well as research examining specific skills related to writing and writing problems.

Comprehensive Writing Process Models

Models of the writing process that have been described in the literature vary on the degree to which they rely on theory and the extent to which they have been subjected to empirical validation. They are also distinguished by the processes they identify and relate to writing production. Whereas some models link outcomes to isolated writing skills, others include inferences to underlying cognitive and metacognitive processes.

Writing skills models that feature observable writing behaviors. Poteet (1980) argued that written expression skills are comprised of four major components: (a) penmanship, (b) spelling, (c) grammar, and (d) ideation. Penmanship involves legibility of handwriting. Spelling, of course, refers to the correct spelling of individual words. Grammar refers to compliance with accepted rules and conventions of written language, and ideation concerns the thoughts and ideas that the writer generates. Although this model provides useful descriptive information that may prompt additional inquiry, it fails to link observable skills to potentially influential cognitive and metacognitive processes.

Writing skills models that include inferred cognitive and metacognitive processes. Other writing process models attribute some qualities of written text to characteristics of cognitive and metacognitive processes that underlie observable writing behaviors. According to Bradley-Johnson and Lesiak (1989), there are five interrelated writing components, four of which are observable skills and one that is an inferred process: (a) mechanics, (b) production, (c) conventions, (d) linguistic, and (e) cognitive. *Mechanics* (i.e., handwriting) refers to the ability to form legible letters, words, numbers, and sentences. It requires the ability to perceive and imitate, visual-motor coordination (including pencil grasp, posture, paper position, correct letter formation, spacing, slant, size, and alignment), and an accurate memory of sufficient capacity. *Production* refers to the number of words, sentences, and paragraphs an individual is able to generate or produce. Fluency measures may capture a large portion of the variance of this writing skill because they measure speed, efficiency, and accuracy. *Conventions* are the often arbitrary rules for spelling, punctuation, and capitalization. This writing skill requires attention to detail and adequate memory. Ability to use a diverse vocabulary and correct syntax indicates linguistic skill. Like conventions, *linguistic* skills are frequently arbitrarily applied (i.e., although some rules may be deduced from linguistic forms, there are frequent exceptions to the rules). This skill is derived from oral language ability and requires adequate memory for retrieval of rules and exceptions. *Cognitive* processing ability is required to organize writing into a logical gestalt that is sequenced properly and conveys an understandable content. Bradley-Johnson and Lesiak (1989) have not specified the requirements for adequate cognitive processing ability. However, reliance on organization and evaluation would suggest that metacognitive knowledge and executive functions (planning, monitoring, self-regulation, organization, and inhibition) are likely to be involved.

Though Berninger and her colleagues (Berninger, 1999; Berninger et al., 1995; Swanson & Berninger, 1996) have conceptualized writing somewhat differently from Bradley-Johnson and Lesiak (1989), Berninger's conception of the writing process also includes an inferred cognitive construct. She has described writing as the recursive interaction of three general abilities, two of which are observable writing skills: (a) text generation (a subcomponent of translation, which is related to the classic Hayes & Flower model from 1980 described in greater detail below), (b) transcription, and (c) working memory. *Text generation* refers to the translation of ideas into language representations in memory. This skill depends on oral language development. It could be observed and measured by assessing text for fluency, vocabulary, and clarity of meaning. *Transcription* refers to the transformation of oral language representations into written words. This skill also depends on observable behaviors, such as handwriting and spelling. Working memory, an inferred cognitive process construct, contributes to writing outcomes because the process of writing requires an individual to manage several simultaneous goals, implying a need for metacognitive knowledge and ability. While writing, a person must decide what to say, how to say it, select words, sentences, and structures, produce text, monitor what has been written and what is about to be written, and revise as needed. As previously noted from the working memory resource allocation model, the pool of cognitive resources available for employment in the service of working memory tasks is finite (Graham et al., 1993). As some tasks are initiated or processed, working memory resources available for new tasks will be reduced.

Swanson and Berninger (1996) have defined working memory as the cognitive space within which executive functions are deployed and operated, further providing for metacognitive involvement. They have also argued that working memory is time constrained. Writing goals must be addressed immediately before information retrieved from long term memory begins to decay.

Berninger and her colleagues have applied this model in research. In their study of 300 fourth, fifth, and sixth grade students (who had a mean Full Scale IQ of 108.40 (*SD*=12.93) on the Wechsler Intelligence Scale for Children, Revised), Swanson and Berninger (1996) found evidence of differential contributions of long term memory, short term memory, and working memory to the quality of students' writing. They administered multiple measures of working memory and short term memory and assessed their effects on students' compositions by calculating correlations, factor analyses, and a variety of modeling techniques. Their data revealed that working memory and short term memory shared no common factors and operated independently to influence writing skills. A four factor model that included phonological short term memory, verbal working memory, visual-spatial working memory, and executive functions related to working memory was found to be the most efficient predictor of writing quality measures. Short term memory correlated more highly with transcription measures (i.e., spelling and handwriting) than working memory measures did, and working memory measures correlated more highly with reading comprehension measures than short term memory did. Stepwise regression techniques revealed that working memory related to executive functioning was the only significant predictor of compositional fluency and organization. This construct also contributed unique variance to quality ratings beyond the contribution of reading comprehension. The authors concluded that because the contribution of working memory was not general, but rather was restricted to executive function-related skills, their results did not support the resource allocation model that has been generally described in the literature. Instead they viewed their results as support for recognition of differential effects of specific processes on writing output. Their finding of underlying factors, however, was important in the context of the present study because it may suggest the presence of subtypes of writing problems, an issue the present study was designed to explore.

Examining even a limited sample of theoretical perspectives on written language component skills reveals the lack of consensus in specifying the subcomponents of this complex task. Models that rely on isolated writing skills seem rudimentary and incomplete when examined along with the models that include inferred cognitive and metacognitive constructs. Compared to Berninger's model (Berninger, 1999; Berninger et al., 1995), the components in the model by Bradley-Johnson and Lesiak (1989) were relatively more distinctly specified because they separated handwriting skills from spelling, fluency, and vocabulary. Berninger’s model however, is superior in its inclusion of the role of working memory (versus the relatively vague reference provided by Bradley-Johnson and Lesiak’s cognitive component). Both models could be improved by combining skills specificity with additional information on metacognitive skills and their contributions to written language skills, a goal of the present study.

The following section introduces a writing process model that is grounded in the historical Hayes and Flower (1980) work and the Berninger (1995) modification of that early model. This process model was considered in this research to address gaps regarding the relations of isolated writing skills, executive function, and working memory processes and their potential contributions to connected text production in these classic models.

Writing process model considered in the present study. The design of the present study was founded on a writing model constructed by the author. The model contains some elements of traditional cognitive information processing models and the Hayes and Flower (1980) writing process model. Hayes and Flower conceived of the writing process as the product of the interaction of the task environment, the writer’s long term memory, and the writer’s behavior. In order to produce clearly written text, the writer must set goals, plan, and generate ideas (*Planning*), translate those ideas into words, sentences, and paragraphs (*Translating*), and evaluate and revise as needed (*Reviewing*). In order to accomplish all of these tasks, Hayes and Flower postulated the presence of a construct called *Monitor* that serves a metacognitive function, though the nature of the monitor function remained unspecified. Critical of Hayes and Flower for lack of developmental perspective, Berninger (1994) offered an adaptation of their work.

The Hayes and Flower model had been created to describe the interactive processes employed by skilled adult writers. Berninger and her colleagues (Berninger, 1994; Berninger et al., 1995) made developmental changes in the model based on research with students in first through ninth grades. Studies with children in first through third grades led to the addition of subcomponents to Hayes and Flower's translating skill. These subcomponents, text generation and transcription, permit researchers and educators to explain how some children have much stronger abilities to express ideas verbally (text generation) than to transform those ideas into written letters, words, and sentences (transcription). Work with children in grades four through six led Berninger to differentiate text generation from revising, and work with these and older (seventh through ninth grade) students led her to differentiate between planning at the advanced stage (prior to writing) and online stage (while producing text), between online revising and post-writing review and revision, and between declarative and procedural knowledge and metacognition. With these older students, she recognized the need for a working memory construct in the writing process model to explain the interaction between long term memory and writing processes. This working memory construct should also be relevant in understanding college students' production of connected text.

The model developed for the present study included some of the elements that Berninger incorporated into her adaptation, but it sought to extend that formulation by including specific constructs that are closely aligned with the neuropsychological literature. The bottom half of the current model in Figure 1 (below the box for "Understanding of the Task") represents the basic information processing that occurs in response to writing task demands. The top half of the model accounts for developmental progress by adding variables for assorted levels of task difficulty and an individual student's knowledge and motivation. The model includes factors that are thought to influence writing performance, and the arrows identify directions of predicted influence. For example, the objective demands of the writing task (i.e., required length, level of difficulty, type of writing, narrative, expository, etc., and time limit) combine with the student's knowledge and motivation to influence the individual's understanding of the task. In turn, understanding leads to retrieval of knowledge from long term memory, activation of short term memory (a temporary holding space), and selection and deployment of executive functions (knowledge of which is also retrieved from long term memory). These factors operate within working memory to create output that includes behavior (i.e., the observable isolated and higher level writing skills that have been described previously), the written product, and potential changes in the student's knowledge and motivation that may influence future writing performance. Testing all of the model's components would be beyond the scope possible in this project. Knowledge (measured by assessing Isolated Writing Skills) and metacognition (Executive Functions) were of primary interest because of their potential for instructional intervention. It is believed that these skills operate within, and would be constrained by, working memory skills. Therefore, the present study focused on these three constructs and examined their relations to the production of connected text (Figure 2).

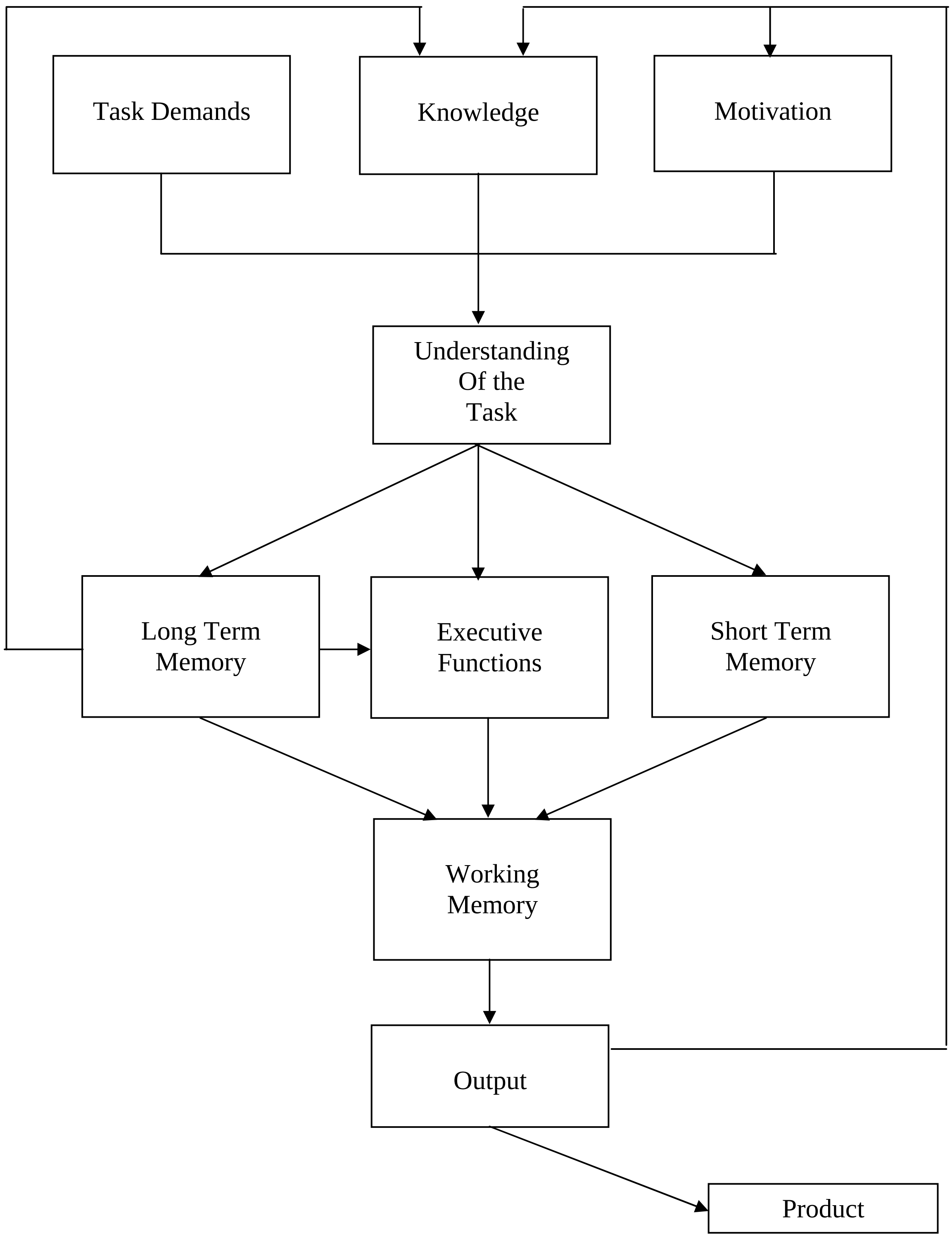

Figure 1. Proposed writing process model.

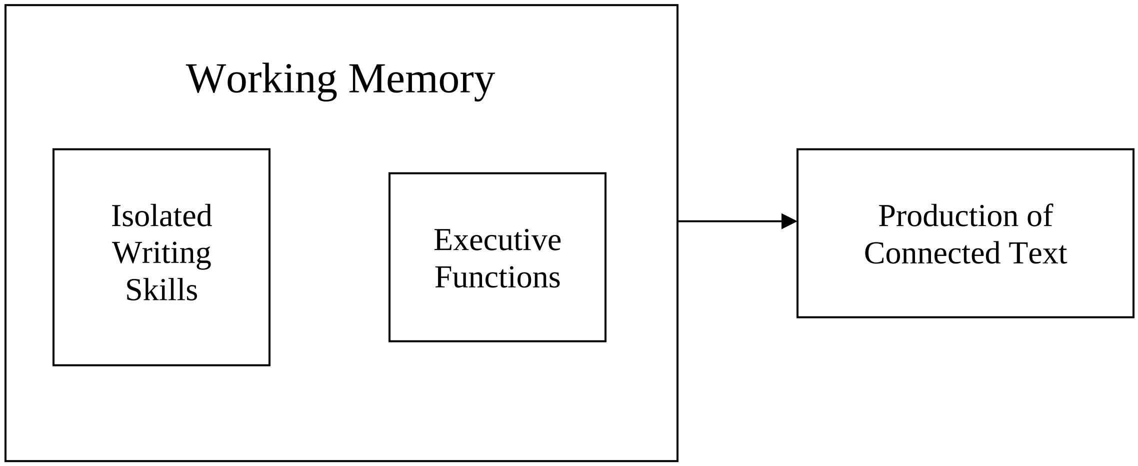

Figure 2. Elements of the model tested in the present study.

Other Studies of Writing Skills and Processes

The following sections provide a review of studies published by investigators who were working to understand isolated writing skills, cognitive processes, and their potential relationships to production of connected text. Researchers summarized in this section have focused on exploring writing processes by examining writing problems. As with the comprehensive writing process models, these studies can be differentiated by their focus on isolated writing skills or their inclusion of inferred cognitive and metacognitive processes. Isolated writing skills that have been associated with global written expression scores include handwriting skills (Brooks, Vaughan, & Berninger, 1999; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997), spelling (Brooks et al., 1999; Graham, 1997; Graham et al., 1997; MacArthur, Graham, Schwartz, & Schafer, 1995; Wong, Wong, & Blenkinsop, 1989), orthographic processes (Brooks et al., 1999), story or essay length (Danoff, Harris, & Graham, 1993; De La Paz & Graham, 1997; De La Paz, Swanson, & Graham, 1998; Graham, 1997; MacArthur et al., 1995), fluency (De

La Paz & Graham, 1997; Wong et al., 1989), and mechanics (Danoff et al., 1993; MacArthur et al., 1995; Welch, 1992; Wong et al., 1989).

Cognitive and metacognitive processes have been inferred after observation of specific behaviors in student writers. These processes include metacognitive knowledge (Graham et al., 1993; MacArthur, Graham, & Schwartz, 1991; Welch, 1992; Wong et al., 1989), executive control (Graham, 1997), planning time (De La Paz & Graham, 1997), organization (Wong et al., 1989), and revising behavior (De La Paz & Graham, 1997; MacArthur et al., 1991). The processes have been related to quantitative and holistic ratings of quality (Brooks et al., 1999; Danoff et al., 1993; De La Paz & Graham, 1997; De La Paz et al., 1998; Graham, 1997; MacArthur et al., 1995; Wong et al., 1989), as well as the writers' affect (Graham et al., 1993; Welch, 1992), and sense of self-efficacy (Danoff et al., 1993; Graham et al., 1993).

Constructs associated with writing problems. Students with learning disabilities and writing problems have been the focus of descriptive, observational, and intervention studies. Descriptive and observational studies have served to increase knowledge without attempting to change students' behavior or outcomes. On the other hand, intervention studies create knowledge about skills and processes and serve as direct tests of causal models regarding the relation of component skills to skilled writing. Studies from both of these approaches are described in the following section and summarized in Tables 2 (Descriptive and Observational Studies) and 3 (Intervention Studies).

Descriptive and observational studies. Findings from three descriptive and observational studies are summarized in Table 2. These studies, completed by Graham and his colleagues, are notable for their findings regarding knowledge, attitude, and behavior. Students identified by teachers as having writing problems demonstrated weaknesses when compared to normally achieving peers on measures of their knowledge of the communicative purposes of writing and the qualities of effective writing and revising (Graham et al., 1993). They also had a limited view of the purpose of revising and thought it was used merely to correct errors (MacArthur et al., 1991). Although they thought they were as effective as normally achieving peers as writers, students with writing problems viewed the writing process less favorably than competent writers (Graham et al., 1993). They verbally offered appropriate and substantive revision ideas, but their actual revisions were deficient (MacArthur et al., 1991). The basic spelling and handwriting skills of poor writers accounted for a significant portion of the variance (25 - 42%) in ratings of compositional quality of the stories written by elementary students (Graham et al., 1997).

Table 2

Findings from Descriptive and Observational Studies of Weaknesses in Skills Related to Written Expression.

Study	Sample	Methodology	Constructs Related to Writing	Findings
Graham, Schwartz, & MacArthur (1993)	39 students with writing problems 29 normally achieving comparison peers Grades 4, 5, 7, & 8	Survey of attitudes, beliefs, and knowledge	Knowledge of writing and composing process	Comparison groups significantly stronger on measures of knowledge of communicative purposes of writing and qualities of effective writing and revising
			Attitudes toward writing	Poor writers viewed writing process less favorably than comparison group, but differences not significant
			Sense of self-efficacy as a writer	Groups did not differ on self-evaluations as effective writers

Table 2 (continued)

Study	Sample	Methodology	Constructs Related to Writing	Findings
MacArthur, Graham, & Schwartz (1991)	26 students with writing problems Grades 7 & 8	Interview survey of beliefs	Revision knowledge	Students believed purpose of revision was to correct errors
		Task that required students to suggest revisions for provided text	Revising behavior	Students offered substantive suggestions for revision that tended to address information included in the text
		Task that required students to revise provided text	Revision quality	Actual revisions were targeted at mechanical and minor word changes that had not effect on text meaning Fewer than half of the revisions were rated as improving text Revisions resulted in no overall change in length, quality, or number of mechanical errors
Graham, Berninger, Abbott, Abbott, & Whitaker (1997)	300 students from 8 schools 50 males and 50 females each from grades 1, 2, & 3	Students completed handwriting, spelling, and composition (story writing) measures	Mechanics (Spelling & Handwriting) Text generation Planning Organization Evaluation Content Generation	Mechanics accounted for significant portion of variance in ratings of compositional quality Authors suggested that the effect of mechanics on compositional quality may operate through the working memory resource allocation mechanism

Intervention studies. Findings from intervention studies are summarized in Table 3. Some studies have targeted basic skills for intervention and have accomplished mixed results. Although handwriting automaticity was increased with a long, intensive individual tutorial (Brooks et al., 1999), spelling has proven difficult to improve consistently (Brooks et al., 1999; De La Paz et al., 1998; MacArthur et al., 1995). Capitalization and punctuation skills have also resisted intervention efforts (De La Paz et al., 1998; MacArthur et al., 1995).

Metacognitive skills have also been the focus of intervention research. In addition to the teaching of a process approach to writing (Danoff et al., 1993), planning (Brooks et al., 1999; De La Paz, 1999; De La Paz, 2001; De La Paz & Graham, 1997) and reviewing and revising (Brooks et al., 1999; De La Paz et al., 1998; Graham, 1997; MacArthur et al., 1995) have been studied. Students have received direct instruction in the communicative purpose of writing (MacArthur et al., 1995) and have been supplied with checklists of the steps to complete in essay or story writing (De La Paz, 1999, & 2001; De La Paz et al., 1998; Welch, 1992).

These interventions have resulted in longer stories (Danoff et al., 1993) or essays (De La Paz, 1999, 2001, De La Paz et al., 1998; MacArthur et al., 1995). Quality ratings increases have typically been found (Brooks et al., 1999; De La Paz, 1999, 2001; De La Paz & Graham, 1997; De La Paz et al., 1998; MacArthur et al., 1995, Welch, 1992). Increased metacognitive knowledge (Welch, 1992), likelihood of creating a plan (De La Paz, 1999, 2001), and planning time (De La Paz & Graham, 1997) have occurred in response to intervention. Students have learned to make improvements through revision (Graham, 1997) and have gained a more positive attitude toward writing (Welch, 1992).

Some studies have assessed maintenance of gains and found that students retained their improved abilities for 2-4 weeks (Danoff et al., 1993; De La Paz, 1999).

Table 3

Findings from Intervention Studies of Weaknesses in Skills Related to Written Expression.

Study	**Sample**	**Methodology**	**Constructs Related to Writing**	**Findings**
Danoff, Harris, & Graham (1993)	3 students with learning disabilities and writing problems (2 in 5th grade & 1 in 4th grade)	Multiple baseline procedure with baseline story probe, instruction (process approach to writing), post-instruction story probe, and generalization story probe	Number of story elements produced	Students doubled or tripled number of story elements produced
				Gains were maintained over 2-4 week interval
			Story quality ratings	Story quality ratings were mixed after intervention
	3 normally achieving peers (classmates of students with LD)		Survey of opinions about intervention	Students and teachers rated the intervention positively

Table 3 (continued)

Study	**Sample**	**Methodology**	**Constructs Related to Writing**	**Findings**
Brooks, Vaughan, & Berninger (1999)	17 students with severe writing disabilities (14 males & 3 females) Grades 4 & 5	Pre- and Post-Treatment assessment Intervention: 8 months of weekly, 1-hour individual tutorials (Writer's Warm-up for 10 minutes, Orthographic & phonetic spelling practice for 20 minutes, Instruction and *Practice with Plan, Write, Review, & Revise (PWRR)* strategy)	Spelling	Spelling skills (WIAT and WRAT-3) did not reliably improve over the course
			Handwriting	Handwriting automaticity (Fluency and Retrieval measures) improved though post-test scores still fell in low average range
			Compositional quality	Ratings of compositional (WJ-R Writing Samples) quality improved from low average to average range scores

Table 3 (continued)

Study	**Sample**	**Methodology**	**Constructs Related to Writing**	**Findings**
Welch (1992)	18 students with poor writing skills (7 in treatment group, 11 in comparison group) Grade 6	Pre- and Post-Treatment assessment Intervention: *PLEASE* strategy (Pick topic, List information, Evaluate list, Activate paragraph, Supply supportive statements, End with concluding sentence and proofread with *COPS* procedure)	Attitude toward writing Metacognitive knowledge about writing Writing sample scores	Treatment group exceeded comparison group on post-test measures

Table 3 (continued)

Study	**Sample**	**Methodology**	**Constructs Related to Writing**	**Findings**
MacArthur, Graham, Schwartz, & Schafer (1995)	Students identified as having learning disabilities and poor writing skills 113 students in 12 classes in treatment group 94 students in 10 classes in control group	*Self-Regulated Strategy Development (SRSD) Model* Emphasized communicative purpose of writing, used direct instruction of writing skills, featured planning, drafting, revising, and editing	Spelling Capitalization Punctuation	No significant group differences on spelling, capitalization, or punctuation measures
			Quality ratings on narrative and informative essays	Treatment group scored significantly higher on quality ratings of both types of essays
			Length of essays	Treatment group wrote significantly longer narrative essay, but no significant length differences on informative essays

Table 3 (continued)

Study	**Sample**	**Methodology**	**Constructs Related to Writing**	**Findings**
Graham (1997)	12 students receiving resource room services for learning disabilities and writing problems Grades 5 & 6	Students were asked to write and revise 2 stories based on picture prompts. For the first story they were instructed to read the story carefully and revise it to "make it better." For the second story they were instructed in the use of the *Compare-Diagnose-Operate (CDO)* Procedure.	Revision types and quality of revisions	Most revisions were rated as improving text Rate of surface revision & non-surface revisions that changed meaning unaffected by revising condition CDO procedure associated with significantly more non-surface meaning preserving changes than normal revising process CDO revisions significantly more likely to be rated as improvements that normal revisions
			Overall story quality ratings Story length	Revising condition had no effect on length of story or overall quality change measures
			Student opinions of CDO procedure	83% of students expressed positive opinions of CDO procedure and stated they would recommend it to others

Table 3 (continued)

Study	Sample	Methodology	Constructs Related to Writing	Findings
De La Paz, Swanson, & Graham (1998)	12 students identified as having a learning disability and problems in writing Grade 8	Pre- and Post-Treatment assessment Intervention: Students wrote narrative and informative essays. They were instructed to ignore errors of spelling, capitalization, and punctuation and focus on higher level content revision. Also had groups for the CDO procedure and normal revising Completed 2 revision cycles: global (structure, organization, and ideas) and local (potential trouble spots within sentences)	Composition quality ratings	Composition quality ratings significantly higher for essays using CDO procedure than for normal revising procedures CDO revisions associated with significant quality improvements and increased length No significant differences for spelling, capitalization, or punctuation based on revising condition

Table 3 (continued)

Study	Sample	Methodology	Constructs Related to Writing	Findings
De La Paz & Graham (1997)	42 students identified as having a learning disability and problems in writing Grade 5, 6, & 7	Pre- and Post-Treatment assessment Intervention: 2 * 2 design that included dictation (vs. writing) and advanced planning instruction (vs. no advanced planning instruction) Comparison group students learned about the characteristics of good essays, read & revised sample essays for meaning and structure, and compared & shared their own essays with peers	Planning time Essay length Number of ideas in essay Essay coherence Survey of writer's beliefs about benefits of dictation and planning instruction	Advanced planning instruction associated with significantly increased time spent on planning for both dictation and writing conditions Planning + Dictation condition was associated with essays that were rated significantly higher than comparison group essays on measures of length, number of ideas, & coherence Participants believed dictation increased speed of planning essays and reduced worries about correct spelling, capitalization, and punctuation, but were frustrated by slow scribes and need to attend to own ideas as well as the words being placed on paper by scribe Two-thirds of participants expressed positive opinions and stated that they believed intervention improved their writing

Table 3 (continued)

Study	**Sample**	**Methodology**	**Constructs Related to Writing**	**Findings**
De La Paz (1999)	Regular education students	Pre- and Post-Treatment assessment	Planning	Prior to intervention, 7% produced plans. After intervention, 100% produced plans rated high in quality
		Maintenance probes 4 weeks after intervention was completed		Most students continued to use plans on maintenance essay
		Intervention: *PLAN* strategy targets planning (Pay attention to the prompt, List main ideas, Add supporting ideas, Number ideas)	Essay quality ratings	Essay quality scores rose for every student at post-test
			Essay quality gain ratings	All students maintained quality gains over baseline at post-test
		WRITE strategy reminded writers to keep planning while composing. (Work from plan to develop thesis statement, Remember goals, Include transition words, Try to use different kinds of sentences, & Exciting words)		All students except low-achieving (but not LD) maintained quality gains that were exhibited at initial post-test
				Quality gains were correlated with baseline ratings of ability. Higher achieving students made greater gains than others
		Cue cards provided with strategies to produce 5-paragraph essays	Essay length	Average essay length at post-test was more than double length at baseline for students of all abilities

Table 3 (continued)

Study	**Sample**	**Methodology**	**Constructs Related to Writing**	**Findings**
De La Paz (2001)	3 Students (2 with specific language impairment & 1 with ADHD)	Pre- and Post-Treatment assessment Intervention: Also used PLAN and WRITE strategies	Planning Essay quality ratings Essay length	All 3 students generated plans in post-test essay Post-test essay quality ratings exhibited substantial gains compared to baseline Average length of essays increased after intervention
Zimmerman & Kitsantas (2002)	72 Undergraduates Mean age 19-9	Social cognitive model Modeling Observational learning Sentence combining task	Post-exposure writing skills score	Students' degree of observational learning was related to writing skills scores
Johnstone, Ashbaugh, & Warfield (2002)	664 University sophomores, juniors, & seniors Accounting & other Business School majors Mean age 21	Students completed 8 writing assignments that were relevant to a series of 4 courses 60 minute writing task Multiple choice test of grammar, punctuation, and organization	Grammatical conventions, organization, professionalism of presentation (as well as technical accuracy & quality of analysis)	Writing skills scores correlated with writing initiative treatment (r = .17 - .19)

Weaknesses in the Writing Skills Literature

Although investigators have studied the influences of specific skills and identified potential contributions of underlying cognitive and metacognitive processes to writing outcomes, areas of weaknesses in the literature remain. For example, comprehensive formulations describing writing processes tend to be predominantly theoretical. Although there appear to be broadly held assumptions regarding developmental trends and sequences (e.g., the school and school district publications that disseminate information about typical development of writing skills in children), many publications do not cite an empirical base and appear to be anecdotal in origin. The literature lacks rigorous empirical validation. The present study was conducted in an attempt to increase the empirical research base regarding writing skills.

In addition to this weakness, some comprehensive models that have been tested have featured only observable isolated writing skills constructs. Exceptions to this trend include the classic Hayes and Flower (1980) model and Berninger and her colleagues' (1995) developmental adaptation of that early work. These models include inferred cognitive and metacognitive constructs, but there is a lack of consensus regarding the definitions of the inferred concepts.

This issue is discussed in greater detail in a later section covering executive functions. One objective of the present study was to add empirically based measures of cognitive and metacognitive functioning to measures of isolated writing skills and explore potential relationships of these constructs to the production of connected text. Whereas the measures selected for inclusion in the present study may not represent the final consensus on measures of executive function (a designation that is not likely to be conferred soon) the specific instruments and the functions they measure have been assembled because they have been included in the work of investigators in educational psychological and neuropsychological disciplines because they are thought to demonstrate adequate reliability and validity for their purpose.

Integration of these literatures is a goal of the present study in order to address the current failure to incorporate constructs and methods from neuropsychology into the study of writing skills. In part, it will be useful to create links between studies published in the educational literature to the neuropsychological literature. For example, prominent research on students who have weak writing skills has attributed outcomes to poor planning (DeLaPaz, 1999; DeLaPaz & Graham, 1997; Graham, 1997; MacArthur, Graham, & Schwartz, 1991). However, in this work, planning was defined as the time that elapsed between the delivery of the instruction to begin and the point at which writing actually did begin, with the inference that the interval was occupied by the student creating a plan for completion of the assigned task. This definition of planning may be related to the definition of planning that is operationalized in a typical neuropsychological measure of planning ability, but this empirical question has so far remained unexamined. Linking writing research to the neuropsychological literature would require investigators to collect executive function data on research participants along with writing measures and to test for potential relations. This goal was a primary objective of the current study.

Cognitive and Metacognitive Processes

Evidence in the writing literature indicates that cognitive and metacognitive processes are deployed to facilitate and constrain the production of written text. However, extensive testing of specific processes and their relations to writing outcomes has yet to occur. After a review of a cognitive construct (working memory) and a collection of metacognitive constructs (executive functions), the following section includes a summary of recently published work that examined the executive functioning of students with and without writing problems. Based on this review, working memory and executive function measures were included in the current study.

Working Memory

Working memory, and its relation to writing skills, may be best understood using the model first published by Baddeley and Hitch in 1974. Recently, Alan Baddeley received the American Psychological Association Award for Distinguished Scientific Contributions, largely in appreciation for the work he has done on this model. Baddeley (2001) used the occasion to review the model, its revisions, and its current formulation. As defined by Baddeley, working memory is defined as computational space, “the system or systems involved in the temporary maintenance and manipulation of information” (p. 852). He argued that the importance of working memory is in its functioning as well as its storage capacity.

The Baddeley and Hitch model was originally comprised of three components: (a) the phonological loop (formerly known as the articulatory loop), (b) the visuospatial sketchpad, and (c) the central executive. The phonological loop is concerned with acoustic and verbal information. It includes a phonological store, which has a duration of approximately two seconds without rehearsal, and an articulatory rehearsal system, which has been compared to subvocalization. The visuospatial sketchpad is concerned with visual or spatial information, such as spatial orientation. Both of these so-called slave systems are used for active temporary storage and may process information from stimulus input or long term memory. They are managed and directed by the central executive, an admittedly vaguely defined construct that comprises a limited capacity pool of general processing resources. Originally, Baddeley believed that the central executive possessed a separate storage capacity of its own, but he has recently argued that it is best understood solely as an attention allocation resource. He now asserts that the central executive serves three functions: (a) focusing available attention, (b) dividing attention in the face of multiple competing goals, and (c) switching attention when appropriate. A fourth component, the episodic buffer, has recently been added to Baddeley's working memory model. The function of this new component is to serve as an interface between the other subsystems and long term memory because it can make use of information in more than one format (i.e., it is not limited to a single modality in the same manner as the phonological loop or visuospatial sketchpad).

Baddeley's construction of the central executive may be useful for understanding the relation between working memory and writing skills, partially in relation to the resource allocation model that has been suggested by Graham (Graham et al., 1993) and Berninger (Berninger et al., 1995). If working memory is a computational space that integrates both structure and function, and the central executive is the attention allocation resource within working memory, then the capacity and efficiency of working memory may influence an individual's ability to plan, organize, compose, monitor, and revise written text through the deployment of specific executive function skills by the central executive. The extent to which working memory resources are strained by the demands of simultaneous writing tasks is related to the use of executive functions (Welsh, 2002). When limited resources are consumed by non-automatic processes, performance on a task declines because accumulated task demands exceed resource capacity (Lea & Levy, 1999). These processes would occur within working memory's space, and their effectiveness would depend in part on working memory skills.

Executive Functions

The following section provides a summary of metacognition and executive functions from two empirical perspectives, neuropsychological and cognitive developmental. These two approaches to the study of metacognitive knowledge and behavior are reviewed, and a basis for understanding the relationship of the two perspectives is offered. The variety of definitions of executive functions from the neuropsychological literature are then reviewed, along with one recent study that examined the executive functioning of elementary school children with and without problems in written expression. Finally, the specific definition of the construct for the purpose of the proposed research is detailed.

Two perspectives on executive functions. Investigators have explored executive function processes and behavioral outcomes from two broad perspectives, neuropsychological and cognitive developmental. Barkley and others (e.g., Denckla, Pennington, Seidman, and Biederman, among others) have framed and investigated their questions within the traditions of neuropsychological research. A slightly different perspective has been exercised in the cognitive developmental psychology literature.

There, investigators such as Flavell and Kuhn have studied and described metamemory, metacognition, metacognitive skills, and metacognitive knowledge, concepts that are grounded in the information processing models of cognitive developmental psychology. Notably, fundamental information processing models form the foundation of writing skills (according to Hayes & Flower, 1980; Berninger, 1994; and the model developed for the present study), cognitive and metacognitive skills, and executive functions (the investigation of which may improve the writing literature).

Considering the remarkable variability in terminology across the two theoretical and empirical traditions, it becomes important to clarify the constructs included in the proposed research. Therefore, for the purposes of the proposed research, usage of the terms metamemory, metacognition or metacognitive skills or knowledge refers to Flavell's (1976) definition: "metamemory refers to one's knowledge concerning one's own cognitive processes and products or anything related to them, e.g., the learning-relevant properties of information or data" (p. 232), and his specification that the term "refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or directive" (p. 232). This definition is the standard and is consistently cited as an empirical assumption in the metacognitive literature. The term executive function refers conceptually to the processes and behaviors that an individual generates and deploys in the deliberate pursuit of a goal.

Metacognition and executive functions can be linked neurologically to one another through their associations with the frontal and prefrontal regions of the brain and through their functional interrelationship. Research in both literatures has provided evidence of frontal and prefrontal activity during metacognitive and executive function tasks (Seidman, Biederman, Faraone, Weber, & Ouelette, 1997). Theoretically, metacognitive knowledge can be said to underlie the behaviors that comprise executive functions. It is believed that executive functions are deployed, facilitated, and constrained by metacognitive knowledge. For example, metacognitive knowledge concerning the difficulty of a writing task, appropriate writing strategies, and one's own writing skills may lead an individual to generate and deploy executive function behaviors such as planning and outlining an essay prior to writing it out completely. The relationship of the two constructs, metacognitive knowledge and executive functions, is therefore believed to be one of source and product, of knowledge and behavior.

Defining executive functions. Although contributors to the cognitive and developmental psychological literatures appear to enjoy consensus in the conceptual and operational definitions (if not in terminology) of metamemory and metacognition, contributors to the neuropsychological literature continue to grapple with defining the construct and processes of executive functions. In 1996, Lyon and Krasnegor published a compilation of contributions to the National Institute of Child Health and Human Development (NICHD) Conference on Attention, Memory, and Executive Function. In an introduction to that text, Lyon acknowledged that understanding of executive functions remains "limited and fragmented" (p. 4) because of the divergent assumptions, questions, and methodologies that underlie the work of investigators who study and publish in this field. He defined executive functions as the "ability to select, deploy, monitor, and control cognitive strategies to learn, remember, and think" (p. 3). This and other definitions of executive functions can be considered extensions of Flavell's (1976) characterization of metamemory. Whereas Flavell referred to the knowledge that concerns cognitive processes, definitions of executive functions refer to abilities (which relate to knowledge) and behaviors (which imply the action of processes and their outcomes).

Contributors to the NICHD conference formulated conceptual and operational definitions from three perspectives: (a) information processing, (b) neuropsychological, and (c) behavioral. Problems with definition specificity and the psychometric properties of attention, memory, and executive function measures have been broadly acknowledged. Definitions of executive functions vary across theorists. For example, Morris (1996) cited lack of consensus in the definitions of the constructs and considerable overlap in the constructs that are assessed by measures in the literature in a meta-analysis of all of the articles published during a five-year period in the following journals: (a) *Brain & Language*, (b) *Child Development*, (c) *Educational Psychology,* (d) *Journal of Clinical and Consulting Neuropsychology,* (e) *Journal of Learning Disabilities,* (f) *Learning Disability Quarterly*. In studies that reported assessments of school-aged children, Morris found more than 25 measures of attention, 15 measures of memory and learning, and more than 20 measures of executive function. Despite all of this variety, it is possible to find broad conceptual consistencies across theorists and research. For example, though Lyon (1996) asserted that the construct of executive function seemed resistant to being defined specifically, he did recognize its links to the constructs of metacognition and mental control processes. Executive functions have frequently been studied in the context of attention research. Impairment in executive function has come to be strongly associated with the presence of attention disorders.

The following sections summarize definitions of executive function and identify characteristics that are common across investigators. Finally, one recent study that examined the relationship of executive functioning to writing skills in elementary students is reviewed, and a specific definition of executive function for the purposes of this study is proposed.

Borkowski and Burke (1996) defined executive function as referring to “task analytic, strategy selection, and monitoring skills necessary for higher-level problem solving” (p. 256). They argued that the construct was synonymous with planning and self-regulation and specified task analysis, strategy selection, strategy monitoring, and strategy revision as essential components of executive functioning.

Denckla (1996) defined executive functions as domain-general processes that subsume other constructs, such as anticipatory set, preparedness to act, freedom from interference, and ability to sequence behavioral outcomes. She argued that executive functions exert control over inhibition, delayed responding, maintenance of a response, and planning of a sequence of behaviors. She further argued that measures of executive function were only useful to the extent that they were not automatized in an individual because tasks that are easy or automatic fail to require the deployment of executive functions for successful completion. According to Denckla, potential measures of executive function include the Stroop Color Word Test, the Rey-Osterreith Complex Figure Test, the California Verbal Learning Test, visual search tasks, motor sequencing tasks, Tower of London or Hanoi, Diamond’s Six Boxes, the Contingency Naming Test, the Tinker Toy Test, temporal order memory tasks, and self-ordered pointing tasks.

Hayes, Gifford, and Ruckstuhl (1996) defined executive functions as a component of metacognition that involves selecting, monitoring, and revising behavioral strategies based on task analysis, planning, strategy selection, attention allocation, monitoring of behavior, reflecting on progress, and revision of behavior if necessary. They noted that hundreds of tests have been used in executive function research, including measures of inhibition (the Stroop Color Word Test, the Wisconsin Card Sorting Test, the Tower of Hanoi, the Tapping Test, the Trail Making Test, and hand movement tasks), ability to switch solutions (the Wisconsin Card Sorting Test, the Tapping Test, Rapid Alternating Stimulus Naming Test, Visual Search Test, and the Trail Making Test), planning (Tower of Hanoi, hand movement tasks, and Rey-Osterreith Complex Figure Test), attentional control (Tapping Test, Rapid Alternating Stimulus Naming Test, and Visual Search tasks), and verbal fluency (Controlled Oral Word Association Test).

Barkley (1996) cited four characteristics as essential for determining whether an action is “executive.” First, the action in question must be a behavior that is about and that acts upon behavior. It must also alter the probability that a subsequent behavior may be performed. It must involve time delay between an environmental event and subsequent response, and the initial executive act must involve inhibition and delay of other competing behaviors. In short, Barkley defined executive functions as inherently self-regulating. In addition to inhibition, executive functions include self-monitoring, working memory, planning, organizing, interference prevention, and intention to act.

Pennington, Bennetto, McAleer, and Roberts (1996) described executive function as a provisional and general means of self-regulation, specifically “the ability to maintain an appropriate problem-solving set for attainment of a future goal” (p. 327). Pennington and his colleagues were critical of the psychometric characteristics of executive function measures and argued that they fail to demonstrate acceptable discriminant validity. Nevertheless, they stated that the construct of executive function generally refers to inhibition, planning, and mental representations of tasks and goals. In contrast to Barkley's (1996) formulation, they stated that working memory, though critical to understanding executive functioning, is not an executive function itself. Rather, in their conceptualization, working memory is a limited capacity computational arena that functions to select behaviors and monitor and evaluate their outcomes. It interacts with both short term memory and long term memory and is critical because it functions across time, thereby accounting for the ability to inhibit current behaviors in favor of postponed gratification.

In a separate review of executive functions and developmental psychopathology, Pennington and Ozonoff (1996) stated that typical lists of executive functions include set-shifting, set-maintenance, interference control, inhibition, integration across space and time, and planning. In fifteen of the eighteen studies they reviewed, these investigators found significant differences in the executive functioning of children with Attention Deficit/Hyperactivity Disorder (ADHD) compared to members of control groups. Across the studies, sixty measures of executive function were used. Approximately two-thirds of these measures demonstrated impairment in children with ADHD. The measures with the most consistent record of impairment were the Tower of Hanoi, the errors score on the Matching Familiar Figures Test, the Stroop Color Word Test, the Trail Making Test form B, and measures of motor inhibition. Verbal memory and language tasks did not result in consistent differences between groups.

Other investigators have proposed definitions, components, and measures of executive function as well. In their review of neuropsychological evaluation of executive functions, Stern and Prohaska (1996) stated that "executive functions refer to those abilities that allow one to carry out social and instrumental activities successfully, such as engaging with others effectively, planning activities, solving problems, and interacting with the environment to get needs met" (p. 243). They specified response set, inhibition (including impulse control), planning, organization, judgment, reasoning, concept formation, abstraction, initiation, and fluency as executive functions and linked them to specific measures. For example, response set (i.e., the ability to establish, maintain, and shift a set of specific responses) was measurable by the Trail Making Test and the Wisconsin Card Sorting Test. Inhibition and impulse control were measurable by Go/No Go tasks and the Stroop Color Word Test. Planning and organization were measurable by Porteus Mazes, the Tower of London, and the Hooper Visual Organization Test. Judgment, reasoning, concept formation, and abstraction were measurable by the Proverb Test, the Category Test, Raven's Progressive Matrices, and the Wechsler Adult Intelligence Scale (Revised Edition) Comprehension and Similarities subtests. Initiation and fluency were measurable by the Controlled Oral Word Fluency Test and the Ruff Figural Fluency Test.

Lazar and Frank (1998) explored frontal systems dysfunction in children with ADHD and learning disabilities. They defined executive function as the "ability to explore, to monitor and shift the direction of attention, to initiate and direct language, to organize methods of memorization, to temporarily discriminate items in memory, and to inhibit interference during recall" (p. 161). They averaged scores from Raven's

Progressive Matrices, the Token Test, the Boston Naming Test, and the Word Structure subtest of the Comprehensive Evaluation of Language Functioning, Revised, to obtain a general executive function score. Inhibition was assessed by the three tasks of the Gordon Diagnostic System and the Matching Familiar Figures Test. Problem solving was measured by the Wisconsin Card Sorting Test, and working memory was evaluated using the Wechsler Intelligence Scale for Children, Revised or Third Edition, Digit Span subtest, the Illinois Test of Psycholinguistic Abilities Visual Sequencing of Memory subtest, and the Kaufman Assessment Battery for Children Hand Movement subtest.

Kempton, Vance, Maruff, Luk, Costin, and Pantelis (1999) examined the effects of stimulant medication on the executive function performance of children with ADHD. They defined executive functions as “cognitive processes through which performance is optimized in situations requiring the operation of a number of cognitive processes” (p. 527-528). These functions, linked theoretically to frontal brain structures, included organization, attentional processes, inhibition of inappropriate responses, and self-monitoring.

Morgan and Liliefield (2000) also defined executive functions in their meta-analysis of studies of antisocial behaviors and neuropsychological measures of executive functioning. They noted that executive functions were difficult to operationalize because they could only be inferred from observed changes in lower level cognitive functions. Components of executive function included volition, planning, purposive action, and effective performance. Their analysis indicated that, though no measures were entirely specific to frontal brain damage, the Category Test of the Halstead-Reitan Neuropsychological Battery, the Qualitative score on the Porteus Mazes, the Stroop

Interference score, the Trail Making Test, form B, the Perseverative error score on the Wisconsin Card Sorting Test, and Verbal Fluency tests were useful markers of executive dysfunction.

Houghton and his colleagues (1999) did not offer a conceptual definition in their study of differential patterns of executive function in children with ADHD according to gender and subtype. However, they did include response inhibition, forethought, planning, organization, set shifting, categorization, inhibition, visual search, attention, mental flexibility, motor function and working memory as components of executive function in the 122 student participants in their study and found significant differences on the Wisconsin Card Sorting Test and Stroop Color Word Test. Klorman and her colleagues (1999) also did not specify a conceptual definition of executive function, but included components of volition, planning, purposive action, and effective performance in their study of children with attentional, oppositional defiant, and reading disorders. They linked the Wisconsin Card Sorting Test to flexibility and set shifting and the Tower of Hanoi to planning and management of goal conflict. They found that executive deficits characterized only the combined subtype of Attention-Deficit/Hyperactivity Disorder but not the inattentive subtype. They further found that results were not affected by the presence of reading disability or oppositional defiant disorder.

When examined together, there is notable consistency across researchers in the conceptual definitions of executive function and with some of the operationalized components of the construct. For example, in his summary of the NICHD conference contributions, Eslinger (1996) noted that definitions emphasized: (a) an orderly approach to problems, (b) maintenance of a problem-solving set for future goals, (c) control processes for organization of behavior over time, (d) flexibility and effectiveness of verbal self-regulation, (e) skillful use of strategies, and (f) behaviors that alter the likelihood of later events and behaviors (p. 380). Espy and Kaufmann (2002) noted continuing difficulty in defining the characteristics of executive functions but argued that they "involve higher order, integrative control-type skills" (p. 117). Linking executive function processes to writing skills may be more difficult than finding conceptual consistency in executive function definitions. One recent study examined the executive functioning of elementary students with and without writing problems.

Executive functions in elementary school children with and without problems in written expression. To date, studies that examine possible relationships between executive functions and written expression in college students have not been published. Hooper and his colleagues (2002) published the first study that examined the executive functioning of children in relation to their writing skills. In that work, they conceptually defined executive functions as "the higher order control processes that regulate cognition during tasks such as writing" (p. 61), and they attributed the four executive function domains of their study to Denckla (1996): (a) initiation, (b) set shifting, (c) sustaining, and (d) inhibition/stopping. After controlling for reading decoding skills, their analysis revealed that children with weaknesses in written expression performed significantly more poorly than their normal peers on measures of initiation (Sentence Formulation subtest total score from the Comprehensive Evaluation of Language Fundamentals, Revised; Controlled Oral Word Association Test total score; and a working memory test designed for this study) and set shifting (Wisconsin Card Sorting Test number of categories correct and number of perseverative errors; and the Tower of Hanoi). They also demonstrated relative weaknesses that approached but did not attain significance on measures of sustaining attention (Visual Search and Attention Test omissions score; and the Matching Familiar Figures Test number of errors). No significant differences emerged on measures of inhibition and stopping (Visual Search and Attention Test commissions score; and the Matching Familiar Figures Test latency score). Notably, effect sizes were small (.09 - .16), indicating that the variance in children's writing skills was greater than could be explained with knowledge of executive functions as defined and measured in this study. Clearly, in executive function research, care must be taken to operationalize the components of executive function and to select measures that minimize the shared variance of executive functions across measures.

Executive functions defined for the present study. Conceptually, all of the reviewed definitions describe the importance of metacognitive control processes that govern and regulate behavior by allocating cognitive resources and deploying strategies in the service of goal-directed behavior. In an informal survey of ten respondents in 1994, the NICHD collected componential definitions of executive function (Lyon, 1996). Thirty-three terms were generated, and more than 40% of respondents agreed on six characteristic executive functions: (a) self-regulation, (b) sequencing of behavior, (c) flexibility, (d) response inhibition, (e) planning, and (f) organization of behavior. This conceptual formulation and these components were incorporated into the present study and contributed to the definition and component skills of executive function. Executive functions were defined as processes and behaviors that are generated in the deliberate pursuit of a goal, including organizing, planning, monitoring, and inhibition of competing behaviors.

Relationship Between Working Memory and Executive Functions

An important question seems unresolved in the review of executive function definitions. Although Barkley (1996) includes working memory in his list of executive function components, few other theorists have constructed lists that are consistent with his perspective. The present study was based on a model that specifies that working memory is a separate construct, and although it is related to executive functioning, working memory is not itself an executive function. This perspective is consistent with this aspect of Baddeley's (2001) working memory formulation and with the Swanson and Berninger (1996) statement that working memory tasks tap executive functioning, an assertion that describes related but separate constructs. Thus, the relationship of working memory and executive functions can be said to be one of cognitive structure (working memory) and behavior (executive function). Previously, it was noted that metacognitive knowledge constrains and facilitates the use of executive function strategies. Working memory can be viewed as the space within which metacognition operates and executive functions are deployed. Baddeley's central executive component can be viewed as the operator that functions under the influence of metacognitive knowledge to deploy executive function strategies. These actions occur within the cognitive space described as working memory.

CHAPTER THREE: STATEMENT OF THE PROBLEM

Creating written text may be one of the most difficult tasks that educators ask students to perform. In order to produce a sample of connected text, students must generate ideas, retrieve information from long term memory, create an organizing plan, fit thoughts and ideas into the plan, place the strokes of letters, words, and punctuation symbols on paper, read the partially completed product, evaluate it in the context of task requirements, and revise and extend it as appropriate. Operation of all these simultaneous activities occurs in the computational arena known as working memory and may be facilitated and constrained by a variety of factors, including the student's proficiency in isolated writing skills, the extent to which the student's ability to generate and deploy executive functions is developed, and the student's working memory capacity.

Although the linguistic, metacognitive, and cognitive skills that are required to plan, organize, compose, and revise written text are acquired at rates that are specific to each individual, these abilities are typically believed to develop across childhood and be generally in place by early to mid-adolescence (Kuhn, 1999). Demands for writing in order to communicate, inform, and persuade readers also increase across these years. Requirements for in-class essays and research papers produced outside of class increase substantially in secondary grades, and assessments of writing skills have begun to be recognized as important indicators of readiness to progress to the next grade. In fact, many states have included writing assessments in the battery of tests that measure schools' performance and determine student promotions (Feifer & De Fina, 2002). For example, the state of North Carolina has implemented statewide writing assessments that are administered in fourth, seventh, and tenth grades. Students are expected to demonstrate grade level competence in writing skills, and these measures are considered in grade placement decisions. Colleges and universities have also increased demands for demonstration of writing competence and have begun to emphasize writing improvement across departments and disciplines (Bernard-Donals, 2004).

Despite recognizing the importance of writing skills to long term academic success, the skills and processes that contribute to the production of written text have received little empirical examination, particularly in comparison to reading performance. Although reading skills and the development of fluent, accurate reading have been extensively studied, understanding the development of written expression ability remains largely an exercise in theoretical or anecdotal description. Researchers who study written expression have failed to identify component writing skills and cognitive and metacognitive processes that may be related to success. Rather than focus on this analysis, contributors to the school psychology literature, in particular, have sought to create and test intervention strategies (e.g., De La Paz, 1999; De La Paz & Graham, 1997). Clearly, helping children become better writers is an important goal. However, intervention strategies that have been created without understanding of the component skills and processes of written expression may demonstrate diminished efficacy because they have not been empirically linked to specific skills deficits.

Eventually, the science and practice of school psychology can be better informed by empirical study of written expression from a developmental perspective. That ambitious work was beyond the scope that was possible in the present study. An initial, exploratory step toward this understanding was to examine individual writing skills and related cognitive processes in a sample of students who are old enough to have fully developed writing abilities. For the present study, students studying introductory psychology were recruited to complete a battery of measures that assessed a variety of writing skills and underlying cognitive and metacognitive processes. The data were examined to gain a better understanding of how isolated writing skills, executive functions, and working memory are related to the production of connected text and to each other. This approach was intended to provide an opportunity to develop a model of written expression that could later be tested for downward extension to younger students. It was predicted that results might provide guidance such that it may eventually become possible to design and implement interventions targeted at specific skills or process weaknesses. An additional goal was to identify directions for further research in this area. The purpose of the present study was to examine isolated writing skills, executive functions, working memory, and production of connected text in a college-aged sample as an exploratory step toward these goals.

For the purposes of the present study, the following key terms were defined:

- *Production of connected text* was defined as one or more paragraphs rendered in the form of a letter, essay, story, or report. In the present study, production of connected text was assessed by performance on the Wechsler Individual Achievement Test (WIAT) Written Expression test (The Psychological Corporation, 1992), which required participants to produce a letter that described either an ideal place or a desired day trip. *Unsupported production of connected text* (UNS WIAT score) refers to a letter written without the assistance of an outline designed to support executive functions. It was measured by the sum of scores on the component skills assessed by the WIAT

Written Expression Test (without outline), including Ideas and Development; Organization, Unity, and Coherence; Vocabulary; Sentence Structure and Variety; Grammar and Usage; and Capitalization and Punctuation. *Supported production of connected text* (SUP WIAT score) refers to a letter written with this supportive outline. It was measured by the sum of scores on the component skills assessed by the WIAT Written Expression Test (with outline).

- *Isolated writing skills* (IWS) were defined as measurable, observable writing skills that are deployed in relative isolation to produce words or sentences. These skills were assessed using the Mather-Woodcock Group Writing Tests (GWT; Mather & Woodcock, 1997). The GWT Basic Writing Skills composite score incorporated scores on tests of Spelling (spelling individual words) and Editing (the ability to identify and correct errors in individual sentences).
- *Executive functions* (EF) were defined as processes and behaviors that are generated in the deliberate pursuit of a goal. These processes and behaviors were measured with the use of a self-report questionnaire, which included items that were adapted from the Behavior Rating Inventory of Executive Function (Gioia, Isquith, Guy, & Kenworthy, 2000). The executive function composite score was comprised of the sum of the scores of organizing, planning, monitoring, and inhibition of competing behaviors subscales. A second measure of executive function, the Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993), was also

administered to participants. It was available for use to validate the self-report questionnaire (which was adapted from a validated parent rating scale designed for younger children).

- *Working memory* (WM) was defined as the cognitive space within which isolated writing skills and executive functions are activated and coordinated in order to produce a response such as connected text. Participants' working memory abilities were assessed with subtests from the Woodcock-Johnson III Tests of Cognitive Skills (McGrew & Woodcock, 2001). The working memory score was the composite of scores on tasks that required participants to repeat strings of numbers in reverse order and to sort lists of objects and numbers and repeat them according to instructions.

Present study goals, their related hypotheses, and the data analysis strategies that were used to test them are listed in the following section:

1. Investigate the extent to which the constructs of isolated writing skills, executive functions, and working memory predicted scores on a measure of connected text production.

- Hypothesis 1: Isolated writing skills, executive functions, and working memory variables in combination will account for a significant portion of the variance in scores on a measure of production of connected text.
    - Isolated writing skills, executive functions, and working memory and their interaction terms were entered into a regression equation to predict scores on unsupported production of connected text.
    - Regression equation: UNS WIAT score = IWS + EF + WM

  - The hypothesis would be supported if the overall R^2 were significant.

2. Investigate the extent to which executive function and working memory might interact to influence scores on an unsupported connected text production measure.

   - Hypothesis 2: The relationship of executive functions to the production of connected text will be conditional on working memory, such that the impact of executive processes will be greater as working memory scores increase.
     - Regression equation: UNS WIAT score = EF + WM + EF*WM
     - This hypothesis would be supported if the EF*WM interaction in the regression were significant and follow-up analyses were consistent with the pattern described.
   - Exploratory analyses: The semipartial correlations from the multiple regression analysis and the bivariate correlation matrix for all variables were examined to determine to what extent each of the dependent variables accounts for unique or shared variance in the prediction of connected text production.

3. Test the role of executive functioning in the production of connected text by assessing the extent to which reducing the organizational demands on a connected text production task reduced the relationship between executive functions and quality of connected text production.

   - Hypothesis 3: Students who have weak executive function skills will benefit more from the provision of a supportive outline than students who have strong executive function skills.

- Students were divided into high and low EF groups using a median split. A 2 (EF Level) * 2 (Essay Type) analysis of variance with repeated measures on Essay Type (SUP WIAT and UNS WIAT) was used to test the hypothesis.
- The hypothesis would be supported if the EF*Essay Type interaction were significant, and the tests for simple main effects showed greater improvement for the SUPP WIAT for the low EF group.

CHAPTER FOUR: METHOD

Participants

Sixty-three undergraduate students from a large university in the southeastern United States participated in the present study. Fifty-seven percent of the participants were female, and 43% were male. The sample was relatively evenly distributed across class, with 22% freshmen, 29% sophomores, 25% juniors, and 24% seniors. Students ranged in age from 17 to 53 years old, with a mean age of 23.31 years (*SD* = 7.84 years). More than half (51%) were younger than 20 years old, another 27% were between 20 and 25 years old, and 22% were more than 25 years old. Most students (55%) reported that they had previously been identified as academically gifted students, including four students who had a dual identification of academic giftedness and specific learning disability in reading. Two other students (3% of the total sample) reported that they had specific learning disabilities in reading. No learning disabilities in written expression or mathematics were reported. Three percent of participants reported having been diagnosed with Attention-Deficit/Hyperactivity Disorder.

Measures

Each participant completed a battery of tests that included measures of isolated writing skills, executive function, working memory, and production of connected text. The measures are described in the following subsections. For each measure, a general description of the purposes and format of the instrument is followed by a summary of its normative sample, the types of scores that are derived from the measure, levels of clinically relevant scores (for measures for which normative data is available), and, when available, reliability and validity information.

Mather-Woodcock Group Writing Tests (GWT)

The GWT consists of four tasks that assess different writing skills. The Dictation Spelling subtest requires students to spell a list of individual words. The Editing subtest requires students to read sentences and correct errors of spelling, usage, capitalization, or punctuation. There is one error in each sentence, and participants are given twelve minutes to complete the task. The Writing Fluency subtest allows students seven minutes to write as many short sentences as possible, given a picture and three words per picture as stimuli. The Writing Samples subtest requires students to read directions and write sentences in accordance with item-specific instructions.

The GWT was standardized on a sample of 5,480 individuals in over 100 geographically diverse communities in the United States. The sample included 3,345 individuals aged 6 to 18 years and 2,135 individuals aged 19 to over 90 years old. The college/university sample included 912 individuals.

The GWT yields standard scores for each of the subtests and composite scores for three clusters: (a) Basic Writing (Dictation Spelling and Editing), (b) Written Expression (Writing Fluency and Writing Samples), and (c) Total Writing (all four subtests). These scores have a mean of 100 and a standard deviation of 15. Standard scores below 85 represent the lowest sixteen percent of scores obtained by members of the normative sample and are considered weak.

Reliability. Split-half reliability coefficients reported for individuals aged 20 to 29 were .88 for Dictation Spelling, .90 for Editing, .75 for Writing Fluency, .92 for Writing Samples, and .93 for the GWT Basic Writing cluster score (Mather & Woodcock, 1997).

Validity. The GWT manual (Mather & Woodcock, 1997) reports the results of validity studies that compared GWT scores with scores obtained on the Basic Achievement Skills Individual Screener, the Kaufman Tests of Educational Achievement, the Peabody Individual Achievement Test, and the Wide Range Achievement Test-Revised for students in third, fourth, tenth, and eleventh grade. Validity studies were not reported for college-aged students. However, many items on the GWT have been derived from the Woodcock-Johnson Psychoeducational Battery, Revised Tests of Achievement, which has demonstrated validity in this population.

Woodcock-Johnson III Tests of Achievement Handwriting Subtest

Participants' handwriting was scored using the rubric from the WJ-III Handwriting subtest. Scores are derived by comparison of an individual's handwriting on a selected task to standard samples provided in the manual (McGrew & Woodcock, 2001).

The subtest yields standard scores that have a mean of 100 and a standard deviation of 15. Standard scores below 85 represent the lowest sixteen percent of scores obtained by members of the normative sample and are considered weak.

Reliability. Interrater reliability was .71-.85 for Handwriting. Alternate Forms reliability for Handwriting was also .71-.85. With an interval of one year, test-retest reliability was .60-.69 for Handwriting (McGrew & Woodcock, 2001).

Executive Function Questionnaire (EFQ)

A questionnaire, adapted from items that appeared in the Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000), was developed for the present study to assess behaviors related to executive functioning in the home and school settings. The questionnaire can be found in Appendix A. Subscales measure an individual's ability to control one's own impulses and to stop behavior when appropriate (*Inhibit*), to hold information in mind to complete a task (*Working Memory*), to anticipate future events, set goals, and develop steps to achieve goals systematically (*Plan/Organize*), to keep one's personal workspace, play areas, and materials in order (*Organization of Materials*), and to check one's own work and evaluate performance in the context of a goal (*Monitor*). Raw scores on the subscales are summed for a Questionnaire Total score.

In order to assess the reliability of the questionnaire, a separate sample of 34 college students was recruited to complete the questionnaire during two sessions that were separated by a four-week interval. That sample consisted of 15 males and 19 females. Twenty-four students reported that they had been identified as academically gifted, including one student who had been identified as being both academically gifted and having a specific learning disability in reading. One other student had been identified as having a specific learning disability in reading, and one student had been diagnosed as having Attention-Deficit/Hyperactivity Disorder. Participants for this part of the project ranged in age from 17 to 24, with a mean age of 18.24 years (SD = 1.58 years). In this sample, 81% of participants reported age less than 20 years, and 19% reported age between 20 and 24 years.

Test-retest correlations for the self-report questionnaire ranged from .71 for the Monitoring subscale to .81 for the Inhibit subscale, with the test-retest correlation for the questionnaire composite score at .85. This composite self-report correlation is consistent with the published test-retest composite correlations for parent (r = .82) and teacher (r = .88) raters on the BRIEF (Gioia et al., 2000).

Wisconsin Card Sorting Test (WCST)

The WCST assesses executive function by testing an individual's ability to sort cards according to a principle of class membership and to alter his or her approach as unannounced shifts in the sorting rule occur during the test administration. It provides information about overall success as well as potential difficulty areas such as inefficient initial conceptualization, perseveration, failure to maintain set, and inefficient learning (Heaton et al., 1993).

To complete the task, students are presented with images of cards on a computer screen. There are four key cards across the top of the screen, with images of one red triangle, two green stars, three yellow crosses, and four blue circles. At the bottom of the screen, a single card is presented to the student to be matched to one of the key cards on the basis of color, form, or number. After the student makes the match, the screen provides feedback about whether the match was correct or incorrect. Incorrect matches cannot be moved, but the student can make use of the information as he or she goes forward. After ten cards are correctly matched in a row, the matching rule changes. The task ends when 128 cards are matched or when the student has correctly completed six ten-card categories.

The WCST was normed by aggregating the data from six separate studies, for a total of 899 participants aged 6 to 89. Three hundred eighty-four participants were at least 20 years old.

The WCST yields raw scores for Total Administered and Total Correct; standard score for Perseverative Responses, Perseverative Errors, Nonperseverative Errors, and Conceptual Level Responses; and cumulative percentile scores for Categories Completed, Trials to Complete First Category, Failure to Maintain Set, and Learning to Learn. Standard scores have a mean of 100 and a standard deviation of 15. Standard scores below 85 represent the lowest sixteen percent of scores obtained by members of the normative sample and are considered weak.

Reliability. The WCST manual (Heaton et al., 1993) reports the results of three reliability studies conducted on the card-based (not computer administered) version of the test. Interscorer reliability coefficients ranged from .88 to .95 for Perseverative Responses, .92 to .97 for Perseverative Errors, and .75 to .88 for Nonperseverative Errors.

Validity. The WCST has been used extensively and validated as a neuropsychological measure that is particularly sensitive to frontal lobe dysfunction (Heaton et al., 1993; Romine et al., 2004). Students with frontal lobe dysfunction have performed more poorly than normal controls on measures of perseverative and nonperseverative errors, total trials administered in order to complete six categories, and learning efficiency.

Woodcock-Johnson III (WJ-III) Tests of Cognitive Abilities Working Memory Cluster

The WJ-III Working Memory Cluster is part of the Tests of Cognitive Abilities (McGrew & Woodcock, 2001), a battery of tests designed to measure an individual's general intellectual ability within the Cattell-Horn-Carroll theory of cognitive abilities. The Tests of Cognitive Abilities were normed with the WJ-III Tests of Achievement on a nationwide sample of 8,818 individuals aged two to ninety-plus years. The Working

Memory cluster was selected for administration to participants because it includes two tests that meet criteria for verbal working memory tasks. Each test requires the retention and manipulation of information in memory in order to produce a response and cannot be performed using only a rehearsal strategy. The Numbers Reversed test requires an individual to listen to a sequence of numbers (that increase in length after successful responses) and repeat it backwards. The Auditory Working Memory test requires an individual to listen to a set of words, sort them into two categories (objects and numbers), and recite the list of items in the two groups aloud.

The Working Memory Cluster yields standard scores for each of the two subtests and a composite score for the cluster. These scores have a mean of 100 and a standard deviation of 15. Standard scores below 85 represent the lowest sixteen percent of scores obtained by members of the normative sample and are considered weak.

Reliability. Split-half reliability correlation coefficients were reported in the WJ-III Technical Manual (McGrew & Woodcock, 2001). The Numbers Reversed subtest yielded a split-half reliability coefficient of .84 - .93 across norm group members whose ages ranged from two to more than eighty. The Auditory Working Memory subtest yielded split-half reliability coefficients of .80 - .94 for the same group. These scores were used to calculate cluster reliability scores in the .89 - .96 range.

Validity. Using cross-sectional normative data (McGrew & Woodcock, 2001), the authors observed that test and cluster scores produced growth curves that rose sharply from baseline at five years old, peaked in the early to mid-twenties, and declined gently after that. They asserted that this curve fit developmental theory concerning the working memory construct and provided evidence of validity. Further evidence was provided in the form of factor analysis. Numbers Reversed and Auditory Working Memory had high loadings (.69 and .72 respectively) on the Working Memory factors and nonsignificant loadings on other possible factors.

Correlations of the Working Memory cluster with clusters and indices on other IQ tests were also strong. In a preschool sample, the correlation of the Working Memory cluster with the Stanford-Binet, Fourth Edition Short Term Memory score was .64. In a group of third- through fifth-graders, the correlation of the Working Memory cluster with the Wechsler Intelligence Scale for Children, Third Edition Freedom From Distractibility Index score was .57. In a group of college students, the correlation of the Working Memory cluster with the Working Memory Index of the Wechsler Adult Intelligence Scale, Third Edition was .67. Evidence for lack of overlap with other constructs has been provided in studies that compared the Working Memory cluster tests with the Test of Variables of Attention, which yielded correlations in the range of .04 - .16 and the Behavior Assessment System for Children School Problems subscale, which yielded a correlation of .37.

Wechsler Individual Achievement Test (WIAT) Written Expression Subtest

The WIAT is an individually administered achievement battery (The Psychological Corporation, 1992). The Written Expression subtest assesses a variety of writing skills including development and organization of ideas (which may involve generating ideas and prewriting), unity and coherence of text (staying on topic without digression), vocabulary (word choice), sentence structure and variety (which may involve errors or lack of variety), grammar (may include verb tense, subject-verb agreement, and double negatives), capitalization, and punctuation. In the present study, participants completed the task by writing two letters that met the criteria specified in the instructions (either a letter describing the student's ideal place or inviting a friend to take a day trip to a location chosen by the participant). The first letter was written according to WIAT standard instructions; the second letter was written after the student was provided an outline that was designed to support production of connected text by reminding students to plan, write, review, and revise (Appendix B). The letters were then scored by a rater trained in the administration and scoring of the WIAT who was blind to the conditions under which the letters were written. The six writing skills domains measured by the test were rated on a scale from 1 (lowest) - 4 (highest). Raw scores were summed to create composite scores, which typically would be used to determine a norm referenced standard score. Norms are not available for students older than nineteen or for letters written with a supportive outline. Nonetheless, the test was included in the study design because the scoring criteria provided domain-specific information (domain scores) in addition to general information (composite scores) related to writing skills and because the task involves a fifteen minute time limit that is thought to increase the level of difficulty (and therefore the likelihood of executive function deployment). Domain and composite raw scores for unsupported and supported production of connected text were used in analyses.

The WIAT was normed on 4,252 children in thirteen age groups. Across middle school ages, the norm sample groups ranged from 334 - 366 students, with approximately equal numbers of males and females in each group. The norm sample was also designed to be representative of race/ethnicity as reported in the March 1988 census data and of geographic region. It was stratified according to parent education level.

Reliability. The manual (The Psychological Corporation, 1992) reports split-half reliability correlation coefficients for children and adolescents aged 8 - 17 that ranged from .76 to .84. Test-retest reliability for students in eighth grade was .76. Interscorer agreement was .89 for Prompt 1 (Ideal Place) was and .79 for Prompt 2 (Day Trip).

Validity. The WIAT manual (The Psychological Corporation, 1992) reports that content validity of the original measure was addressed through the use of expert reviewers who assessed whether prompts were unbiased and induced examinees to produce complex responses that included sufficient length and variety to allow scorers to apply the scoring criteria. Construct validity was established by correlating Written Expression scores with the composite scores derived for the WIAT. Written Expression scores were more highly correlated with Writing Composite scores than with Language Composites, which was interpreted as evidence that the test measures characteristics that are strongly related to writing but less related to broader language skills. Whereas correlation coefficients between Written Expression and the Writing Composite ranged from .82 - .86 for 11 - 14 year olds, coefficients between Written Expression and other composites ranged from .34 (Language Composite for thirteen-year-olds) to .90 (Language Composite for eleven-year-olds). The correlation coefficient of Written Expression with the Dictation subtest from the Woodcock-Johnson Psychoeducational Battery, Revised, Tests of Achievement was .72. Correlations of Written Expression with school grades were .34 (Reading), .34 (Math), and .36 (Spelling).

Procedure

After the proposed research received approval from the North Carolina State University Institutional Review Board, participants were recruited from a pool of students who were enrolled in an introductory psychology course.

Students completed the battery of measures during two testing sessions (Table 4). The first session was conducted in groups of two to eight students and included an explanation of the study, informed consent, and completion of the questionnaire and the GWT subtests. The second session was completed either with individual students or with groups of two students (with individual administration of the WCST and Working Memory tasks). In that session, students completed the WIAT Written Expression letters without and with the assistance of a supportive outline, the WCST, and the WJ-III Working Memory subtests, as well as debriefing on the purposes of the study.

The WIAT Written Expression letters were administered first without an outline and then with an outline (see Appendix B for administration instructions). This order was selected instead of a fully counterbalanced administration because administering the supported task before the unsupported task (which would occur in half of the sample if counterbalanced) could influence the scores obtained on the second (unsupported) task. The order of which prompt was completed first was counterbalanced. Thirty-two students completed Prompt 1 (without outline) first, followed by Prompt 2 (with outline). Thirty-one students completed Prompt 2 (without outline) first. Testing for order effects by comparing means revealed that there were no significant differences ($t(61) = -.20$, $p = .84$), regardless of which letter prompt was answered first.

Table 4

Order of Measures Completed by Participants

First Session:

- Group Writing Tests
    - Dictation Spelling
    - Editing
    - Writing Fluency
    - Writing Samples
- Questionnaire

Second Session:

- WIAT Written Expression letters
  (without & with outline)
- WJ-III Tests of Cognitive Skills
    - Numbers Reversed
    - Auditory Working Memory
- Wisconsin Card Sorting Test

CHAPTER FIVE: RESULTS AND DISCUSSION

This chapter presents the data analysis procedures and their results for the present study, including the descriptive, a priori, and post hoc analyses. Following the reporting of descriptive data, the results of testing for hypotheses, rationale for additional procedures, and post hoc exploratory analyses are presented.

Descriptive Statistics

Table 5 presents information for the composite predictor variables and the outcome variables that were analyzed for the hypotheses tested in the present study.

Table 5

Descriptive Statistics for Composite Predictor Variables and Outcome Variables

Variable	Mean	Standard Deviation	Possible Range	Obtained Range
Isolated Writing Skills	109.71	13.48	57-160	89-152
Executive Functions	23.17	9.58	0-74	7-47
Working Memory	102.27	10.36	14-160	82-129
Unsupported Production of Connected Text	17.38	2.30	6-24	13-23
Supported Production of Connected Text	17.90	2.75	6-24	12-24

The Isolated Writing Skills score is a standard score composite of the GWT Dictation Spelling and Editing subtests. The Executive Functions score represents the sum of the Inhibit, Plan/Organize, Organization of Materials, and Monitoring subscales of the executive functioning questionnaire. The Working Memory score is the standard score composite of the WJ-III Numbers Reversed and Auditory Working Memory subtests. The Unsupported Production of Connected Text score is the sum of ratings of

Ideas and Development; Organization, Unity, and Coherence; Vocabulary; Sentence Structure and Variety; Grammar and Usage; and Capitalization and Punctuation subscales of the WIAT Written Expression letter written without the assistance of an outline designed to support the deployment of executive functions. The Supported Production of Connected Text score represents the sum of the WIAT Written Expression ratings for the letter that was written with the support of the outline. Descriptive statistics for the individual measures completed by study participants can be found in Appendices C through G.

Table 6 presents intercorrelations for the independent and outcome variables that were included in the present study.

Table 6

Intercorrelations Among Predictor and Outcome Variables

Variable	1	2	3	4	5
1. Isolated Writing Skills	- -	-.20	.25*	.14	.01
2. Executive Functions		- -	.15	-.07	-.04
3. Working Memory			- -	.36**	.18
4. Unsupported Production of Connected Text				- -	.53**
5. Supported Production of Connected Text					- -

* $p < .05$, ** $p < .01$

Among the predictor variables, Isolated Writing Skills was significantly correlated with Working Memory. Not surprisingly, Unsupported and Supported Production of Connected Text were significantly correlated. Only one of the predictor variables, Working Memory, was significantly correlated with the Unsupported Production of Connected Text.

Hypothesis 1

Initial Analysis and Results

The first hypothesis was designed to investigate the extent to which the constructs of isolated writing skills, executive functions, and working memory were related to unsupported connected text production. It was hypothesized that these predictor variables, in combination, would account for a significant portion of the variance in scores on the measure of production of connected text. Hypothesis 1 was tested using standard regression, with all three predictors entered into a regression equation simultaneously. Table 7 presents the results of this regression.

With an alpha level of .05, the multiple regression equation that included all three predictor variables was statistically significant. The hypothesis was supported, but the proportion of the variance in the Unsupported Production of Connected Text accounted for by the predictor variables was modest, only 15%. The large majority of the variance was unaccounted for by Isolated Writing Skills, Executive Functions, and Working Memory as defined and measured in this study.

Brief Discussion of Results Related to Hypothesis 1

It is unclear why the variables included in the present study accounted for such a small proportion of the variance in the Unsupported Production of Connected Text. One possible explanation could be that restriction of range in the predictor or outcome variables affected the amount of variance explained. When the means and standard deviations of the variables (Table 5) in the regression model were examined, it was

Table 7

Prediction of Unsupported Connected Text Production Scores

Source	Sum of Squares	df	Mean Square	*F*
Regression	49.18	3	16.39	3.46*
Residual	279.68	59	4.74	
Total	328.86	62		

Variable	Standardized Beta
Isolated Writing Skills	.01
Executive Functions	-.12
Working Memory	.38**

* $p < .05$, ** $p < .01$, $R^2 = .15$

discovered that although the predictor variables demonstrated adequate ranges of variability, scores on the outcome measure (Unsupported Production of Connected Text) were restricted in range. Out of a possible range of 6 to 24, obtained scores fell only between 13 and 23, with more than half of the scores (for 35 of 63 participants) ranging from 16 to 18. If these scores had been entered into a normative table for nineteen year olds, they would have yielded standard scores of just 88 – 96. If fact, if all of the raw scores had been related to standard scores, 92% of participants would have earned scores lower than 110. It is likely that restriction of range in the outcome variables affected the observed relationships between the predictor and outcome variables. This possibility and its implications will be discussed in detail in the General Discussion.

Hypothesis 2

Initial Analysis and Results

The second goal of the study was to investigate the extent to which executive function and working memory might interact to influence scores on an unsupported connected text production measure. It was predicted that the relationship of executive functions to the production of connected text would be conditional on working memory, such that the impact of executive processes would be greater as working memory scores increased. This hypothesis would be supported if the EF*WM interaction term were significant and follow-up analyses were consistent with the pattern described. To test this hypothesis, three variables were centered by subtracting the mean of the variable from

Table 8

Effect of Interaction of Executive Function and Working Memory on Unsupported Production of Connected Text

Source	Sum of Squares	df	Mean Square	*F*
Regression	57.40	3	19.13	4.16**
Residual	271.46	59	4.60	
Total	328.86	62		
Variable	Standardized Beta			
Executive Functions (EF)	-.13			
Working Memory (WM)	.39**			
EF*WM	.16			

** $p < .01$, $R^2 = .18$

each obtained score. A regression including the centered variables for executive function, working memory, and the EF*WM interaction was run. Table 8 presents the results of this analysis. This model accounted for 18% of the variance in the Unsupported Production of Connected Text. With an alpha level of .05, it was statistically significant. However, the EF*WM interaction term was not significant. Although the hypothesis was not supported, Working Memory was again identified as the variable that was most strongly correlated with the Unsupported Production of Connected Text.

Brief Discussion and Additional Analyses Related to Hypothesis 2

Given the relatively weak correlations between the composite measures of isolated writing skills, executive functions, and working memory, and the participants' production of connected text, additional Pearson correlations between the scores on the individual tasks and the scores for the Unsupported Production of Connected Text were calculated in order to assess the extent to which the individual tasks were correlated with the production of connected text. Table 9 presents the results of these correlations.

With an alpha level at .05, most measures of isolated writing skills and executive functions that were incorporated into this study were not significantly correlated with the measure of unsupported production of connected text. When a Bonferroni correction for multiple comparisons was applied, all correlations were nonsignificant. Even without such correction, few individual tasks were significantly correlated with the measure assessing production of connected text. Among isolated writing skills, only Handwriting significantly correlated with Unsupported Production of Connected Text. Among executive functions, the questionnaire subscales named Working Memory and Plan/Organize were significantly correlated with the Unsupported Production of

Table 9

Correlations Between Individual Task Variables and Production of Connected Text

Individual Task Variable	Correlation	Significance (2-tailed)
GWT Dictation Spelling	.15	.25
GWT Editing	.10	.46
GWT Writing Fluency	-.10	.44
GWT Writing Samples	.16	.21
WJ-III Handwriting	.26	.04*
Questionnaire Inhibit	.16	.20
Questionnaire Working Memory	.26	.04*
Questionnaire Plan/Organize	-.24	.05*
Questionnaire Organization of Behavior	-.14	.28
Questionnaire Monitoring	.04	.73
WCST Total Trials Administered	-.22	.08
WCST Total Correct	-.04	.73
WCST Total Errors	.16	.21
WCST Perseverative Responses	.18	.15
WCST Perseverative Errors	.19	.14
WCST Nonperseverative Errors	.14	.27

Table 9 (continued)

WCST Conceptual Level Responses	.18	.15
WCST Total Numbers of Categories Completed raw score	.20	.12
WCST Trials to Complete First Category	-.10	.45
WCST Failure to Maintain Set	.05	.72
WCST Learning to Learn	.04	.74
WJ-III Numbers Reversed	.27	.03
WJ-III Auditory Working Memory	.38	<.01

* $p < .05$

Connected Text. A positive correlation between the questionnaire Working Memory subscale and Unsupported Production of Connected Text measure may represent a Type II error. It would be unexpected that elevated scores on the questionnaire Working Memory subscale (which reflect relatively high levels of problems with issues such as forgetfulness) would be related to high scores on Unsupported Production of Connected Text.

Among working memory tasks, Numbers Reversed and Auditory Working Memory were both significantly correlated with the Unsupported Production of Connected Text. However, none of the scores on individual tasks accounted for much variance. The strongest correlation (Auditory Working Memory) accounted for only about 14% of the variance in scores of Unsupported Production of Connected Text. A complete table of intercorrelations of variables examined in the study appears in Appendix H.

Hypothesis 3

Initial Analysis and Results

The final goal of the research was to test further the role of executive functioning in the production of connected text by assessing the extent to which reducing the organizational demands on a connected text production task would reduce the relationship between executive functions and ratings of quality of connected text production. It was predicted that students who have weak executive function skills would benefit more from the provision of a supportive outline than students who have strong executive function skills. To test this hypothesis, students were divided into high and low Executive Function (EF) groups using a median split. A 2 (EF Level) * 2 (Essay Type)

Table 10

Role of Executive Functioning in the Production of Connected Text

Source	Sum of Squares	df	Mean Square	*F*
Between Subjects				
EF Level	.11	1	.11	.01
Error	605.32	61	9.92	
Within Subjects				
Essay Type	8.64	1	8.64	2.76
Essay Type * EF Level	.16	1	.16	.05
Error	190.70	61	3.13	

All *F* values were nonsignificant, $p > .05$

analysis of variance with repeated measures on Essay Type (Unsupported and Supported Production of Connected Text) was calculated to test the hypothesis (Table 10). The hypothesis would be considered supported if the EF Level*Essay Type interaction were significant, and the tests for simple main effects showed greater improvement in scores for the supported production of connected text for students in the Low EF group than for students in the High EF group.

The median split yielded a Low EF group that included 31 students and a High EF group that included 32 students. With an alpha level of .05, the analysis of variance resulted in nonsignificant effects for EF Level, Essay Type, and the interaction of EF level and Essay Type. The hypothesis was not supported.

Further examination of ratings of production of connected text revealed that students in both groups appeared to show some benefit from the provision of the supportive outline, although the gains were nonsignificant (Table 11).

Table 11

Gains in Writing Scores Associated with the Provision of a Supportive Outline

EF Level	N	Unsupported Mean (SD)	Supported Mean (SD)	Gain
Low EF	31	17.39 (2.28)	17.84 (2.53)	.45
High EF	32	17.38 (2.36)	17.97 (2.98)	.59

Brief Discussion and Additional Analyses Related to Hypothesis 3

Because the analyses that tested the relationships of executive function to the composite writing scores were nonsignificant, additional analyses were conducted in order to determine whether the use of the outline resulted in significant benefit for one of the scoring components of the measure of connected text production called Organization, Unity, and Coherence (Table 12). This subscale assesses the smooth flow of ideas contained in the text, sequencing and use of transitions, and staying on topic without digression, so it was thought that the ratings of this characteristic may have been influenced by the use of the outline designed to support these skills.

With an alpha level at .05, the exploratory analysis of variance to examine the potential effects of EF Level and Essay Type on the Organization, Unity, and Coherence

Table 12

Relationship of Executive Functioning and Organization, Unity, and Coherence

Source	Sum of Squares	df	Mean Square	*F*
Between Subjects				
EF Level	.003	1	.003	.01
Error	31.30	61	.51	
Within Subjects				
Essay Type	1.56	1	1.56	3.37
Essay Type * EF Level	.31	1	.31	.67
Error	28.14	61	.46	

All *F* values were nonsignificant, $p > .05$

ratings of the Unsupported and Supported Production of Connected Text measure also resulted in nonsignificant effects for EF Level, Essay Type, and the interaction of EF Level and Essay Type. Provision of a supportive outline resulted in small but nonsignificant gains in ratings for Organization, Unity, and Coherence for letters written by students in both groups (Table 13).

Results of analyses conducted to test Hypothesis 3 failed to support the idea that students with weak executive function skills would benefit more from the provision of a supportive outline than students who have strong executive function skills. Given significant correlations between Working Memory and Unsupported Production of Connected Text (Table 6), a post hoc question emerged about the extent to which the

Table 13

Gains in Organization, Unity, and Coherence Scores Associated with the Provision of a Supportive Outline

EF Level	N	Unsupported Mean (SD)	Supported Mean (SD)	Gain
Low EF	31	2.16 (.45)	2.48 (.77)	.32
High EF	32	2.25 (.67)	2.38 (.83)	.13

outline may have provided support for weak working memory instead of executive function skills. Additional exploratory analyses were conducted to examine this possibility in more depth. An exploratory 2 (WM Level) * 2 (Essay Type) ANOVA to test the role of Working Memory in the production of connected text was calculated (Table 14).

A median split yielded a Low WM group that included 32 students and a High WM group that included 31 students. With an alpha level of .05, the ANOVA resulted in significant effects for WM level, but nonsignificant effects for Essay Type and the interaction of WM level and Essay Type.

Table 14

Role of Working Memory in the Production of Connected Text

Source	Sum of Squares	df	Mean Square	*F*
Between Subjects				
WM Level	37.02	1	37.02	3.97*
Error	568.41	61	9.32	
Within Subjects				
Essay Type	8.64	1	8.64	2.79
Essay Type * WM Level	2.16	1	2.16	.70
Error	188.70	61	3.09	

* $p < .05$

Table 15

Gains in Writing Scores Associated with the Provision of a Supportive Outline

WM Level	N	Unsupported Mean (SD)	Supported Mean (SD)	Gain
Low WM	32	16.72 (2.36)	17.50 (2.91)	.78
High WM	31	18.06 (2.06)	18.32 (2.55)	.26

Further examination of ratings of production of connected text revealed that students in both groups seemed to demonstrate some gains from the provision of the supportive outline (Table 15). Although the gains in both groups are small, Low WM students gained almost three times as much as High WM students, suggesting that the sample in the present study may have lacked power to detect a possible small effect. The ability to detect an effect may have been further weakened by the use of an ANOVA calculation with a median split of a continuous variable (Aiken & West, 1991). To address this concern, analyses using comparisons of extreme groups (with High EF students earning scores more than one standard deviation above the mean and Low EF students earning scores more than one standard deviation below the mean) were run. The groups were very small, and comparisons yielded nonsignificant results.

CHAPTER SIX: GENERAL DISCUSSION

The purpose of the present study was to explore potential relations between isolated writing skills, executive functions, working memory, and the production of connected text. The goal was to increase empirical knowledge about writing skills by bringing together concepts and measures from diverse perspectives on writing and cognitive processes to examine relationships among cognitive processing constructs and students' writing skills. Sixty-three students enrolled in introductory psychology were recruited to complete a battery of measures of isolated writing skills, executive functions, working memory, and production of connected text. The scores from the battery for this sample were examined to test the hypothesized relationships.

The study's original hypotheses predicted that executive functions would exhibit specific relationships to the production of connected text. For example, it was predicted that executive functions would interact with working memory to contribute significant unique variance to the production of connected text. It was also predicted that providing a supportive outline to students during a writing task would lead to greater improvements in scores for Low EF students than for High EF students. These relationships were not found. Instead, working memory emerged as the predictor most strongly related to connected text production. Working memory was significantly related to the quality of text production and contributed a modest amount of unique variance. The contribution of executive function to written expression did not differ significantly from zero, and the manipulation designed to examine the role of executive function in writing by reducing the organizational demands of the writing task did not have its predicted effect on the performances of Low EF and High EF students.

There are many possible explanations for the present study's limited findings and failure to support two of the three original hypotheses. One explanation is that the original hypotheses were correct, but methodological limitations made it difficult to detect the hypothesized relationships. A second explanation is that working memory capacity plays a role in the production of connected text, with executive function playing a less critical role. A final explanation is that current models of the cognitive processes underlying writing are not accurate and must include additional environmental and cognitive variables to describe writing performance more fully.

Each of these explanations is considered in this extended discussion of the results of the present study. The chapter begins with a discussion of the second possible explanation for the study's results, that working memory plays a critical role in writing performance, because this explanation is most consistent with the one significant finding of the study, that Working Memory was related to Unsupported Production of Connected Text. The discussion then moves to the possible role of executive function in the production of connected text and the limitations in the study that might have led to the failure to observe a significant relationship between Executive Function and Unsupported Production of Connected Text. The third explanation is considered as part of the general elaboration of the study's limitations. In this discussion of possible explanations for the findings, both the results of the planned and post hoc analyses are considered. This chapter concludes with a discussion of future directions for research and practice.

Relations between Predictor Variables and Production of Connected Text

Among the original predictor variables, Isolated Writing Skills and Executive Function failed to demonstrate significant relations with the outcome variables. This finding was unexpected, given theoretical assumptions that knowledge of correct spelling, capitalization, and punctuation, and metacognitive knowledge about planning, organizing, monitoring, and revising would contribute to performance on an assignment to write an extended passage. In the context of the writing models (Berninger et al., 1995; Hayes & Flower, 1980) discussed previously, the extent to which these skills are developed would be expected to partially influence students' scores on a writing task. This assumption fits also with Baddeley's (Baddeley, 2001; Baddeley & Hitch, 1974) working memory model and the resource allocation model (Graham et al., 1993) that were presented in the literature review because the extent to which isolated writing and executive function skills are developed would be expected to reduce the drain of resources available in a capacity-limited working memory, thereby freeing resources for other composition tasks. Although the predicted results that were based on these assumptions were not found, the relationship between working memory and writing performance that was revealed is consistent with the theoretical assumptions outlined in the review of the literature upon which the study was founded.

Working Memory was significantly correlated with the measure of Unsupported Production of Connected Text, accounting for 13% of the variance. This percentage is consistent with the results of research by Swanson and Berninger (1996) who found that measures reflecting a working memory factor related to executive skill accounted for 15% of the variance in compositional fluency (measured by counting the number of words in three five-minute writing samples produced by 300 third-, fourth-, and fifth-graders) and 10% of the variance in ratings of compositional quality of the samples.

One interpretation of the correlation between working memory and text production found in previous research and the present study is that a writer's working memory capacity places a limit on the extent to which he or she can respond to the multiple simultaneous cognitive demands imposed by the composition process, which directly affects the quality of text produced. If this interpretation were true, then interventions that reduce working memory demands during writing should lead to improved writing performance, particularly for students with working memory limitations. The study's original hypothesis was that reduced executive function demands would be the mechanism by which additional working memory resources would be freed. This hypothesis was directly tested by the provision of the essay outline, which supported executive function by reminding students to think, plan, write, review, and revise. It was predicted that students with lower scores on executive function would show greater benefit from provision of the essay outline. Results of hypothesis testing failed to find a significant relationship between executive function and writing quality, or an interaction of executive function with essay type.

The possibility that provision of the essay outline might improve writing quality by operating directly on working memory, rather than through executive function was tested in post hoc analyses where working memory scores were substituted for executive function scores in the analyses related to the outline manipulation. A significant interaction between working memory and essay type in the analysis would have provided strong support for the hypothesis that working memory capacity plays a central role in the production of connected text. Although this interaction was not significant, the fact that the gains associated with the use of the outline by Low WM students were almost three times the magnitude of the gains achieved by High WM students (.78 compared to .26, see Table 15) suggests that the failure to find this interaction may be a result of the study design and power limitations.

According to Baddeley's model (Baddeley, 2001; Baddeley & Hitch, 1974), working memory is defined as computational space within which information in temporarily maintained and manipulated to produce a response. Its resources are necessarily limited, and interpreting the findings of the present study in terms that relate them to the limitations of working memory is consistent with Baddeley's model, even though an executive function mechanism for reducing demands on working memory was not identified. In other words, the capacity of working memory may underlie variations of levels of resources available for use, with higher levels of working memory associated with higher performance on writing tasks.

This interpretation of the study results is also consistent with the resource allocation model (Berninger et al., 1995; Graham et al., 1993) that was discussed in the second chapter, as well as with the comprehensive writing models that have been published by Hayes and Flower (1980) and Berninger et al (1995). If resource allocation processes influence writing outcomes, it would be reasonable to suggest that juggling multiple demands within the limitations of capacity and efficiency of working memory would result in score differences related to measured capacity and manipulation of level of demands on that capacity. Providing the outline would free resources for creation of higher quality compositions.

Limitations of the Present Study

The previous section explored the fit between the present study's results and an explanatory framework that focused on the role of working memory in production of written text. Another possibility is that the relationships between predictor and outcome variables hypothesized in Chapter Four do exist but eluded adequate examination in the present study. Several of the study's characteristics may have contributed to the failure to find the predicted relationships between working memory, executive function, isolated writing skills and production of connected text. For example, the study's ability to detect effects may have been reduced by range restriction in the sample that was particularly reflected by outcome measure scores that were tightly clustered together. There may also have been problems with measure selection. Most of the measures selected for use in the study were chosen because they had demonstrated validity in clinical application. However, the data collected in the present study revealed a lack of strong association between measures within the predictor constructs, raising questions about the measures' actual ability to describe the constructs adequately, as well as questions about the conceptualization of the constructs.

Additional questions about the construct definitions, and the inconsistent ability to link vague constructs to individual measures, may also have contributed to limitations within the study. The study may have been further weakened by failure to include important constructs in the model that was tested. Finally, the manipulation may have been too weak to illuminate executive function effects. Each of these sources of limitation is discussed in the following sections.

Participant Characteristics

The decision to conduct the study with college students introduced issues related to range restriction within the sample. Had the study been conducted with a less “self-selected” group, variability within obtained scores may have been greater, and the results may well have reflected differences of greater magnitude. For example, it might be expected that, in a sample of young adults that includes but is not limited to college students, results on writing outcome measures would have a larger standard deviation than was found in the present study. Variability in scores may be even greater in children or adolescent participants than in young adults, due to variation in the emergence and development of isolated writing skills, executive functions, and working memory. Under such conditions, the model’s ability to account for the variance in connected text production measures may have become much stronger.

Measurement Characteristics

Measures selected for predictor variables demonstrated adequate means and standard deviations for the participants in this sample (Table 5). Obtained scores on the outcome measures, however, were relatively similar for most students and tended to cluster together. This pattern within the data led to the situation of trying to predict tightly clustered scores by scores that displayed a larger spread, which may have reduced the likelihood of finding effects in the data. As previously discussed, one experienced rater, blind to the conditions under which essays were written, scored all of the samples of connected text production. Although this aspect of the study may lead to questions about the validity of the essay scores, it is unlikely that the use of a single rater differentially affected scores in the unsupported and supported essay conditions. If rater error were operative, it is likely that it was systematic, and shifted the distribution of scores up or down, while maintaining the same rank order of scores among participants.

Another measurement issue in the study may be related to the selection of measures and their links to the constructs for which they were used. Appendix H includes a bivariate correlation matrix for the measures in the study. The matrix reveals that within isolated writing skills, correlations between individual measures ranged from .09 (for Editing * Handwriting) to .71 (Spelling * Editing).

Correlations between executive function subscale measures on the executive function questionnaire were modest and ranged from .26 (Organization of Behavior * Inhibit) to .60 (Monitoring * Inhibit). Correlations between executive function subscale measures on the Wisconsin Card Sorting Test ranged from -.27 (Perseverative Responses * Failure to Maintain Set) to .99 (Perseverative Errors * Perseverative Responses). These correlations tended to be stronger than the correlations between the executive function questionnaire subscales because of the design of the Wisconsin Card Sorting Test. It is not surprising, for example, that a WCST Perseverative Error measure is highly correlated with the WCST Perseverative Response measure because the individual scores on the WCST are designed to be interrelated. Across the executive function measures (the EF Questionnaire and the Wisconsin Card Sorting Test), however, correlations were relatively weak and ranged from .25 (EFQ Monitoring * WCST Learning to Learn) to -.31 (EFQ Planning * WCST Categories Completed).

The correlation between working memory measures was .43 (Numbers Reversed * Auditory Working Memory). These correlations suggest that within the isolated writing skills and working memory constructs, correlations between the measures that were combined to form the construct scores were modest and that correlations across executive function measures were weak, which raises questions about the measures' construct validity.

As noted, selection of the outcome measure may have further limited the study. The WIAT Written Expression Test (The Psychological Corporation, 1992) was chosen because it was thought that its timed component would increase the likelihood of executive function deployment. The restricted range of scores on the measure may have contributed to the failure of the manipulation, which may have resulted from recruiting a sample too homogenous and too small to detect the very small effect size obtained with the manipulation. Madigan and Brosamer (1990) found similar difficulties in their attempt to improve the writing skills of 94 students enrolled in an introductory psychology course that had been designed as part of a writing-across-the-curriculum project. Sample size issues may prove extremely difficult to resolve, however. Post hoc calculations revealed that the present sample of 63 college students had power of only .05 to detect the .01 effect size that was obtained in the repeated measures ANOVA calculated for the third hypothesis. The small size of the effect would also need to be addressed, perhaps through the completion of a more difficult writing task (that would identify differences in the writing skills of college students), the use of a finely tuned scoring rubric for the connected text production measures (that would describe these sometimes subtle differences) and the implementation of a writing intervention powerful enough to have a stronger effect on college students' writing skills.

Hunter and Schmidt (2004) have noted problems with the use of statistical testing and power calculations in behavioral science research. They raise two particular issues that appear relevant to the present study, error of measurement and range restriction. Their techniques for addressing these issues are discussed in a later section of this chapter.

A different outcome measure, such as one that was computer administered, may have yielded very different results, if the processes required for composition by hand are different from the processes required for word processing with a computer program. For example, level of keyboarding skills may influence results, and the opportunities for revision that word processing provides may lead to highly improved content and organization of writing samples.

Construct Characteristics

As previously noted, within the executive function construct, scores within measures shared some consistency, but scores across measures were often more different than similar. This finding, which is consistent with observations across studies within the literature, reflects the lack of consensus on measurement of executive functions (Lyon, 1996). For example, planning may be measured by a questionnaire (either self-report or completed by a separate rater), measurement of the interval between receiving instructions and beginning to write an essay, by error patterns on the Wisconsin Card Sorting Test, by counting the number of moves on a tower task, or by implementing and scoring a think aloud protocol. The specific measure selected by investigators may vary for many reasons, including convenience, empirical or theoretical support, personal preference, or collegial tradition. The rationale for selection of measures in the present study was one of clinical utility. It was believed that, because measures were selected, when possible, based on a history of demonstrated clinical usefulness, problems associated with measure selection would be minimized. In the end, however, the weak correlations within constructs may reflect a degree of poor validity.

Model Characteristics

The model tested in the study may not have been adequate because it may have failed to include constructs important to the production of connected text. Among isolated writing skills, handwriting was significantly correlated with the connected text production, but it was not included in the construct composite variable during the design of the study. Inclusion of other isolated writing skills may have strengthened the relationship between the composite isolated writing skills variable and connected text production.

The selection of the EF Questionnaire Composite score as the measure for the executive function construct may have limited the model's ability to detect effects. Participants completed the Wisconsin Card Sort Test as a possible comparative executive function measure in post hoc analyses. However, examination of the intercorrelation matrix in Appendix H reveals that WCST subscale scores were not significantly correlated with the production of connected text. For example, WCST Trials Administered (a composite that summarizes performance on the sorting task) had a nonsignificant correlation of -.22 with unsupported production of connected text. Selecting scores from this measure instead of the questionnaire would not have improved the model.

Definitional weaknesses within executive functions may have led to exclusion of some important construct in this area as well. For example, a serious and as yet unresolved issue within the executive function literature relates to the problem of shared variance. Dawson and Guare (2004) suggested that because frontal brain regions are related to executive functions, a variety of factors may influence executive skills, such as depression, anxiety, fatigue, situational stress, and attention disorders. These factors, also recognized by Hale and Fiorello (2004), may exert general effects across multiple executive functions because their management functions are traced to a common prefrontal brain region.

Current executive function definitions attempt to describe specific behaviors, but in actuality, executive functions that have been described in the literature (including planning, monitoring, and organizing) must include some ability to inhibit prepotent or competing behaviors, as well as involve attention and allocation of working memory resources. Efforts to identify orthogonal executive function variables may not seem likely to succeed. Instead, attempts to identify individual executive functions may eventually be replaced by development of composite constructs that demonstrate adequate validity in relation to outcome measures, including connected text production. The use of a composite construct variable was attempted in the present study. Though the results provided only weak support for this approach, it would still seem the most fruitful approach for future research, given that individual executive functions appear to possess little unique variance.

Within working memory, the model included only measures of auditory working memory. Addition of visual working memory measures may serve to influence or alter the relationship between a composite working memory construct and the production of connected text. For example, visual working memory may account for additional variance in connected text production measures because it may capture characteristics of orthographic processes related to written expression skill, which would not be tapped by an auditory working memory task.

In summary, all three predictor variable constructs may have been improved with the inclusion of additional skills measures. Research using factor analysis techniques may be useful in identifying additional variables to include in the composite constructs. Given that working memory was, among the three original predictors, most strongly associated with connected text production, and that the study's model assumed that working memory would be important as a facilitator or constrainer of other skills included in the model, structural equation modeling (with working memory as a mediator variable) may cast some future light on the hypothesized relationships.

Manipulation Characteristics

Finally, it seems possible that the manipulation tested in the present study may have been too weak to result in significant improvement in the writing skills of college students. The design of the present manipulation was chosen for its potential for future use with younger students. Had it demonstrated significant effects in the present sample, it could have been examined further by implementing it with secondary (or even older elementary) students. It may yet have some utility with a younger population, but this is a question that remains to be studied. The limitation of the intervention with the college population may be addressed by conducting additional research in cooperation with freshman English instructors. This approach could provide access to the more complex measures of writing skills that were previously discussed as an improvement to future research, and implementing interventions designed to help entering freshmen improve their production of connected text by thinking, planning, writing, and revising could prove helpful.

Future Directions for Additional Research

The current study was conceived as an exploratory attempt to examine potential relations between isolated writing skills, executive functions, and working memory, and the production of connected text. Although a modest proportion of the variance in Unsupported Production of Connected Text was accounted for by the predictor variables, much work remains before the processes related to written expression can be adequately described. For example, with a college sample, a more difficult writing task, which would be more likely to tax working memory resources and elicit the generation of executive functions, may address the problem with range restriction in the outcome variable that was an issue in the present study. A larger sample and multiple, robust measures of the predictor constructs may also improve the design of future research.

As noted in specific ideas already described, one broad area that would benefit from additional research is examination of the three predictor constructs. It would be helpful to develop construct definitions that clearly describe the constructs and are free, to the extent possible, of unmeasured external influences. Multiple measures within each construct could be administered to large groups of students and factor analyzed to determine the extent to which they measure the same underlying characteristics. For example, work could be targeted to identify or create additional measures of isolated writing skills that could be combined into a composite variable but also provide for individual skills assessment. Additional measures of working memory (such as visual working memory) would be useful and could be included in a global working memory composite. Improving the construct definition for executive functions by measuring specific skills may prove difficult, however. Even with the limited experience of the present study, it seems clear that the behaviors that are currently considered representative of executive functions are extremely difficult to sort into clearly defined isolated constructs. For example, most executive functions seem to incorporate inhibition in addition to other skills needed for planning, organizing, or monitoring, but when Boone, Ponton, Gorsuch, Gonzalez, and Miller (1998) factor analyzed results of a battery of measures administered to 250 participants, they found that correlations among prefrontal measures were only modest, which suggested that the individual tests may have been measuring somewhat different abilities. It is common to refer to and use measures of executive function as proxies for inferred executive functions, but the extent to which current measures represent underlying executive functions remains to be determined. Use of a composite that integrates the concepts into one superordinate executive function construct may be the most effective approach to examining and studying the relationships of executive functions and the production of connected text.

Another area for exploration that is related to measurement issues is the need for identification of measures that reflect developmental change. The present study focused on individual differences, but it may be possible to identify individual measures or linked measures that permit investigators to test for potential developmental differences in the effects of isolated writing skills, executive functions, and working memory on connected text production. It would be useful to explore the possibility (or likelihood) that identified measures may demonstrate usefulness that varies with age. This work would allow researchers to move toward specification of a writing process model that accounts for developmental change.

Implications for Research

Many possibilities for future study have been described in the context of the limitations of the present study. Given these limitations and possibilities, the results of the present study suggest that, among the individual predictor constructs, working memory plays the most important role in the production of connected text. Alone, the constructs of isolated writing skills and executive functions could not account for significant variance in the Unsupported or Supported Production of Connected Text. However, working memory may operate through interaction with executive functions to influence the production of connected text. Further testing of these relationships should include a sample of participants with broadly varying levels of writing skill, a sensitive measure of writing skill that will illuminate differences in the sample, and an intervention that is more likely to influence writing behavior than the manipulation that was employed in the present study.

Hunter and Schmidt (2004) have noted that population effects may not be detected in small sample studies because of error of measurement, which “systematically lowers the correlation between measures in comparison to the correlations between the variables themselves” (p. 95) and range restriction in the sample. In other words, in a small sample, error of measurement can lead to artificial reduction in correlations, even though the variables are related in the population. These attenuated correlations can be further reduced by range restriction effects. Hunter and Schmidt (2004) presented mathematical techniques for correcting for these two issues. When applied to the present study (Appendix I), the correction for attenuation in correlation related to error of measurement yields a Working Memory*Unsupported Production of Connected Text correlation of .43. Additional calculations to correct for range restriction yield a Working Memory*Unsupported Production of Connected Text correlation of .57. The results of these calculations may provide some idea of the magnitude of the statistical losses in the findings that can be related to the problems of error of measurement and range restriction and suggest that hypothesized effects may actually be present in the population. Had these problems not been present in this study, stronger support for the hypotheses may have been found.

Implications for School Psychologists

As previously noted, the skills and processes related to the production of connected text have not been extensively studied empirically and are not as well understood as processes related to other academic skills, such as reading. The present study incorporated hypothesized relationships between isolated writing skills, executive functions, working memory, and connected text production and was designed with the assumption that understanding these relationships could lead to the development of useful instructional techniques for the classroom setting.

Results of the study provided weak support for the idea that underlying skills and processes (particularly working memory) influence writing outcomes. Indeed, the fact that working memory emerged as significantly related to performance on an academic task in this study, which was limited by restriction in range and methodological weaknesses, suggests that psychologists who work with college students need to attend to possible effects of working memory weakness in this population. Working memory can be compromised by many causes, such as depression, anxiety, or stress, that are quite prevalent among college students. Assessment, detection, and intervention for these conditions should be made available to them. Furthermore, the fact that students in a select population such as university students received relatively low standard scores on a standardized writing test intended for a somewhat younger population suggests that remediation of writing difficulties is an important area for further research.

If future research (with improved methods) finds additional support for the contributions of isolated writing skills, executive functions, and working memory to the production of connected text, writing instruction could be designed to support working memory and to generate executive functions in order to improve students' writing skills. Moreover, interventions could be targeted to specific skills deficits. For example, a student who possesses adequate isolated writing skills but has problems with connected text production may eventually be served by interventions that support and improve executive function skills.

School psychologists and educators have long referred to the cognitive constructs that were incorporated into the present study. The low inter-correlations obtained among measures of the same cognitive constructs and study's modest results, however, suggest that these professionals must think critically about their routine use of these constructs in explaining students' writing deficits. Care must be taken not to reify concepts that remain empirically unvalidated or inadequately measured in day-to-day practice.

Although the present study did not succeed in illuminating the relationships that were originally hypothesized, it did suggest potentially useful questions for additional research. This process of research design, implementation, analysis, and additional question formulation comprises the scientist component of the scientist-practitioner model. As research advances, the findings that are revealed may serve the practitioner component of the model by specifying the defining characteristics of isolated writing skills, executive functions, working memory, and connected text production.

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APPENDICES

APPENDIX A

Questionnaire

How often are the following situations a problem for you? Please circle the letter that corresponds to your answer.

	Never	**Sometimes**	**Often**
Needing to be told “no” or “stop that”	N	S	O
Not thinking before acting	N	S	O
Interrupting others	N	S	O
Behaving impulsively	N	S	O
Getting out of your seat at the wrong times	N	S	O
Acting too wild or out of control	N	S	O
Having trouble putting the brakes on your behavior	N	S	O
Getting out of control more than your friends	N	S	O
Getting in trouble with parents, teachers, others	N	S	O
Not thinking of consequences before acting	N	S	O

	Never	**Sometimes**	**Often**
When given 3 things to do, remembering only the first or last	N	S	O
Having a short attention span	N	S	O
Having trouble concentrating on schoolwork, etc.	N	S	O
Being easily distracted by noises, activity, etc.	N	S	O
Having trouble with tasks that require more than 1 step	N	S	O
Needing help from someone else to stay on task	N	S	O
Forgetting what you were doing (in the middle of a task)	N	S	O
When sent to get something, forgetting what it was	N	S	O
Having trouble finishing chores, homework, etc.	N	S	O
Having trouble remembering things, even for a few minutes	N	S	O

	Never	**Sometimes**	**Often**
Forgetting materials needed for homework	N	S	O
Having good ideas but not being able to get them on paper	N	S	O
Forgetting to hand in homework, even when finished	N	S	O
Getting caught up in details and missing the big picture	N	S	O
Having good ideas but not getting the job finished	N	S	O
Becoming overwhelmed by large assignments	N	S	O
Underestimating time needed to finish tasks	N	S	O
Starts assignments or chores at the last minute	N	S	O
Failing to plan ahead for school assignments	N	S	O
Producing poorly organized written work	N	S	O

	Never	Sometimes	Often
Losing assignments, homework, etc.	N	S	O
Cannot find shoes, clothes, glasses, books, keys, etc.	N	S	O
Having a disorganized backpack	N	S	O
Losing items in room or desk	N	S	O
Leaving a trail of belongings throughout room	N	S	O
Leaving messes that others have to clean up	N	S	O
Having a messy desk	N	S	O

	Never	Sometimes	Often
Failing to check work for mistakes	N	S	O
Making careless errors	N	S	O
Being unaware of how your behavior affects or bothers others	N	S	O
Leaving work incomplete	N	S	O
Not noticing when your behavior causes negative reactions	N	S	O
Being unaware of your own behavior when in a group	N	S	O
Having a poor understanding of your strengths and weaknesses	N	S	O
Talking too loudly	N	S	O
Producing sloppy work	N	S	O
Not realizing that certain actions bother others	N	S	O

Please answer the following:

How old are you:

Are you? _____ male or _____ female

Think about your driving record.

How many warning tickets have you had?

How many other traffic tickets have you had?

Please list the infractions:

What was your most recent class in the English Department?

What grade did you earn?

Have you ever been identified, diagnosed, or have you received services for (please check):

_____ Academically Gifted

_____ Attention Deficit/Hyperactivity Disorder

_____ Learning Disabilities. What area?

APPENDIX B

Outlines and Procedures for WIAT Written Expression Letters

To write a good letter, you should
THINK, PLAN, WRITE, REVIEW, and REVISE.

______	**<u>THINK</u>** about your ideal place. <u>Quickly</u> write down 5 words or short phrases that would <u>describe</u> your ideal place:
______	**<u>PLAN</u>** your letter Remember that you are writing down your ideas to share with someone else You need to <u>organize</u> your description to help that person understand.
______	**<u>WRITE</u>** your letter Follow your plan and include at least 3 of your ideas
______	**<u>REVIEW</u>** your letter at least once for <u>each</u> of the following questions 1. Are the words spelled correctly? 2. Is the letter punctuated correctly? 3. Did you elaborate on your ideas? 4. Did you include words to spark the reader's interest? 5. Have you thoroughly answered the prompt?
______	**<u>REVISE</u>** your letter based on your review.

To write a good letter, you should
THINK, PLAN, WRITE, REVIEW, and REVISE.

______	**<u>THINK</u>** about somewhere you would like to go. <u>Quickly</u> write down 5 words or short phrases that would <u>describe</u> that place and things you would like to do there:
______	**<u>PLAN</u>** your letter Remember that you are writing down your ideas to share with someone else You need to <u>organize</u> your description to help that person understand.
______	**<u>WRITE</u>** your letter Follow your plan and include at least 3 of your ideas
______	**<u>REVIEW</u>** your letter at least once for <u>each</u> of the following questions 1. Are the words spelled correctly? 2. Is the letter punctuated correctly? 3. Did you elaborate on your ideas? 4. Did you include words to spark the reader's interest? 5. Have you thoroughly answered the prompt?
______	**<u>REVISE</u>** your letter based on your review.

<u>Instructions for Administering WIAT Written Expression Subtests</u>

***** Important ******

Participants whose data fills odd numbered files will complete Prompt 1 (without outline) first, followed by Prompt 2 (with outline) For even numbered participants, administer Prompt 2 (without outline) first, followed by Prompt 1 (with outline) Always complete a prompt without outline first, then a prompt with outline support.

<u>The procedure is:</u>

<u>For the first letter that the student is to write</u> (Prompt 1 for odd numbered participants, Prompt 2 for even numbered participants), follow administration procedures that are specified in the WIAT Stimulus Booklet 2.

<u>For the second letter that the student is to write</u> (Prompt 2 for odd numbered participants, Prompt 1 for even numbered participants), use the WIAT Stimulus Booklet 2 **and** the additional outline

1. First, read the instructions that are presented to the student in the stimulus booklet (beginning with “Imagine that you could . . .”)
2. Then, give the outline to the student and review each step on it
3. Finally, read the second instruction paragraph from the stimulus booklet (beginning with “You may either print or write in cursive.”). Begin timing.

<u>Administration of the two prompts differs only in two ways:</u>

1. Some students (for odd numbered files) complete Prompt 1 first, but others (for even numbered files) complete Prompt 2 first.
2. Every student receives the supportive outline for the second letter he or she writes.

APPENDIX C

Descriptive Statistics for Isolated Writing Skills Subtests

Variable	Mean	Standard Deviation	Possible Range	Obtained Range
GWT Dictation Spelling	108.41	12.23	62-160	87-151
GWT Editing	110.51	15.22	63-160	88-160
GWT Writing Samples	96.46	9.75	38-180	79-130
GWT Writing Fluency	110.37	19.64	24-160	73-151
WJ-III Handwriting	94.03	17.59	54-127	54-126

Scores for GWT Writing Samples, GWT Writing Fluency, and WJ-III Handwriting subtests were not included in the initial analyses, but they were available for exploratory analyses.

APPENDIX D

Descriptive Statistics for Executive Function Subtests

Variable	Mean	Standard Deviation	Possible Range	Obtained Range
EFQ Inhibit	5.14	2.97	0-20	0-12
EFQ Plan/Organize	7.87	3.27	0-20	1-16
EFQ Organization of Materials	3.94	3.05	0-14	0-14
EFQ Monitoring	6.06	3.26	0-20	0-13
WCST Total Trials Administered	81.65	14.22	1-128	69-128
WCST Total Correct	68.48	7.11	0-128	61-94
WCST Total Errors	111.62	10.58	55-145	72-125
WCST Perseverative Responses	120.37	18.00	55-145	60-145
WCST Perseverative Errors	119.00	17.59	55-145	64-145
WCST Nonperseverative Errors	108.48	9.09	55-145	79-122
WCST Conceptual Level Responses	111.38	11.20	55-145	73-127
WCST Total Number of Categories Completed	5.92	.45	0-6	3-6
WCST Trials to Complete First Category	13.94	8.71	10-128	10-65
WCST Failure to Maintain Set	.43	.71	0-21	0-3
WCST Learning to Learn	.77	3.27	-26.50-14.99	-10.23-14.99

WCST scores were not included in the initial analyses, but they were available for exploratory analyses.

APPENDIX E

Descriptive Statistics for Working Memory Subtests

Variable	Mean	Standard Deviation	Possible Range	Obtained Range
Numbers Reversed	98.13	10.55	24-160	80-131
Auditory Working Memory	109.19	12.00	36-160	78-130

Both of the working memory subtests were included in the calculation of the Working Memory composite that was employed in the analyses.

APPENDIX F

Descriptive Statistics for Unsupported Production of Connected Text Subscales

Variable	Mean	Standard Deviation	Possible Range	Obtained Range
Ideas and Development	2.67	.78	1-4	1-4
Organization, Unity, and Coherence	2.21	.57	1-4	1-4
Vocabulary	2.98	.55	1-4	2-4
Sentence Structure and Variety	2.73	.63	1-4	2-4
Grammar and Usage	3.29	.61	1-4	2-4
Capitalization and Punctuation	3.51	.54	1-4	2-4

All of the unsupported production of connected text subscales were included in the composite score for unsupported production of connected text that was used in the analyses.

APPENDIX G

Descriptive Statistics for Supported Production of Connected Text Subscales

Variable	Mean	Standard Deviation	Possible Range	Obtained Range
Ideas and Development	2.76	.66	1-4	2-4
Organization, Unity, and Coherence	2.43	.80	1-4	1-4
Vocabulary	2.92	.55	1-4	2-4
Sentence Structure and Variety	2.79	.63	1-4	2-4
Grammar and Usage	3.44	.56	1-4	2-4
Capitalization and Punctuation	3.56	.64	1-4	2-4

All of the supported production of connected text subscales were included in the composite score for supported production of connected text.

APPENDIX H

Pearson Correlations and Significance (2-tailed)

	1	2	3	4	5	6	7	8	9	10
1. EFQ Inhibit	1 .	.49** .00	.51** .00	.26* .04	.59** .00	.76** .00	.03 .80	.06 .63	-.02 .85	-.03 .81
2. EFQ Working Memory	-- --	1 .	.42** .00	.37** .00	.40** .00	.54** .00	.12 .35	.08 .53	-.16 .22	-.00 .99
3. EFQ Planning & Organization	-- --	-- --	1 .	.38** .00	.49** .00	.79** .00	.07 .57	-.08 .52	-.06 .62	-.05 .68
4. EFQ Organization of Behavior	-- --	-- --	-- --	1 .	.21 .10	.62** .00	.09 .47	-.03 .82	-.17 .17	-.16 .22
5. EFQ Monitor	-- --	-- --	-- --	-- --	1 .	.79** .00	.08 .51	.00 .99	-.05 .68	-.04 .74
6. EFQ Total	-- --	-- --	-- --	-- --	-- --	1 .	.08 .53	-.03 .80	-.09 .50	-.09 .50
7. WCST Trials Administered	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.81** .00	-.82** .00	-.67** .00
8. WCST Total Correct	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .	-.47** .00	-.38** .00
9. WCST Total Errors	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.86** .00
10. WCST Perseverative Responses	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .
11. WCST Perseverative Errors	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
12. WCST Nonperseverative Errors	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
13. WCST Conceptual Level Responses	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
14. WCST Categories Completed	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

	11	12	13	14	15	16	17	18	19	20	21
1. EFQ Inhibit	-.04	.01	.03	-.06	.10	.18	.05	-.08	-.25*	.11	-.24
	.73	.96	.84	.62	.46	.15	.71	.53	.04	.38	.05
2. EFQ Working Memory	-.05	-.16	-.13	-.17	.01	.17	-.01	-.20	-.20	-.22	-.14
	.72	.20	.30	.19	.91	.18	.91	.11	.12	.08	.28
3. EFQ Planning & Organization	-.06	.02	-.04	-.31*	.20	.14	.10	-.08	-.21	.06	-.22
	.66	.90	.74	.01	.12	.27	.44	.53	.10	.65	.08
4. EFQ Organization of Behavior	-.16	-.14	-.16	-.20	-.02	.04	-.23	-.12	-.11	-.13	-.10
	.20	.29	.20	.11	.84	.74	.07	.36	.40	.33	.44
5. EFQ Monitor	-.06	-.02	-.00	-.18	.25*	.18	.25*	-.02	-.15	.12	-.15
	.63	.91	.99	.15	.04	.15	.05	.90	.23	.33	.24
6. EFQ Total	-.10	-.02	-.05	-.25*	.17	.17	.06	-.08	-.20	.05	-.22
	.43	.87	.71	.05	.18	.18	.66	.53	.11	.71	.08
7. WCST Trials Administered	-.69**	-.80**	-.76**	-.58**	.55**	.62**	.17	-.17	-.16	-.11	-.16
	.00	.00	.00	.00	.00	.00	.18	.18	.22	.40	.20
8. WCST Total Correct	-.40**	-.54**	-.40**	-.08	.21	.73**	-.04	-.18	-.12	-.17	-.13
	.00	.00	.00	.52	.10	.00	.76	.15	.37	.18	.30
9. WCST Total Errors	.88**	.94**	.97**	.65**	-.56**	-.32**	-.23	.06	.12	-.01	.07
	.00	.00	.00	.00	.00	.01	.07	.66	.36	.95	.60
10. WCST Perseverative Responses	.99**	.70**	.84**	.55**	-.50**	-.26*	-.21	.08	.10	.05	.03
	.00	.00	.00	.00	.00	.04	.11	.55	.42	.67	.81
11. WCST Perseverative Errors	1	.73**	.86**	.54**	-.49**	-.29*	-.19	.09	.12	.06	.05
	.	.00	.00	.00	.00	.02	.13	.48	.34	.63	.70
12. WCST Nonperseverative Errors	--	1	.93**	.47**	-.47**	-.33**	-.21	.02	.07	-.03	.05
	--	.	.00	.00	.00	.01	.10	.86	.57	.83	.71
13. WCST Conceptual Level Responses	--	--	1	.59**	-.53**	-.21	-.23	.12	.13	.07	.09
	--	--	.	.00	.00	.10	.07	.35	.30	.57	.50
14. WCST Categories Completed	--	--	--	1	-.60**	-.19	-.23	-.02	.07	-.10	.07
	--	--	--	.	.00	.13	.08	.90	.58	.43	.58

	22	23	24	25	26	27	28	29	30	31	32
1. EFQ Inhibit	-.03 .84	-.21 .10	.14 .27	.09 .48	.10 .44	.28* .03	.22 .09	.21 .10	.16 .20	.13 .31	-.01 .92
2. EFQ Working Memory	-.14 .26	-.19 .13	-.20 .12	.02 .88	.15 .23	.25* .05	.23 .07	.34** .01	.16 .20	.30* .02	.13 .31
3. EFQ Planning & Organization	-.01 .95	-.16 .22	.08 .54	-.30* .02	-.06 .67	.01 .91	-.01 .94	.02 .87	-.09 .49	-.18 .16	-.24 .06
4. EFQ Organization of Behavior	-.06 .62	-.08 .52	-.08 .51	-.17 .19	.15 .23	.02 .87	.12 .35	.00 .97	-.09 .46	-.01 .94	-.07 .60
5. EFQ Monitor	.01 .95	-.14 .26	.14 .29	-.09 .49	.04 .74	.17 .19	.14 .29	.10 .45	.02 .88	.01 .94	-.01 .96
6. EFQ Total	-.03 .84	-.15 .25	.08 .54	-.16 .20	.07 .58	.16 .21	.15 .25	.09 .47	-.01 .94	-.05 .69	-.10 .43
7. WCST Trials Administered	-.35** .00	-.14 .29	.04 .77	.02 .90	-.23 .07	-.12 .36	-.19 .13	-.10 .42	.03 .84	-.04 .74	-.25* .05
8. WCST Total Correct	-.38** .00	-.09 .50	-.03 .84	-.09 .50	-.05 .68	-.02 .90	-.05 .70	-.04 .74	.15 .24	.05 .69	-.10 .45
9. WCST Total Errors	.16 .20	.14 .28	-.08 .54	-.03 .82	.07 .57	.00 .99	.02 .86	.03 .80	-.04 .77	-.01 .94	.19 .14
10. WCST Perseverative Responses	.19 .14	.13 .30	-.02 .87	.01 .96	.01 .92	.08 .53	.02 .88	.01 .91	-.04 .78	-.01 .94	.21 .10
11. WCST Perseverative Errors	.22 .09	.15 .24	-.03 .83	.02 .90	-.02 .89	.05 .70	-.02 .90	.03 .81	-.06 .63	.02 .91	.19 .14
12. WCST Nonperseverative Errors	.14 .29	.09 .48	-.09 .49	-.03 .80	.06 .61	-.03 .79	.01 .95	.06 .63	-.01 .92	.03 .81	.18 .16
13. WCST Conceptual Level Responses	.17 .18	.15 .23	.01 .92	-.05 .70	.10 .43	.00 .99	.04 .74	.06 .66	-.02 .86	.06 .66	.18 .17
14. WCST Categories Completed	.04 .72	.05 .68	-.13 .30	-.17 .19	.26* .04	.14 .29	.20 .11	.02 .91	.06 .62	-.00 .97	.21 .10

	33	34	35	36	37	38	39	40	41	42
1. EFQ Inhibit	.15 .25	-.07 .60	.16 .20	.14 .27	-.02 .88	.06 .66	.14 .28	.16 .22	.02 .84	.11 .40
2. EFQ Working Memory	-.03 .81	.02 .91	.26* .04	.26* .04	.03 .81	.23 .07	.25 .05	.17 .18	.10 .43	.23 .07
3. EFQ Planning & Organization	-.25* .05	-.24 .06	-.24 .05	-.01 .91	-.29* .02	-.26* .04	-.05 .68	-.13 .32	-.18 .16	-.22 .08
4. EFQ Organization of Behavior	-.23 .06	-.14 .28	-.14 .28	.16 .21	-.02 .86	-.09 .48	-.11 .40	-.09 .50	-.12 .34	-.06 .66
5. EFQ Monitor	.06 .62	-.05 .72	.04 .73	.07 .60	-.01 .93	-.03 .80	.15 .24	.08 .53	-.03 .80	.05 .70
6. EFQ Total	-.10 .43	-.15 .25	-.07 .58	.09 .47	-.13 .32	-.11 .40	.05 .72	.02 .87	-.09 .47	-.04 .74
7. WCST Trials Administered	-.18 .17	-.29* .02	-.22 .08	-.39** .00	-.26* .04	-.16 .21	-.25 .05	-.26* .04	-.12 .33	-.34** .01
8. WCST Total Correct	-.12 .33	-.08 .52	-.04 .73	-.38** .00	-.13 .31	.02 .89	-.16 .20	-.22 .08	-.11 .38	-.24 .06
9. WCST Total Errors	.14 .28	.31* .01	.16 .21	.13 .31	.15 .25	.08 .53	.16 .22	.17 .19	.01 .95	.16 .20
10. WCST Perseverative Responses	.29* .02	.24 .06	.18 .15	.10 .42	.01 .44	.13 .31	.15 .25	.30* .02	.14 .27	.21 .10
11. WCST Perseverative Errors	.28* .02	.27* .03	.19 .14	.10 .42	.10 .42	.12 .36	.13 .31	.28* .03	.13 .32	.20 .12
12. WCST Nonperseverative Errors	.02 .90	.27* .03	.14 .27	.14 .29	.12 .35	.03 .83	.15 .24	.11 .38	-.05 .69	.12 .35
13. WCST Conceptual Level Responses	.14 .26	.31* .01	.18 .15	.08 .56	.12 .34	.07 .57	.12 .33	.15 .24	-.02 .87	.12 .34
14. WCST Categories Completed	.20 .11	.30* .02	.20 .12	.20 .11	.32* .00	.30* .02	.23 .07	.14 .27	.16 .23	.32* .01

	1	2	3	4	5	6	7	8	9	10
15. WCST Trials to Complete 1st Category	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
16. WCST Failure to Maintain Set	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
17. WCST Learning to Learn	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
18. GWT Total Score	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
19. GWT Basic Writing Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
20. GWT Written Expression Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
21. GWT Dictation Spelling	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
22. GWT Writing Samples	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
23. GWT Editing	-- --		-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
24. GWT Writing Fluency	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
25. WJ-III Handwriting	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
26. WJ-III Numbers Reversed	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
27. WJ-III Auditory Working Memory	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

	11	12	13	14	15	16	17	18	19	20	21
15. WCST Trials to Complete 1st Category	--	--	--	--	1	.24	.75**	-.00	.03	-.05	-.04
	--	--	--	--	.	.06	.00	.99	.80	.68	.79
16. WCST Failure to Maintain Set	--	--	--	--	--	1	.14	-.10	-.12	-.08	-.16
	--	--	--	--	--	.	.27	.41	.33	.52	.21
17. WCST Learning to Learn	--	--	--	--	--	--	1	.04	.07	-.04	-.02
	--	--	--	--	--	--	.	.78	.57	.74	.89
18. GWT Total Score	--	--	--	--	--	--	--	1	.85**	.77**	.78**
	--	--	--	--	--	--	--	.	.00	.00	.00
19. GWT Basic Writing Composite	--	--	--	--	--	--	--	--	1	.37**	.90**
	--	--	--	--	--	--	--	--	.	.00	.00
20. GWT Written Expression Composite	--	--	--	--	--	--	--	--	--	1	.36**
	--	--	--	--	--	--	--	--	--	.	.00
21. GWT Dictation Spelling	--	--	--	--	--	--	--	--	--	--	1
	--	--	--	--	--	--	--	--	--	--	.
22. GWT Writing Samples	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--
23. GWT Editing	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--
24. GWT Writing Fluency	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--
25. WJ-III Handwriting	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--
26. WJ-III Numbers Reversed	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--
27. WJ-III Auditory Working Memory	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--

	22	23	24	25	26	27	28	29	30	31	32
15. WCST Trials to Complete 1st Category	-.10 .45	.07 .59	-.03 .79	.08 .51	-.11 .37	-.08 .52	-.07 .57	.06 .65	-.09 .48	.02 .90	-.19 .14
16. WCST Failure to Maintain Set	-.34** .01	-.08 .55	.07 .59	-.10 .39	-.15 .25	-.21 .10	-.20 .12	.12 .37	.14 .29	.10 .44	-.13 .30
17. WCST Learning to Learn	.03 .84	.11 .41	-.08 .55	.12 .36	-.04 .74	-.15 .25	-.07 .58	.08 .55	-.08 .52	.04 .76	-.09 .47
18. GWT Total Score	.59** .00	.78** .00	.61** .00	.09 .47	.14 .28	.24 .06	.22 .08	-.09 .47	-.09 .46	-.01 .96	.15 .23
19. GWT Basic Writing Composite	.51** .00	.94** .00	.18 .16	.11 .37	.15 .24	.28* .02	.25* .05	-.04 .77	-.04 .75	-.00 .97	.22 .08
20. GWT Written Expression Composite	.53** .00	.30* .02	.91** .00	.13 .30	.05 .72	.10 .45	.09 .48	-.16 .20	-.12 .36	.01 .94	.04 .78
21. GWT Dictation Spelling	.52** .00	.71** .00	.16 .20	.10 .43	.19 .13	.26* .04	.27* .03	-.07 .60	-.01 .94	.03 .80	.23 .07
22. GWT Writing Samples	1 .	.40** .00	.13 .31	.01 .96	.20 .11	.23 .07	.26* .04	-.01 .93	-.14 .29	.11 .38	.28* .02
23. GWT Editing	-- --	1 .	.15 .25	.09 .49	.10 .42	.27* .04	.21 .10	-.00 .98	-.04 .74	-.04 .75	.17 .19
24. GWT Writing Fluency	-- --	-- --	1 .	.14 .29	-.04 .76	-.02 .86	-.03 .80	-.20 .11	-.10 .44	-.07 .57	-.13 .32
25. WJ-III Handwriting	-- --	-- --	-- --	1 .	-.01 .92	.02 .85	.01 .94	.11 .39	.19 .13	.19 .13	.11 .39
26. WJ-III Numbers Reversed	-- --	-- --	-- --	-- --	1 .	.43** .00	.88** .00	.22 .08	.12 .33	.25* .05	.26* .04
27. WJ-III Auditory Working Memory	-- --	-- --	-- --	-- --	-- --	1 .	.80** .00	.21 .09	.32* .01	.19 .13	.44** .00

	33	34	35	36	37	38	39	40	41	42
15. WCST Trials to Complete 1st Category	-.05 .67	-.14 .29	-.10 .45	-.16 .22	-.22 .08	-.12 .35	-.22 .08	-.28* .02	-.06 .64	-.25* .05
16. WCST Failure to Maintain Set	-.06 .62	.01 .92	.05 .72	-.39** .00	-.16 .22	-.04 .78	-.09 .49	-.16 .21	-.21 .10	-.25* .05
17. WCST Learning to Learn	.15 .23	.05 .70	.04 .74	.03 .81	-.03 .84	-.01 .96	-.03 .81	-.07 .61	.14 .29	.01 .94
18. GWT Total Score	.32* .01	.14 .27	.10 .43	-.15 .23	-.13 .31	.08 .56	-.10 .44	.25* .05	.16 .22	.01 .96
19. GWT Basic Writing Composite	.25 .05	.15 .23	.14 .29	-.11 .40	-.08 .53	.15 .24	-.04 .76	.20 .12	.20 .12	.06 .64
20. GWT Written Expression Composite	.31* .01	-.03 .83	.00 .98	-.14 .29	-.11 .39	-.06 .67	-.13 .30	.25 .05	.10 .44	-.03 .80
21. GWT Dictation Spelling	.23 .07	.18 .15	.15 .25	-.11 .40	-.11 .37	.10 .42	-.02 .90	.22 .09	.22 .09	.05 .68
22. GWT Writing Samples	.38** .00	-.02 .85	.16 .21	.13 .32	.17 .19	.18 .15	.17 .18	.36** .00	.23 .07	.28* .02
23. GWT Editing	.18 .15	.10 .45	.10 .46	-.10 .44	-.06 .66	.18 .15	-.04 .73	.15 .24	.14 .29	.05 .70
24. GWT Writing Fluency	.19 .14	-.01 .94	-.10 .44	-.23 .07	-.21 .10	-.17 .17	-.24 .06	.12 .35	-.01 .92	-.18 .15
25. WJ-III Handwriting	.24 .06	.14 .27	.26* .04	.14 .26	.20 .12	.04 .78	.07 .57	.08 .54	.29* .02	.20 .12
26. WJ-III Numbers Reversed	-.01 .93	.16 .21	.27* .03	.21 .09	.20 .11	.15 .24	-.01 .95	.03 .82	-.01 .93	.14 .27
27. WJ-III Auditory Working Memory	.21 .10	.02 .85	.38** .00	.18 .15	.02 .88	.31* .01	.06 .66	.26* .04	.09 .47	.20 .12

	1	2	3	4	5	6	7	8	9	10
28. WJ-III Working Memory Cluster	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
29. UNS WIAT Ideas & Development	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
30. UNS WIAT Organization, Unity, & Coherence	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
31. UNS WIAT Vocabulary	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
32. UNS WIAT Sentence Structure & Variety	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
33. UNS WIAT Grammar	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
34. UNS WIAT Capitalization & Punctuation	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
35. UNS WIAT Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
36. SUP WIAT Ideas & Development	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
37. SUP WIAT Organization, Unity, & Coherence	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
38. SUP WIAT Vocabulary	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

	11	12	13	14	15	16	17	18	19	20	21
28. WJ-III Working Memory Cluster	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
29. UNS WIAT Ideas & Development	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
30. UNS WIAT Organization, Unity, & Coherence	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
31. UNS WIAT Vocabulary	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
32. UNS WIAT Sentence Structure & Variety	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
33. UNS WIAT Grammar	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
34. UNS WIAT Capitalization & Punctuation	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
35. UNS WIAT Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
36. SUP WIAT Ideas & Development	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
37. SUP WIAT Organization, Unity, & Coherence	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
38. SUP WIAT Vocabulary	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

	22	23	24	25	26	27	28	29	30	31	32
28. WJ-III Working Memory Cluster	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.25* .05	.25 .05	.26* .04	.39** .00
29. UNS WIAT Ideas & Development	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.41** .00	.62** .00	.37** .00
30. UNS WIAT Organization, Unity, & Coherence	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.26* .04	.29* .02
31. UNS WIAT Vocabulary	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.36** .00
32. UNS WIAT Sentence Structure & Variety	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .
33. UNS WIAT Grammar	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
34. UNS WIAT Capitalization & Punctuation	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
35. UNS WIAT Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
36. SUP WIAT Ideas & Development	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
37. SUP WIAT Organization, Unity, & Coherence	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
38. SUP WIAT Vocabulary	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

	33	34	35	36	37	38	39	40	41	42
28. WJ-III Working Memory Cluster	.10	.11	.36**	.22	.13	.25*	.01	.14	.03	.18
	.45	.41	.00	.08	.30	.04	.92	.26	.83	.15
29. UNS WIAT Ideas & Development	.00	.26*	.75**	.46**	.28*	.35**	.32*	.01	-.01	.34**
	1.00	.04	.00	.00	.02	.00	.01	.92	.93	.01
30. UNS WIAT Organization, Unity, & Coherence	.01	.13	.56**	.17	.05	.10	.12	.11	-.05	.12
	.92	.32	.00	.17	.69	.42	.35	.38	.68	.37
31. UNS WIAT Vocabulary	.11	.19	.69**	.30*	.16	.42**	.18	.08	.02	.26*
	.39	.13	.00	.02	.20	.00	.17	.56	.84	.04
32. UNS WIAT Sentence Structure & Variety	.33**	.32*	.72**	.42**	.30*	.55**	.51**	.30*	.34**	.56**
	.01	.01	.00	.00	.02	.00	.00	.02	.01	.00
33. UNS WIAT Grammar	1	.24	.44**	.09	.31*	.26*	.24	.66**	.41**	.45**
	.	.06	.00	.48	.01	.04	.06	.00	.00	.00
34. UNS WIAT Capitalization & Punctuation	--	1	.55**	.12	.20	.08	.12	.15	.24	.22
	--	.	.00	.35	.12	.51	.33	.24	.05	.08
35. UNS WIAT Composite	--	--	1	.44**	.36**	.48**	.41**	.34**	.25	.53**
	--	--	.	.00	.00	.00	.00	.01	.05	.00
36. SUP WIAT Ideas & Development	--	--	--	1	.62**	.39**	.54**	.24	.35**	.76**
	--	--	--	.	.00	.00	.00	.05	.00	.00
37. SUP WIAT Organization, Unity, & Coherence	--	--	--	--	1	.30*	.54**	.32**	.38**	.78**
	--	--	--	--	.	.02	.00	.01	.00	.00
38. SUP WIAT Vocabulary	--	--	--	--	--	1	.61**	.22	.31*	.64**
	--	--	--	--	--	.	.00	.08	.01	.00

	1	2	3	4	5	6	7	8	9	10
39. SUP WIAT Sentence Structure & Variety	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
40. SUP WIAT Grammar	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
41. SUP WIAT Capitalization & Punctuation	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
42. SUP WIAT Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

	11	12	13	14	15	16	17	18	19	20	21
39. SUP WIAT Sentence Structure & Variety	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
40. SUP WIAT Grammar	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
41. SUP WIAT Capitalization & Punctuation	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
42. SUP WIAT Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

	22	23	24	25	26	27	28	29	30	31	32
39. SUP WIAT Sentence Structure & Variety	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
40. SUP WIAT Grammar	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
41. SUP WIAT Capitalization & Punctuation	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
42. SUP WIAT Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

	33	34	35	36	37	38	39	40	41	42
39. SUP WIAT Sentence Structure & Variety	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.31* .01	.45** .00	.80** .00
40. SUP WIAT Grammar	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.47** .00	.58** .00
41. SUP WIAT Capitalization & Punctuation	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .	.69** .00
42. SUP WIAT Composite	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	1 .

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

APPENDIX I

Hunter and Schmidt (2004) Corrections for Attenuation and Range Restriction

Correction for Attenuation

$$\frac{r_{xy}}{\sqrt{r_{xx}} * \sqrt{r_{yy}}} = r_c$$

Where:

r_{xy} = Observed Working Memory * Unsupported Production of Connected Text correlation

r_{xx} = Published Working Memory reliability coefficient (McGrew & Woodcock, 2001)

r_{yy} = Published Unsupported Production of Connected Text (The Psychological Corporation, 1992)

r_c = Correlation corrected for attenuation

$$\frac{.36}{\sqrt{.89} * \sqrt{.76}} = \frac{.36}{.82} = .44$$

Correction for Range Restriction in Unsupported Production of Connected Text

$$\frac{u_x p_1}{\sqrt{(u_x^2 - 1) p_1^2 + 1}} = p_2$$

Where:

u_x = Ratio of the population standard deviation of the Working Memory measure (15) and the obtained standard deviation of the Working Memory measure in the present sample (10.36)

p_1 = The correlation obtained in the Correction for Attenuation equation

p2 = Correlation corrected for attenuation and range restriction

$$\frac{\frac{15}{10.36}(.44)}{\sqrt{((\frac{15}{10.36})^2 - 1)(.44^2) + 1}} = .53$$