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THE RELATIONSHIP BETWEEN EXECUTIVE FUNCTIONS AND BROAD WRITTEN LANGUAGE SKILLS IN STUDENTS AGES 12 TO 14

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THE RELATIONSHIP BETWEEN EXECUTIVE FUNCTIONS AND BROAD WRITTEN LANGUAGE SKILLS IN STUDENTS AGES 12 TO 14 YEARS OLD

by

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First and foremost I must mention and thank Fredrick Schrank of the Woodcock-Munoz Foundation for granting permission and access to the data set used in my dissertation. On a more personal note I would like to dedicate this document to my family. My mother, father, Larry, and Brenda have always supported me in my education, goals, and dreams. No matter how long this goal has taken they all gave me advice, financial support, encouragement, and love. I would not be where I am today without any of them. I would also like to thank my sister for checking up on me, pampering me, telling me to stop worrying so much, and keeping me in line. I want to thank my grandma Opal and Mammaw for the important roles they played in my life. I thank them for giving me opportunities they never had and for believing in me. I want to also thank my extended family, which includes my friends from Hoffman and U of I, my friends from UT and Austin, and my fellow interns and supervisors from Cy-Fair. They have all been there for good and bad times, school-related or not, and have all heard me talk about this document many, many, many times. They have all taught me so much about this field and more importantly about life. Finally, I would like to thank the professors in the school psychology program at The University of Texas at Austin. They gave me time to develop into the school psychologist I wanted to be. They make the program an exceptional learning environment and a program I am not only very proud to complete but also proud to represent in my future endeavors. I am very blessed to have all of the abovementioned people touch my life and I hope to pass this positive energy on to others as I explore the many good things to come.

The Relationship Between Executive Functions and Broad Written Language Skills in Students Ages 12 to 14 Years Old

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The purpose of this investigation was to explore the relationship between executive functions and written language skills. Five hundred and forty-three students between the ages 12 and 14 were administered the Planning, Retrieval Fluency, Pair Cancellation, and Number Reversal subtests from the Woodcock-Johnson Tests of Cognitive Abilities – Third Edition (WJIII; Woodcock, McGrew, & Mather, 2001a) and the subtests included under the Broad Written Language cluster of the Woodcock-Johnson Tests of Achievement – Third Edition (WJIII; Woodcock, McGrew, & Mather, 2001b). The sample was taken from the larger sample used to norm the WJIII tests. Relationships were explored between the executive function subtest scores and Broad Written Language scores and were found to be significantly correlated. The four executive function measures and gender were entered simultaneously into a multiple regression equation and found to significantly predict Broad Written Language scores. Further examination revealed that all the composites with the exception of the Planning subtest significantly predicted Broad Written Language skills. Subtests measuring the

executive functions working memory and attention (Number Reversal and Pair Cancellation) were the most significant contributors when the composite scores were examined. Results provide researchers with a foundation to further investigate the underlying executive functions that may help or hinder students' ability to produce quality written products and eventually design intervention studies based on areas of executive functioning. Limitations of the study are presented as well as implications for research and practice and directions for future research.

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GLOSSARY

Translating: producing written language under the direction of a generated writing plan

Idea Generation: developing ideas that may be used in writing

Text Generation: transforming ideas into language representations in working memory

Transcription: translation of language representations into written symbols

On-line Revision: revisions occurring while writing initial product

On-line Planning: planning conducted while producing initial product

Advanced Planning: planning that occurs before writing

Orthographic Coding: representing a printed word in memory and making conclusions about the whole word, letter, or letter cluster patterns

Phonological Coding: knowledge of letter and sound correspondence as well as the ability to segment spoken words into phonemes

Visual Motor Integration: the integration of fine motor and visual functions or the analysis and production of geometric forms

Orthographic Motor Integration: coordinating the retrieval of alphabet letters from memory and production of letters on paper

Lower Level Processes: skills that may be automatized such as handwriting and spelling

Higher Level Processes: less automatic and more constructive skills involved in writing such as planning and revising

Working Memory: the ability to simultaneously store and process information

Writing Mechanics: text production or the ability to use fine motor skills to form letters and words

Writing Fluency: number of words produced or the rate of text production

Writing Conventions: Rules related to grammatical skills in developing words, sentences, and paragraphs

Writing Semantics: vocabulary used in writing product as well as the cohesion and coherence of the text to convey meaning

CHAPTER 1

Introduction

Although national studies have found that many students are not performing at grade level in writing, research has paid considerably less attention to written expression skills in comparison to other academic domains. A recent study found only 23% of fourth graders could write at or above the appropriate level, 61% wrote at a basic level, and 16% wrote below the basic skill level. Moreover, only 1% of these fourth graders performed at the advanced level (National Center for Education Statistics, 1999). In 1990, the National Assessment of Education Progress asked fourth and eighth grade teachers to submit a sample of their students' best writing work. This research found that 1% of the fourth graders and 8% of the eighth grade students wrote a well-developed narrative story. Moreover, only 22% of the eighth grade students wrote an argumentative essay.

A recent prevalence study reported that between 6-22% of 1,274 students from three middle schools located in southeastern, midwestern, and western regions of the United States demonstrated significant writing problems on a standardized writing test (Hooper et al., 1993). Students with writing difficulties performed two standard deviations below the test mean for their age group on the Test of Written Language – Second Edition (TOWL-2; Hammill & Larsen, 1988). Results also found that, in general, male students (n=624) and minority students (n=301) showed the most difficulty with written expression (Hooper et al., 1993). Males were more likely than females to perform one standard deviation below the mean across all three regional sites. A greater

percentage of minority students in the Southwestern region fell one to two standard deviations below the mean, whereas there was a trend for minority students in the western region to fall at least two standard deviations below the mean. Results of these studies demonstrate that writing is a problematic area for a sizable minority of students and research continuing to address written expression is necessary.

Written expression skills are necessary for students to make adequate academic progress (Baker & Hubbard, 2002). Learning and writing processes are entwined and difficult to tease apart, thus deficits in the writing area often suggest overall academic difficulty. Baker and Hubbard (2002) found that referrals for written expression deficits were higher than any other reason for referral. Previous research (Abbott & Berninger, 1993; Bereiter, Burtis, & Scardamalia, 1988; Berninger, Cartwright, Yates, Swanson, & Abbott, 1994; Berninger & Colwell, 1985; Berninger & Rutberg, 1992; Berninger & Swanson, 1994; Berninger et al., 1992; Hayes & Flower, 1980; Scardamalia & Bereiter, 1986) has gained insight into what skills make an effective writer and what components embody the writing process. Effective writers use specific skills when planning, drafting, and revising their compositions. For example, during the planning stage, effective writers organize collected information, search their memory for related information, and set goals pertaining to the purpose and the style of writing (Graham, Schwartz, & MacArthur, 1993). In contrast, poor writers are more likely to have problems with text organization, idea generation, and knowledge of the writing process (Englert & Raphael, 1988).

Additional research has found that neuropsychological and cognitive processes may interfere with some students having difficulties producing written text (Berninger & Cowell, 1985). Written expression utilizes several neuropsychological processes collectively known as executive processes. Executive functioning encompasses inhibition or responses and includes planning of sequences and actions, organization and integration of cognitive and behavioral processes, and self-regulation (Denckla, 1996). Children with appropriate executive functioning develop these skills and become efficient and productive on various tasks across different situations. Currently, research has used various neuropsychological laboratory measures to assess different constructs underlying executive functioning and research has begun to examine the connection between executive functions and written expression (Berninger, Cartwright, et al., 1994; Berninger, Whitaker, et al., 1996; Berninger, Yates, et al., 1992). Students with writing difficulties may have a disadvantage in executive functions.

In an effort to continue building support for previous research, the present study examined the relationship between adolescents' performances on executive function tasks and written expression task. Adolescents were selected as the target group for this investigation for several reasons. Typically developing students in this age range should be able to develop more complex and longer writing passages. Writing at this level should require more integration of higher order cognitive and neuropsychological processes such as planning and revising. Research also suggests that executive functions should be developmentally intact by the target age used in this investigation (Becker, Isaac, & Hynd, 1987; Denckla, 1994; Passler, Isaac, & Hynd, 1985). Previous research

found that although executive functions were related to writing skills, they did not significantly predict fourth and fifth graders' writing skills (Hooper, Swartz, Wakely, de Kruif, and Montgomery, 2001). It was hypothesized that due to the intact executive functions and the higher complexity of writing in students between the ages 12 and 14, executive functions will predict these students' writing skills.

The research concerning executive functioning and academic problems, particularly written expression, is very limited and should be addressed. Examining these topics would be beneficial to understanding and assisting the needs of students with deficits in writing. Linking these findings to assessment and to developing better intervention strategies for students with writing difficulties appears to be the appropriate next step.

Hypothesis 1

Performance on executive functioning tasks measuring attention, working memory, planning, and verbal fluency will correlate statistically significant to performance on tasks measuring written language skills.

Hypothesis 2

Executive functioning tasks (attention, working memory, planning, and verbal fluency) will explain a statistically significant proportion of the variance to writing performances as measured by the Woodcock Johnson Test of Achievement – Third Edition.

Hypothesis 3

Performance on working memory and attentions tasks will be more important in explaining performance on the writing task with the other variables in the analysis controlled.

CHAPTER 2

Review of the Literature

This literature review will examine several proposed models of written expression, as well as research investigating the cognitive processes and basic neurodevelopmental skills underlying the writing process. Both cognitive and neuropsychological theories and research will be reviewed in order to gain a better understanding of the processes and skills needed to become a skilled writer. The integration between these two fields is important to understand the differences between the good and poor writers. While cognitive psychologists examine the process and instructional influences on the process, neuropsychologists have used assessment and imaging studies to determine the necessary skills and brain functioning needed to construct a written product. These two areas of psychology provide an exciting combination of process and product that builds a better picture of how we become writers and the problem areas associated with writing deficits.

Following a review of the research examining the proposed models of writing, current models using recent research will be summarized. All of the updated models include the construct of working memory, an executive function, and stress the importance of the role executive processes play in implementing cognitive processes. The addition of working memory points to a new line of research examining how executive functions interplay with lower and higher level processes in written expression. A

summary of executive function research as well as research examining the link between executive functions and written expression will be provided. The majority of research in this area concerns the executive function of working memory, while many other executive functions that need to be examined are excluded. The proposed study will focus on some of the additional executive functions such as planning and response inhibition. Although, research concerning these executive functions and writing is very limited, this literature will also be reviewed. Finally, a summary incorporating cognitive and neuropsychological research and a rationale for the proposed study will be presented.

Cognitive Models of Written Expression

Writing Process of Skilled Adult Writers

The most basic theory of writing, the linear stage theory, describes composing as proceeding through the different stages of prewriting, writing, and rewriting. Hayes and Flower (1980) built upon linear stage theories of writing to suggest that several levels of cognitive processes occur simultaneously and work together during the writing process. Data were gathered on skilled adult writers using the think aloud protocol. In this protocol the writer describes his internal thinking processes verbally as he writes a composition. They developed a model describing the writing process they observed in these skilled adult writers. According to Hayes and Flower (1980), the adult writing process can be divided into three recursive processes: planning, translating and reviewing. These three processes are described as continuously interrupting and communicating with each other throughout the writing process.

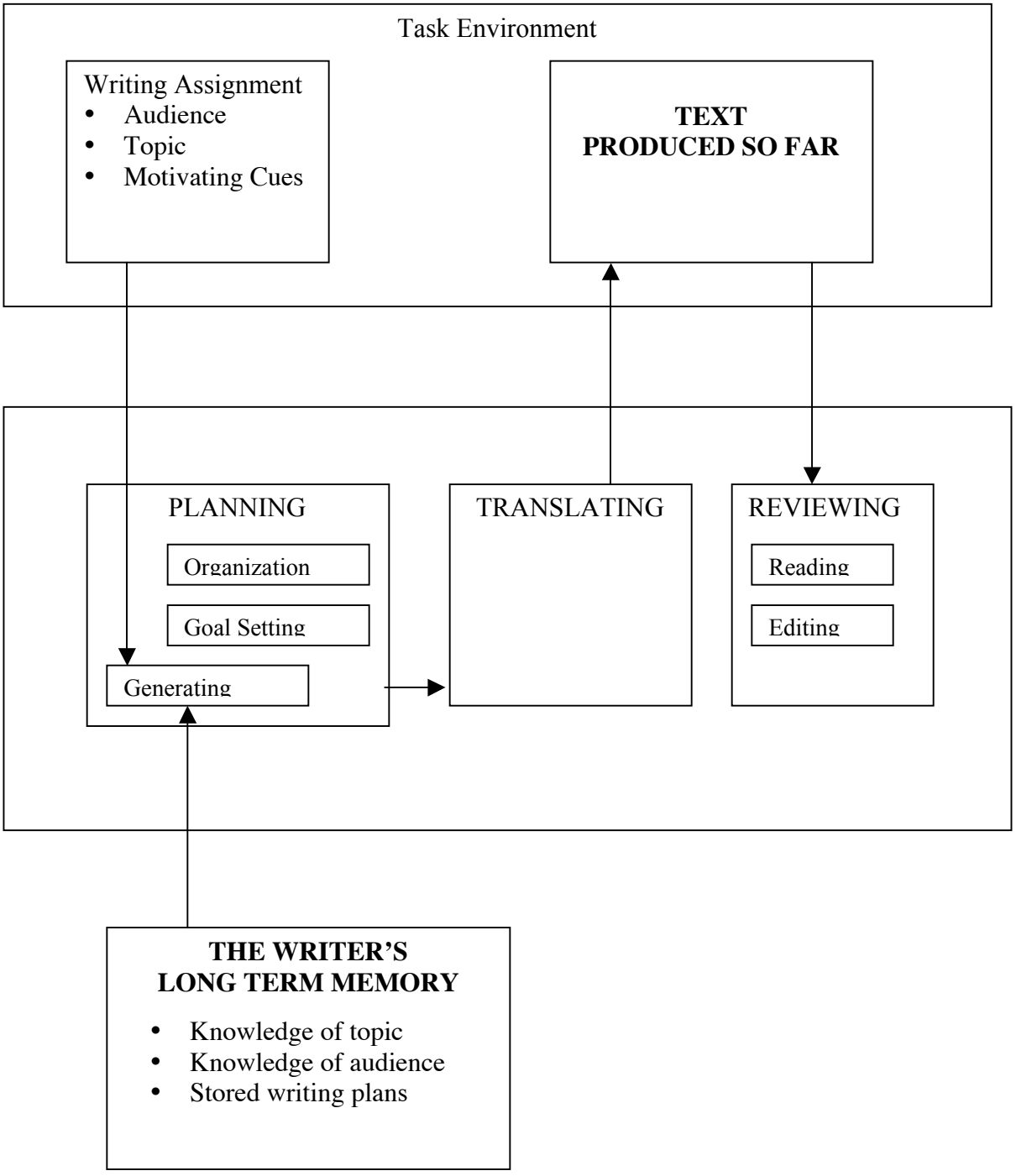

Figure 1. Initial Writing Model: Writing Process of the Skilled Adult Writer. Adapted from "Identifying the Organization of Writing Processes," by J. R. Hayes and L. S. Flower (1980). In *Cognitive Processes of Writing* (p. 12). Mahwah, NJ: Lawrence Erlbaum. Reprinted by permission from Lawrence Erlbaum Associates, INC.

Figure 1 provides a schema for understanding how these variables interact. The processes of planning, translating, and reviewing operate in the writer's long-term memory and task environment. Hayes and Flower (1980) explained that the writer'slong-term memory included the knowledge of the topic, knowledge of language, and knowledge of the genre. The task environment was associated with the type of writing assignment and text already produced by the writer. In the planning phase, the writer retrieves information from the task environment and long-term memory to generate ideas, set goals, and organize a writing plan. During translating, the writer produces written language under the direction of the generated writing plan. Finally during the process of reviewing, the writer improves the quality of produced text by reading and editing it.

In this model the adult writing process can be divided into lower level processes and higher level processes. Lower level processes include the mechanics of writing, such as spelling and handwriting, whereas higher level processes would include the hypothesized processes of planning, translating and reviewing. Hayes and Flower neglected to include the role of the lower level processes in their 1980 model. Although, Hayes and Flower's (1980) model of writing was an important step in understanding the processes involved in written expression, more information was needed to understand these lower level processes as well as the developmental differences between children and adults.

Developmental Differences in Writing Skills

Scardamalia and Bereiter (1986) also produced a model of the writing process in which they attempted to distinguish the differences between younger and older writers.

Developmental differences and skill levels were addressed through the concepts of knowledge telling and knowledge transforming. Knowledge telling entails retrieving information from memory and writing it. Knowledge transforming involves changing the information retrieved from memory into an appropriate manner for the intended audience and writing purpose. Scardamalia and Bereiter (1986) explained that children generate text through retrieving information from memory based on the topic or genre. In comparison to the adult writer, beginning writers translate the text with little evaluation of text appropriateness or revision.

Two different models, knowledge telling and knowledge transforming, were developed in order to explain how beginning writers operate at the level of writing they do and only use the limited cognitive processes available to them. Instead of solely explaining novice writing as deficiencies in the cognitive processes shown to be used by expert writers, two models were developed to explain the alternate route used by beginning writers (Bereiter, Burtis, & Scardamalia, 1988; Bereiter & Scardamalia, 1986; Bereiter & Scardamalia, 1987). The models show that beginning writers are not using cognitive processes to a lesser extent or less developed form, but are using a different method to perform writing tasks in absence of the cognitive processes needed in expert writing. Expert writers are hypothesized to have access to both the knowledge telling and knowledge transforming models and choose the model necessary for a given task. In contrast, novice writers are more likely to follow the knowledge telling model, but may have access to the more effortful knowledge transforming process with teaching assistance.

Cognitive Explanation for Written Expression Difficulties

The earliest theories and models using a cognitive base for explaining written expression examine mostly skilled writers and do not provide many hypotheses for why some individuals have difficulties in the domain of writing. Using the 1980 version of Hayes and Flower's model, it may be assumed that difficulties in written expression are due to a breakdown in one of the processes involved in writing or a lack of coordination between these processes. With the addition of Scardamalia and Bereiter's work a further assumption may be that less skilled writers use an alternate process as described by knowledge telling. Moreover, beginning writers may not have developed all of the necessary processes (e.g., planning) to produce quality written work.

While earlier cognitive models of writing (Hayes & Flowers, 1980; Scardamalia & Bereiter, 1986) addressed important basic components of writing research, researchers like Berninger (1999) and McCutchen (1995) argued that the previous models do not address all of the cognitive processes relevant to translating oral language into written language. Research in the latter part of the twentieth century has provided opportunities to gain knowledge in the areas of brain functioning, brain abnormalities, and how the brain relates to cognitive processes such as reading and writing. Also, neuropsychological literature supports some of the existing cognitive theories with data from assessments and imaging studies.

Neuropsychological Theories of Written Expression

The neuropsychological perspective regards the brain as several interacting systems working together to perform various skills. Thus, this perspective takes the

cognitive models one step further by examining the actual brain systems responsible for the skills noted in learning and academic functioning. Similar to current research in the cognitive domain, most findings come from comparing good and poor writers (or individuals with learning disabilities) on various writing tasks and neuropsychological tasks. Emerging evidence from brain imaging research shows various brain regions associated with language and motor skills to be involved in writing tasks. This literature will be reviewed in the following section.

Brain Structures and Hypotheses of Written Expression Disorders

Research examining the brain structures related to language skills remains unclear. Satz (1991) found that both the left and right hemisphere of the brain play a role in language processing. The right hemisphere (anterior, central, posterior regions) was involved in the visual-spatial, emotional, and affective components of language skills; whereas, the left hemisphere (temporal-parietal, anterior regions) played a role in linguistic, speech, and reading processes. Figure 2 provides an illustration of these structures. Aram and Ekelman (1988) studied 32 children with cerebral vascular lesions and found written language problems to be associated with right-lesioned group. This study may give further support to involvement of the right hemisphere in language and writing processes.

In comparison to reading research, there are few brain imaging studies examining writing and most of them concern the grapho-motor system in writing or patients with acquired agraphia. All of these studies were completed on adult participants. Research examining adult planning of sequential finger movements found activation in the

supplementary motor area and the premotor cortex (van Mier, Tempel, Perlmutter, Raichle, & Petersen, 1998), while the adult execution of sequential finger movements

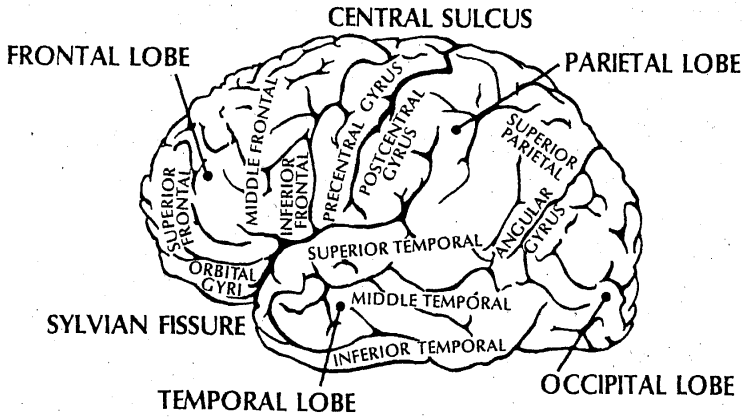

Figure 2. Picture of the left hemisphere showing the four major lobes of the cerebral cortex. Adapted from M. Semrud-Cllikeman and P. A. Teeter, "Personality, Intelligence and Neuropsychology," (1995). In D. Saklofske (Ed.), *International handbook of personality and intelligence in clinical psychology and neuropsychology*. New York:Plenum Press. Reprinted by Permission from Plenum Press.

activated the contralateral primary motor cortex, secondary motor cortex, cerebellum areas, parietal areas, putamen, and globus pallidus (Jenkins, Brooks, Nixon, Frackowiak, & Passingham, 1994; Kuwabara, Watanabe, Tsuji, & Yuasa, 1995). Finally, some research has looked at the difference between the performance of new and learned motor tasks and found that the cerebellum played a bigger role than just assisting with motor control. Several studies found the cerebellum to also be involved in learning of new tasks

as well as executing practiced or automatized tasks (Jenkins et al., 1994; Nicholson, Fawcett, Berry, Jenkins, Dean, & Brooks, 1999; van Mier et al., 1998).

A unique study examined adults performing four tasks similar to handwriting movements in Kanji and Hiragana characters (Matsuo, Nakai, Kato, Moriya, Isoda, Takehara, & Sakahara., 2000). Hiragana characters have corresponding phonological codes and were found to activate Broca's area, whereas Kanji characters do not involve phonological coding and activated the right superior parietal lobe. In fact, all handwriting tasks activated the left superior parietal lobe, except for tasks that didn't involve orthographic symbols (e.g., copying a circle). Thus, this study suggests that visual images with orthographic codes connect visual and language systems in the brain.

In addition to looking at motor movement involved in writing, some imaging research examined adults with acquired writing disorders called agraphia. This disorder impairs a person's spelling or ability to produce letters during composition. Although there are four different types of central agraphia interfering with spelling, lesions for all types have been found in different structures located in the left hemisphere (see Table 1). In comparison, the lesions associated with the peripheral agraphia (agraphia concerning the production of letters) have been found in the left parietal lobe, left parieto-occiptal, the cerebellum, and the right parietal lobe. A range of areas may be associated with different types of peripheral agraphia, because some of the problems are more motor based while other problems are more language based.

TABLE 1

SUMMARY OF LESION LOCATIONS ASSOCIATED WITH CENTRAL AND PERIPHERAL AGRAPHIA

Type of Agraphia	Features of Disorder	Location in Brain
Lexical (Central)	Difficulty spelling irregular and ambiguous words	Left posterior temporo-parietal
Phonological (Central)	Difficulty spelling nonwords,	Left perisylvian
Deep (Central)	Semantic errors in writing	Left-hemisphere perisylvian
Semantic(Central)	Difficulty with spontaneous writing and written naming	Heterogenous left-hemisphere sites (often extraperisylvian)
Allographic (Peripheral)	Inability to produce or choose the correct letter shapes in handwriting	Left pareito-occipital
Apraxic (Peripheral)	Poor letter formation	Left parietal lobe
Nonapraxic Disorders of Motor Execution	Poor regulation movement, force, and speed in handwriting	Basal ganglia, cerebellum
Afferent Dysgraphia	Duplication or omission of letters or lines in letters	Right parietal lobe

Note. Adapted from Aphasia and Language by S. Z. Rapcsak and P. M. Beeson, (pp. 191, 197). New York: Guilford Press. Copyright 2000 by the Guilford Press.

Data used from individuals acquiring writing disabilities helps show how the writing process breaks down, but it does not necessarily show the development of writing processes. Although lateralization and anatomy can be studied, learning disabilities are more likely to be a problem in a network involving various brain systems rather than just one brain structure. Research has demonstrated that learning disabilities are likely the

result of minor brain abnormalities such as malformed or misplaced neurons (Galaburda, 1986; Rosen, Sherman, & Galaburda, 1986; Semrud-Clikeman, Hynd, Novey, & Eliopulos, 1991). Due to these abnormalities, individuals with learning disabilities may develop alternative pathways or compensatory strategies.

Neurodevelopmental Skills Underlying Written Expression

The emphasis of previous writing models (Hayes & Flowers, 1980; Scardamalia & Bereiter, 1986) on higher level processes has been challenged and the lower level processes of handwriting and spelling are now being investigated. Several research teams have taken a step back when looking at the cognitive models of writing and examined the very basic neuropsychological components and building blocks of writing skills seen in children (Berninger & Colwell, 1985; Berninger & Rutberg, 1992; Berninger, Yates, Cartwright, Rutberg, Remy, & Abbot, 1992; Levine et al., 1981). This body of research has begun to answer the questions regarding the basic processes needed in order to successfully use the lower and higher order processes described in writing models.

Berninger and her colleagues (Abbott & Berninger, 1993; Berninger, Cartwright, Yates, Swanson, & Abbott, 1994) reviewed data collected across primary (1-3) and intermediate (4-6) grade levels to see which basic skills contributed to lower level processes of handwriting and spelling as well as the overall compositional fluency. Students completed tasks measuring orthographic coding, phonological coding, motor skills, visual-motor integration, linguistic knowledge, working memory, and verbal IQ. Orthographic coding can be defined as representing a printed word in memory and making conclusions about the whole word, letter, or letter cluster patterns. Phonological

coding involves the knowledge of letter and sound correspondence as well as the ability to segment spoken words. Working memory, the ability to simultaneously store and process information, was measured by task called Listening-Generation Span. For this task, participants were required to listen to a set of sentences, answer a question about those sentences, and then generate a written sentence using the last word of each sentence. Different measures assessing the same developmental skill were administered to the different grade levels to ensure an age-appropriate and sensitive tool was used.

Results showed that motor skills and orthographic coding contributed to the model for handwriting in primary grades, but only the orthographic coding for intermediate grades (Abbott & Berninger, 1993; Berninger, Cartwright, Yates, Swanson, and Abbott, 1994). Also, only orthographic coding was found to contribute to the spelling model for primary grades while orthographic coding and phonological coding were significant for intermediate grades. Reading and oral language contributed to compositional quality in the primary grades, but the model was not clear for the intermediate grades. It was also found that orthographic skills were correlated with handwriting, spelling, and composition, and that phonological skills were correlated with spelling. Working memory measures were correlated with composition skills (generating and organizing text). More specifically, only text-level working memory measures (sentence recall) were found to be related to component writing skills, not word level or sub-word level working memory measures.

Researchers (Berninger, Yates, et al., 1992; Berninger & Swanson, 1994) also discovered that orthographic coding had a more direct relationship with handwriting than

motor skill tests such as finger succession in first graders. Orthographic motor integration was found to have a relationship with handwriting in the primary grades. Un-timed visual motor integration, timed printing of the alphabet from memory, non-word reading, and verbal IQ scores were found to be the best predictors of spelling. Additional analysis of this data found spelling predicted how well and how much a student would write during the primary grades (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997).

Working Brain Systems and Neural Pathways

In several articles Berninger and her colleagues (Berninger & Hart, 1992; Berninger et al., 1994) discussed how Luria's (1973) concept of working brain systems might be more important than localization when examining learning disabilities such as written expression. Luria (1973) explained that the brain has working systems in which structures operate in more than one working system. Moreover, any one system depends on several structures to work and brain systems may reorganize as a result of learning or maturation. Berninger and Hart (1992) also reviewed the ideas of dissociation and normal variation in working brain systems involved with writing. Dissociation refers to an event in which one process is troubled but a related process still works; therefore, the working process continues to develop adequately while the troubled process may fail to develop adequately. Normal variation describes the concept that individuals may have a combination of relative strengths and weaknesses in basic skills contributing to the same academic product and that these skills may not be contingent upon one another. Applying these ideas to the model of writing, a student may have adequately developed orthographic coding skills, yet fine motor skills are a relative weakness. Although the

student continues to excel in understanding what letters represent, the student is unable to write them because of the motor skill's involvement in the writing system.

Ellis (1983) also proposed a systems model for writing and reading development. He explained that writing and reading are not predetermined in the brain but develop through other cognitive abilities such as visual, phonological, and semantic systems. Moreover, reading and writing disabilities could be a result of disorders connected to these cognitive systems. Levine (1993) and Berninger, Mizokawa, and Bragg (1991) provided several examples of how different developmental dysfunctions could impact writing skills due to their role in various working brain systems (see Table 2). Problems in the areas of attention, language, motor, and memory may lead to problems in written expression due to the extra sustained effort necessary to produce written products.

Berninger (1999) proposed that two neurological pathways are involved in written expression and the executive function of working memory. A behavioral pathway consisting of the lower level processes and a cognitive pathway involving higher level processes interact in the writing process. Revisiting the imaging study by van Mier et al. (1998), motor learning was encoded at an abstract level and was independent of performing the motor task. Association areas in the brain code new information more abstractly than the primary brain systems that are more directly related to the motor

TABLE 2

EXAMPLES OF DEVELOPMENTAL DYSFUNCTIONS AND THEIR IMPACT ON WRITING

Attention Problems	Planning problems, erratic writing, poor self-monitoring, careless errors, low persistence
Simultaneous Production Deficits	Spatial planning, visualization of words, organization, spelling
Sequential Production Deficits	Delayed learning of motor movements of letter forms, narrative sequencing, organization deficits
Memory Deficits	Word retrieval, spelling, memory for rules and grammar, punctuation, and capitalization, dysfluent writing
Language Deficits	Poor vocabulary, fluency, dysphonetic spelling patterns, poor narration, production of words, sentences and paragraphs
Fine Motor Problems	Decreased amount of writing, slow productivity, effortful writing, illegible writing, awkward pencil grip, decrease in automatic letter/word writing, visual motor integration

production. Thus the practiced motor task represents the behavioral pathway, and the new motor task represents the cognitive pathway. The new motor task involves more brain areas than just the motor pathway, because it is not yet an automatic task. Some students may have such problems (e.g., handwriting, spelling) with the behavioral pathways that

they have few resources left to activate the cognitive pathways. Therefore, they have difficulties with not only the lower level task and the higher level tasks, but with learning new developmental tasks such as advanced planning or revision.

Research Linking Cognitive and Neuropsychological Concepts in Writing

Recent research from both cognitive and neuropsychological perspectives has investigated the processes illustrated in previous cognitive models of writing (Hayes & Flowers, 1980; Scardamalia & Bereiter, 1986). This body of research has examined the proposed writing components in an effort to provide further information in understanding the development of writers as well as the sub-processes under planning, translating, and revision. In addition, researchers have examined the differences between skills and intervention outcomes of students with and without writing disabilities. This section will review this body of literature to gain a better understanding of writing and is followed by several updated writing models based on the reviewed research.

Examining the Role of Planning: The Ability to Manage the Writing Process

Scardamalia and Bereiter (1986) found that children spend little time on planning before they begin writing. In their writing model, they described that children's writing can be compared to their oral language, in that the quantity and quality of their text is comparable to an oral response with little or no planning. Bereiter, Burtis, and Scardamalia (1988) used think aloud protocols with students in grades 4, 6, and 8 and with adults to examine their process of planning an argumentative essay. This research focused on the writer's ability to establish or plan a main point in their writings. They found older writers developed more sophisticated main points and took longer to plan

these main points. They also found evidence supporting the idea that skilled writers used six problem solving moves that represent characteristics of the knowledge-transforming model of composition. The problem solving moves consisted of search, delimit, fit, cohere, structure, and review and are defined in Table3.

Table 3

Six types of problem solving moves related to knowledge transforming

Search	The writer attempt to find a main point, evaluates prospective main points, and ideas leading toward identifying main point.
Delimit	The writer limits their search of a topic to a particular subset of ideas.
Fit	The writer searches for content that will fit the main idea and decides on whether or not to use content that may not fit with main idea.
Cohere	The writer decides how to connect all generated ideas, thus going beyond just telling content.
Structure	The writer selects a text organizing structure to p resent their generated content and main idea.
Review	The writer recognizes problems with the content or main idea that may require further work using any of the moves.

Another experiment by Bereiter, Burtis, and Scardamalia (1988) looked at children's performances in grades 5 and 11 to select between good and bad paraphrases of a main point in a composition they had previously written. Researchers took the main points from the student's composition and prepared additional statements that did not reflect the main point of the composition. Students were asked to read the statements and

discuss how well they fit with the main point of their composition. Results suggested that the younger students could not reliably select the correct main point of their composition, while the older students could complete this task. The writing selections of the younger students suggested that they did not generate a main point to the selection when they wrote. Bereiter, Burtis, and Scardamalia (1988) interpreted these results to support their models of knowledge telling and knowledge transforming.

Further research supports the notion that younger writers in elementary school with and without learning disabilities rarely plan during writing exercises (Bereiter & Scardamalia, 1987; Graham, Harris, MacArthur, & Schwartz, 1991; MacArthur, Harris, & Graham, 1994; McCutchen, 1995; Perfetti & McCutchen, 1987). Most of the planning actually takes place during the process of translating for children with learning disabilities. In fact, children may have difficulties separating the planning and translating processes (Burtis, Bereiter, Scardamalia, & Tetroe, 1983; MacArthur, Graham, & Schwartz, 1995). Therefore, elementary students spend little time on advanced planning, but plan by generating text. Other research found children do not produce advanced notes, generally write what they think and feel about the topic without planning, and use writing prompts as questions to be answered and not as planning aids (McCutchen, 1988; Scardamalia & Bereiter, 1987). McCutchen (1988) examined think-aloud protocols completed by children and found that they wrote almost exactly what they said. Unlike their adult counterparts, they had no internal dialogue about changes in writing or plans for why they were writing the current content.

Overall, there seemed to be less recursive interaction in the children's writing than in the adults' writing. It is possible that the children were using so many of their cognitive processes to generate words, spell the words, and produce them on paper, that they had little cognitive energy left to use for the higher level components like planning. Due to the overload of using lower level processes, younger children and less skilled writers may switch to another writing strategy such as knowledge telling (McCutchen, 1996). Furthermore, younger and less skilled writers were less likely than expert and older writers to use goals in writing, to use information of text structure in planning, or to use strategies to search memory for writing content (MacArthur, Harris, & Graham, 1994).

Research has found adult females to be rated higher than males on writing skills (Applebee, Langer, Jenkins, Mullis, & Foertsch, 1990; Hyde & Linn, 1988). Also when examining writers in junior high, female students were rated higher on planning than their male counterparts (Berninger, Whitaker, Feng, Swanson, & Abbott, 1996). Berninger et al. (1996) found that when compositional fluency was controlled, the gender effects no longer existed. Therefore, males and females may actually differ on transcription (transcribing their thoughts) not text generation. Research examining gender differences in writing skills across grade levels are summarized in Figure 3 (Berninger et al.,1996; Berninger & Fuller, 1992; Berninger & Rutberg, 1992).

Grades 1-3	Grades 4-6	Grades 7-9
• Boys better at verbal fluency tasks • Girls better at orthographic fluency (alphabet task) • Girls produce more words, sentences • No differences in motor or phonological coding	• Differences in verbal fluency disappeared • Orthographic fluency (Girls>Boys) remains • Compositional fluency (Girls>Boys) remains	• Females better than males on advanced planning, translating, revising • When number of words co-varied gender differences in these areas did not exist

Figure 3. Gender Differences in Writing Skills Across Grades 1-9.

Understanding the Role of Transcription

Berninger, Yates et al. (1992) examined the Hayes and Flower (1980) model more closely and discovered subprocesses under translating. These processes included text generation and transcription. During text generation, ideas are charted onto units of language (words, sentences) in verbal working memory. Text generation involves the student transforming their ideas into language representations in memory, while changing these memory representations into written words occurred during transcription (Berninger & Swanson, 1994; Swanson & Berninger, 1996). Research suggests that individuals' skills in text generation across different language units are not correlated. Thus, a person's text generation of words is not necessarily the same as text generation of sentences or other discourse structures (Berninger, Mizokawa, Bragg, Cartwright, & Yates, 1994; Whitaker, Berninger, Johnson, & Swanson, 1994). Transcription requires the skills to translate language representations stored in verbal working memory into letters on paper or the computer screen.

In her 1996 article, McCutchen explained that text generation is comprised of language generation processes similar to oral speech, whereas transcription entails the cognitive and motor components involved in producing written representations of text. Research suggests that the more lower-level transcription processes such as handwriting, and spelling are automatized the more resources are available for higher level skills of planning, text generation and revision (Berninger, Yates, et al., 1992; MacArthur & Graham, 1987; Scardamalia, Bereiter, & Goleman, 1982). It was also found that mechanical factors involved in transcription no longer interfere with text production after primary grades (Scardamalia, Bereiter, & Goleman, 1982). Other researchers have reported that older students with writing difficulties who used dictation instead of handwriting or typing improved the length of their compositions (Graham, 1990; MacArthur & Graham, 1987; Hidi & Hildyard, 1983, McCutchen, 1987). Furthermore, students with writing problems who used dictation and received planning instruction demonstrated better and more complete essays than control students on a post-test and two week maintenance test (De La Paz & Graham, 1997b).

A large cross-sectional study of primary, intermediate, and junior high students (Berninger, Cartwright, et al., 1994; Berninger et al., 1996; Berninger, Yates, et al., 1992) found transcription contributed statistically significant variance to compositional fluency (amount of text) and compositional quality (overall quality of text) at all developmental levels. Transcription contributed 66% of the variance for how much the primary students wrote and 25% of the variance for the quality of their writing. For intermediate students, transcription contributed to 41% of the variance for compositional fluency and 42% for

compositional quality. Transcription was also found to be statistically significant for junior high students but contributed less to compositional fluency and quality (16%, 18% respectively). Transcription for compositional fluency contributed across grade levels, but was most important in the primary grades and decreases as the students get older. In contrast, transcription for compositional quality contributed to all grades but peaked during the intermediate grades.

Berninger (1999) explained that these findings signify that the new skills of handwriting and spelling require many cognitive resources in beginning writers making it more difficult for them to translate oral language from memory to a written product on paper. Also, she explained that the findings that the contribution of transcription on quality peaks during the intermediate grades could be linked to the increase of difficult writing assignments at this grade level and some children's transcription skills are not parallel to these assignment expectations. Berninger (1999) also argued that transcription does not just correlate with translating but is an important process relative to all the cognitive processes in the model including planning and revising. For example, students may generate notes or use techniques to plan and revise their written composition.

Inspecting the Role of Reviewing

The reviewing component of the Hayes and Flower (1980) model includes evaluating and revising the written product. Additional research found reviewing consisted of the subcomponents problem detection and repair (Beal, 1987; Fitzgerald, 1987). During and after composing, writers look for a mismatch between intentions and resulting text which prompts the need for revision. De La Paz and Graham (1997a) found

that skilled adult writers revise or improve writing goals as they compose and also coordinate many strategies for generating, organizing, monitoring, and revising their final product.

Berninger and Swanson (1994) discovered that, like advanced planning, revision is slower to develop than translation in children. Moreover, preadolescents were unlikely to spontaneously revise (Perfetti & McCutchen, 1987). Less skilled writers lack the capacity to coordinate and monitor multiple elements underlying the revision process (De La Paz, Swanson, & Graham, 1998; Graham, 1997; Scardamalia & Bereiter, 1986). Young and less skilled writers do not revise often, extensively, or skillfully (McCutchen, 1995). Butterfield, Hacker, and Plumb (1994) found that children's revisions included mostly mechanical changes or word substitutions at a superficial level. Less skilled writers and younger writers are better at repairing problems than detecting what problems need repair. Beal (1993) found that children could generally repair problems when they are identified for them. However students with learning disabilities may have difficulties knowing how to repair problems even with assistance in identifying the problems (MacArthur, Graham, & Schwartz, 1991).

Students with learning disabilities make revisions by trying to improve the appearance of the text by making it look neater, correcting spelling errors, and choosing better words, but neglect to revise the meaning of the text (Graham, Harris, MacArthur, & Schwartz, 1991; Graham, MacArthur, & Schwartz, 1995; MacArthur & Graham, 1987; MacArthur, Graham, & Schwartz, 1991). In other words they see revision as just proofreading the text for careless errors. In their 1993 study, Graham, Schwartz, and

MacArthur found that 61% of students with learning problems interviewed responded that they revise their papers by "make it neater" or "spell words correctly." Students without learning problems only gave these types of responses 37% of the time.

In addition to only looking for surface errors, there are several hypotheses as to why children do not take an interest in revising their written products. Children fail to establish goals and intentions in their writing, don't know what to change or how to change it, and have difficulties examining their writing from another person' perspective (Fitzgerald, 1987). Research has also looked at the role of executive control in revising (Graham, 1997). Graham defines executive control as the management and coordination of separate knowledge and skills. Hence, the child doesn't lack components of the revising process, but may lack the skills necessary to orchestrate these components.

Graham, MacArthur, and Schwartz (1995) studied the effects of instructing fifth and sixth grade students with writing problems to develop a specific revising goal to add information, as well as the effects of procedural facilitation in accomplishing this revising goal. Procedural facilitation is defined as assisting the student with help related to the cognitive processes, but not responding to the actual product of what the student is thinking or writing. This instructional strategy takes away some of the student's difficulties by freeing up some of their cognitive resources needed for the desired goals (Scardamalia & Bereiter, 1986). Thus, procedural facilitation involves the instructor providing students with the necessary information to perform a task. For example, in an experiment students were provided with an index card, which had a list of the revision steps (Graham, MacArthur, and Schwartz, 1995). Research assistants also demonstrated

to the participants how these steps were used with a writing sample. Procedural facilitation suggests that providing students with the revision steps on the index card the students will result in improved revision skills. The students can use the processes usually reserved for remembering the revision steps towards actually revising the written product.

Graham, MacArthur, and Schwartz (1995) found students assigned to the group asked to add information as a goal made more meaning-based changes when revising their papers; however the procedural assistance did not increase revision or improve the quality of their text. In fact 40 percent of these students just added information to the end of their texts and 35% added information to points already made in their texts. Although several of the students rewrote large sections of their text, their revisions did not have an important effect on the quality of their writing. Consequently, poor revision may be more than just poor executive control, and may be problems with the components of executive control (self-regulation, working memory, etc.). Additional research has also found support for providing procedural facilitation with executive control processes and increased revising behavior in eighth grade students with writing and learning difficulties (De La Paz, Swanson, & Graham, 1998).

Applying the reviewed research to Hayes and Flower's 1980 model, children do little planning, lots of translating, and no reviewing (Bereiter & Scardamalia, 1987; McCutchen, 1995). Planning and revising are not usually seen in kids before the age of 12 (Perfetti & McCutchen, 1987), whereas translating is the earliest developing component of the formal writing process in the primary grades (Berninger & Swanson, 1994). Students in the higher grades (7-9) were found to have the ability to revise at

word, sentence and text levels, whereas intermediate grade students could not revise at all levels (Whitaker, Berninger, Johnson, & Swanson,1994). Finally, a student's ability in one process cannot be predicted from a skill in another process (e.g., revising skills could not predict planning skills).

Updated Models of Written Expression Based on New Research

This section will discuss three new approaches to the process of writing. The first approach describes developmental differences in writing and is based on a longitudinal study regarding spelling, handwriting, and composition skills. The second approach is based on Hayes adaptation of the original Hayes and Flower model of writing. The final model proposes working memory as the central function overseeing the writing process. All of these approaches include the executive process of working memory and thus expand the research linking executive functions to writing. Following this section, executive functions will be defined and existing research reviewed.

Developing and Beginning Writers: Distinguishing between Idea Generation and Text Generation

Several studies have provided support for a model portraying the development of writing processes (Berninger, Cartwright, et al., 1994; Berninger et al., 1996; Berninger, Yates, et al., 1992). Berninger and Swanson (1994) proposed a model based on this research that not only distinguishes between beginning and adult writers, but also illustrates the progression of writing development across the primary, immediate, and junior high grades. Their research also demonstrated that the adult process of translating could be broken down into the beginning writer's processes of transcription and text

generation. They proposed that students in the primary grades develop writing components in the following order: transcription, text generation, on-line revision, and on-line planning. Moreover, within the text generation, word skills develop before sentences and paragraphs.

During the intermediate grades, Berninger and Swanson (1994) proposed that for some developing writers, transcription becomes automatic and the following processes emerge: revision after text production, advanced planning, and expansion of working memory capacity. Finally, during the junior high years, all of the components discussed continue to develop, although advanced planning lags behind translating and revising abilities. Junior high writers continue to achieve better fluency in transcription and deeper content in translation and revision. This model is a summary of Berninger and Swanson's research findings and is not to be seen as the model of writing development, but how new information can be used to modify existing models.

Writing Model Based on Working Memory

Another model proposed working memory as the center concept of the writing process (Kellogg, 1996). Kellogg took pieces of Baddeley's working memory model (1986) and applied them to each component in his writing model. Baddeley extended the concept of short-term memory to include the concept of working memory. He described working memory as simultaneously storing information and completing a cognitive task in which the stored information is being processed. Baddeley also explained that there are resource limitations within the working memory system. Thus, when more resources are needed for storing information less resources are available for processing tasks and vice

versa. Kellogg's writing model veers away from the original writing model and integrates ideas from Baddeley's working memory model. Kellogg's model consists of three major elements: verbal formulation, execution, and monitoring. Under verbal formulation are the subcomponents of planning and translating, and under execution are the subcomponents of programming and executing. Finally, the component monitoring consisted of the subcomponents reading and editing. This model also included a recursive loop between verbal formulation, execution, and monitoring. Thus, he linked the visual-spatial sketchpad to the formulation, the phonological loop to the monitoring, and the central executive to the execution component.

Expanding Previous Writing Models: Reorganization and Addition of Processes

Hayes (1996) altered the 1980 Hayes and Flower model of writing by including a reorganization of the involved cognitive processes and expanding the model to include several new processes. The new model contains two major components: the task environment and the individual. The task environment is similar to the previous 1980 model, which looks at the social environment, but also includes the physical environment. In addition to the text already produced by the writer, the physical environment also includes the writing medium (e.g., word processor, paper and pencil, dictation).

The other major change to the model illustrates the exchange between working memory, long-term memory, motivation and affect, and cognitive processes (see Figure 4). These components are grouped under the individual writer and work with the task environment. Hayes depicts working memory as the central process in writing and argues that all the

processes in the model must go through working memory to carry out non-automatic tasks. Thus, working memory is essential in managing and executing various tasks in writing, storing visual and phonological information, and retrieving information from long-term memory. Although working memory may represent the monitor component in the original model, motivation is a completely new feature to the 1996 model. Hayes briefly discussed how motivation is necessary in order to engage in activities that do not necessarily have immediate rewards as well as the multiple goals necessary to achieve a written product. Although Hayes agrees that writing is a combination of affective, cognitive, social, and physical conditions, his model focuses on the individual differences rather than the social aspects related to the task environment.

Finally, Hayes renamed the cognitive processes of planning, translating, and reviewing as the cognitive processes of text interpretation, reflection, and text production. Text interpretation is a process that creates representations from linguistic and visual inputs. Processes like reading, listening, and scanning graphics contribute to text interpretation. Reflection is a process that works on these representations to produce other representations and includes processes such as problem solving, decision making, and inferencing. The previous cognitive processes of planning and revision would most likely be housed under this new category of reflection. The final cognitive process, text production is the ability to take the internal representations and produce written, spoken, or graphic material within the task environment.

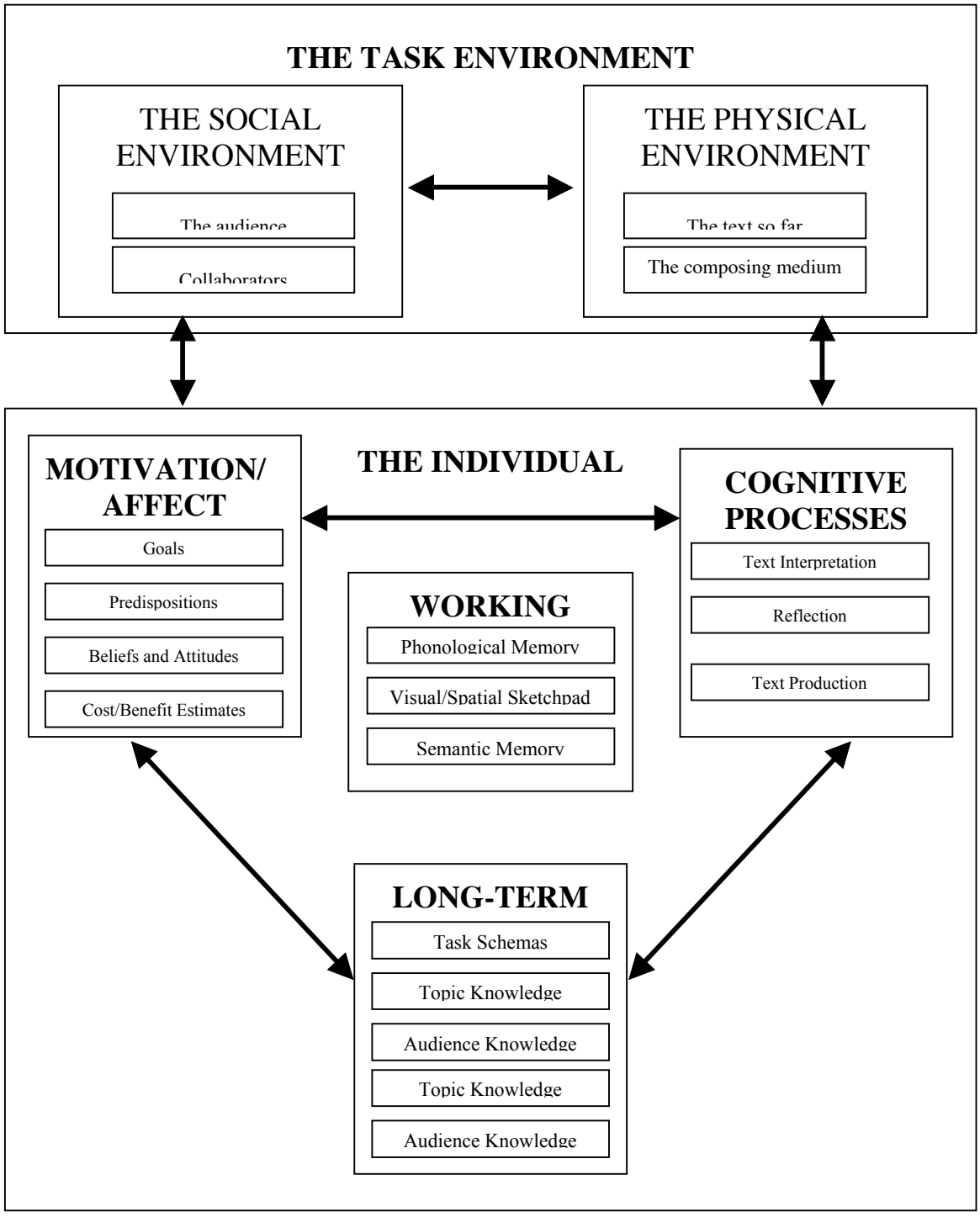

Figure 4. Updated version of Hayes and Flower's 1980 writing model. Adapted from "A new framework for understanding cognition and affect in writing," by J. R. Hayes in The Science of Writing: Theories, Methods, Individual Differences, and Applications (pp1-27). Mahwah, NJ: Lawrence Erlbaum. Reprinted by permission from Lawrence Erlbaum Associates, INC.

Many of the systems associated with difficulties in writing involve executive functions. The next section will review the research literature concerning the development, assessment, and problems associated with executive functions followed by a review of literature looking directly at the relationship between executive functions and written expression. It should be noted that the majority of research examining executive functions has been completed on participants with Attention Deficit-Hyperactivity Disorder. Some of this literature will be also be reviewed, because it is through this literature that better measures were developed and analyzed.

Executive Functions and their Link to Written Expression

Executive functions are described as control processes and are generally linked to prefrontal cortex, although other brain structures may be involved (Denckla, 1994). Several empirical models of executive function exist in the neuropsychological literature and attempt to explain how executive functions affect the individual's overall output. In 1996, Denckla proposed a model consisting of four executive function areas: initiation, sustaining, and inhibition of behaviors, and set shifting. Set shifting includes problem solving, cognitive flexibility, and self-monitoring. Another model names six factors of executive function including planning, execution, self-regulation, maintenance, spatiotemporal segmentation, and sustained mental productivity (Daigneault, Braun, & Whitaker, 1992). An additional model based on children with normal functioning found three factors: set maintenance, planning, and speeded responding (Welsh, Pennington, &

Grossier, 1991). Pennington (1997) later found the factors working memory, inhibition, and set shifting when he used a sample of children with neurodevelopmental disorders.

In addition to working memory, other executive processes such as response inhibition, sustained attention, and planning may serve as building blocks to effective application of lower and higher level processes found in writing. These executive function processes and how they are measured will be examined in the following section. The interrelation between these executive function processes, however, presents difficulties in examining their unique contributions to written expression (Morris, 1994). Currently there are only multi-construct tasks available, but research using factor analysis has provided some ideas of the underlying construct measured by various tasks (Levin et al., 1991). Research concerning the contributions of these cognitive processes in written expression is very limited and should be examined. It is still unclear whether attention, memory, and other executive functions increase in ability over time or if higher order executive systems begin to assist these other systems as the child develops. Thus, as children become adolescents, researchers should use tasks that are more complex and involve higher levels of self-regulation in order to distinguish students with and without difficulties in executive functions or writing.

Summary of Research Concerning Executive Functioning

Response Inhibition and Attention

It is hypothesized that response inhibition may be a prerequisite for higher level executive functioning skills. Response inhibition delays motor activation in order to allow the individual to utilize various executive processes, whereas higher level executive

functions are self-directed behaviors or cognitions that contribute to self-regulation, such as self-control and goal-directed behavior (Barkley, 1997). Individuals may be using executive functions when performing tasks involving temporal delays, producing new responses, organizing, or problem-solving.

Barkley's definition of response inhibition includes three processes that work together. First, response inhibition can be the inhibition of prepotent responses or inhibiting responses for which immediate feedback or reinforcement is available. Secondly, response inhibition can be the ceasing of an ongoing response in order to allow a delay in the decision to respond. Finally, response inhibition plays a part in interference control. When an individual uses interference control, the delay of response is guarded from distraction due to competing events and responses, and therefore allows self-directed responses to take place. In other words, these three processes make up response inhibition and provide the delay in responses necessary for executive function processes to occur.

Neuropsychological measures that tap into response inhibition involve either a task that requires inhibition of prepotent responses, stopping ongoing response patterns when directed, or resistance to distraction. Barkley suggested that some tasks may not show differences between children with deficits and controls because the tasks are not sensitive enough for certain ages or the reward is not big enough to cause conflict and thus inability of inhibition. Researchers have applied several neuropsychological tasks to measure response inhibition in children with ADHD, since response inhibition is hypothesized to be a major deficit in children with ADHD. These measures include

cancellation tasks, continuous performance tests, oculomotor response tasks, the Matching Familiar Figures Test (MFFT; Kagan, Rosman, Day, Albert, & Phillips, 1964), and the Wisconsin Card Sort Test (WCST; Heaton, 1981). Although these tasks are believed to detect response inhibition, they have been inconsistent in discriminating students with ADHD from controls. Some studies have detected poorer performance by children with ADHD than controls on these tasks (Barkley, DuPaul, et al., 1990; Boucugnani & Jones, 1989; Chelune et al., 1986; Dykman & Ackerman, 1991; Fischer, Barkley, Edelbrock, & Smallish 1990; Gorenstein et al., 1989; Grodzinsky, & Diamond, 1992; Lazar & Frank, 1998; Loge et al., 1990; McBurnett et al., 1993; Nyden, Gillberg, Hjelmquist, and Heiman, 1999; Reader et al., 1994; Shue & Douglas, 1992; Weyandt & Willis, 1994). Other studies have found children with ADHD to perform as well as controls on these measures (Houghton et al., 1999; Lazar & Frank, 1998; Loge et al., 1990; McGee, Williams, Moffitt, & Anderson, 1989; Pennington, Grossier, & Welsh, 1993; Weyandt & Willis, 1994; Ozonoff & Jensen, 1999). Conflicting results on the use of these tasks with students with ADHD may be due to insensitive tests or problems in methodology including sample selection and issues with comorbidity.

Researchers and practitioners use the Stroop Word-Color Naming Test to measure the individual's ability to inhibit responses when interfering stimuli is presented during a task (Golden, 1978). For this task individuals must name the ink color of printed color words, even though the word is actually a different color. Thus, the individual must resist saying the actual word and only respond with the print color. For example, the word blue would be presented in red ink. The participant must resist saying the word blue and

respond with the ink color red. Research using this task to compare participants with ADHD to controls has been fairly consistent in showing a significant difference between the groups. Participants with ADHD were more likely to make more errors than the controls during this task (Boucugnani & Jones, 1989; Gorenstein, Mammato, & Sandy, 1989; Houghton et al., 1999; Leung & Connolly, 1996; Ozonoff & Jensen, 1999; Pennington et al., 1993; Seidman, Benedict, et al., 1995; Seidman, Biederman et al., 1997). Houghton et al. (1999) suggest that participants with ADHD experienced problems inhibiting their responses due to their poor ability to resist the distraction of the printed word. These researchers found that although both subtypes of ADHD perform poorly on the Stroop task when compared to controls only the combined ADHD subtype was significant.

Gaultney, Kipp, Weinstein, and McNeil (1999) did not find differences between children with ADHD and the control group, but they did see a difference in the increase of speed on the second trial. Children without ADHD were faster on the second trial while children with ADHD did not increase their response speed. Gaultney et al. (1999) proposed that the children with ADHD in their sample were able to inhibit, but it was a more effortful task for them compared to the control group. Lack of significant differences between the ADHD and control groups may have been due to their sample, which consisted of volunteers from a private school, both genders, and possible coexisting disorders.

Working Memory

Welsh (1994) described working memory as a vital executive function skill because it enables individuals to make choices in which their responses are flexible and effective. Working memory is a piece of the memory system because it maintains sensory representations; however, its main function is involvement in the executive processes of planning and decision making (Torgensen, 1994). Working memory holds information in the mind, thus allowing the individual to direct future actions and thought processes. Research concerning written expression shows that working memory contributes to composition across primary and junior high grade levels (Berninger, Cartwright, Yates, Swanson, & Abbott, 1994; Berninger, Whitaker, Feng, Swanson, & Abbott, 1996; Berninger, Yates, et al., 1992). Working memory contributes to coordinating all the cognitive processes that interact in efforts to produce ideas into language representations. Although it is not clear if working memory is the only cognitive function needed to carry out executive function tasks, it is an important piece to examine when investigating executive functions and written expression.

Working memory is commonly measured by using tasks that require an individual to maintain information in mind for a short time while carrying out another procedure (Danemann & Carpenter, 1980). Measures such as word lists and story retelling tasks require verbal working memory in addition to executive skills of planning and organizing. Verbal working memory tasks that have shown impairments in students with ADHD tend to have higher strategy and effort demands. For instance, boys with ADHD usually make more monitoring and organizing errors on story retelling tasks that have more complex story lines (Pugzles Lorch et al., 1999; Purvis & Tannock, 1997; Tannock,

Purvis, & Schachar, 1993). Word lists that show differences between groups generally have longer lists, use repeated learning trials, and include the need to organize words into categories (August, 1987; Borcherding et al., 1988; Felton et al., 1987; Loge et al., 1990; O'Neil & Douglas, 1991).

Another measure commonly used by researchers to examine working memory is the digit span subtest of the Weschler Intelligence Scales for Children (WISC-III; Weschler, 1991). Several factor analysis studies have found digit span backwards to reflect verbal working memory (Levin et al., 1991; Mirsky, 1996). Research using the digit span backwards has also found students with ADHD to perform poorly on this task (Barkley, Murphy, & Kwasnik, 1996; Mealer, Morgan, & Mescar, 1996).

Organization and Planning

Children with ADHD tend to have poor concentration, high distractibility, inhibition problems, and lack of awareness of consequences. Welsh (1994) explained that these deficits could be interpreted as executive functioning deficits or more specifically, problems with planning, set maintenance, and organization. Students with ADHD may have difficulty manipulating events in their working memory in order to make an effective and organized response (Barkley, 1997).

In addition to performance tasks, planning is a major component in the writing process. Students with planning impairments show problems in developing content and organization in their written composition. Tasks that are believed to measure executive function of planning can help determine the extent and nature of these deficits in students with ADHD.

Similar to response inhibition measures, executive functioning tasks targeting planning and organization show inconsistent results in discriminating students with and without ADHD. The Rey-Osterrieth Complex Figure task is a measure in which the participant must copy a complex design and then later reproduce the drawing from memory (Osterreith, 1946). Several studies trying to look at the organizational piece of this task found significant differences between participants with ADHD and controls (Barr, Douglas, & Sananes, 1990; Douglas & Benezra, 1990; Grodzinsky & Diamond, 1992; Sadeh, Ariel, & Inbar, 1996; Seidman et al., 1997), while other studies did not find significant differences (Carte, Nigg, & Hinshaw, 1996; Moffitt & Silva, 1988; McGee et al., 1989; Reader et al., 1994).

Tower puzzles are a widely used task to measure planning and organization abilities. Participants must move disks or balls on different pegs making a design that duplicates the examiner's design. Barkley (1997) explains that this task entails a large amount of mental planning while actually carrying out the motor piece of rearranging the disks. Individuals must mentally represent and test out various ways of removing and replacing disks or balls on a set of pegs in order to match the examiner's design. Moreover, the individual's mental planning must occur before and during the actual motor piece of this task. Working memory is emphasized in tower tasks, but planning is instrumental to performance (Levin et al., 1991). Research has found that control groups improved their performance across trials on tower tasks significantly more than boys with ADHD (Cornoldi, Barbieri, Gaiani, & Zocchi, 1999). Furthermore, boys with ADHD

made errors such as impulsive responding or failure to adequately plan before making a response (Pennington et al., 1993; Weyandt & Willis, 1994).

Developmental Trends in Executive Functions

There has been speculation about the inconsistent results of using executive functioning tasks to determine deficiencies in students with ADHD. Researchers have argued that these inconsistencies may be due to errors in methodology or the use of developmentally inappropriate measures. Research in this area shows some methodological problems, which may assist in the inconsistencies found. Problems with small sample sizes, lack of control for coexisting disorders, age, and gender, as well as not distinguishing subtypes may account for these problems (Barkley, 1997). Fischer, Barkley, Edelbrock, and Smallish (1990) indicated that due to lack of diagnostic criteria, previous studies might have included more mild cases of ADHD resulting in nonsignificant results.

The latter argument concerns using executive functioning tasks that are too easy for adolescents with or without ADHD. While some tasks are able to discriminate these two populations during the primary grades, they may be too easy for students at the secondary grade level. As mentioned in previous sections, students with ADHD may be developmentally delayed in certain executive functioning areas; therefore, it is necessary for researchers to consider the developmental ceilings for different tasks when investigating this population. The present study will use the digit span, and tasks similar to the Stroop Word-Color Naming task, the tower, and verbal fluency to compare students with and without writing problems. Research has suggested that these measures

are developmentally appropriate for adolescents and measure the desired constructs necessary to examine executive functioning and academic related problems such as written expression.

Research Examining the Role of Executive Functioning in Written Expression Tasks

Recent researchers suggest that executive functions such as response inhibition, attention, working memory, and planning provide skills that are necessary to write effectively (Berninger, 1999; Ellis, 1982; Gregg, 1991). Although, researchers have proposed a relationship between executive functions and written expression, research actually examining and describing this relationship is very limited. The majority of research examines working memory and its influence on planning/text production, text translation, and revision. Since research (Bereiter & Scardamalia, 1987) suggests writers of all ages spend the most time on translating, most of the working memory research has targeted this writing component.

Working Memory

In her 1996 article, McCutchen argued that a capacity theory of writing could explain the developmental and individual differences of writing skills. McCutchen (1996) defined working memory as information being stored during processing. As more cognitive resources are devoted to processing functions, fewer resources are available for storage of new or long-term memory information. Complex processes such as composing the written form, requires writers to manage planning goals, product goals, and text generation (generate and organize words to give meaning to the text) within their

working memory capacity. McCutchen (1996) contends that tasks like composition require large process and storage demands within working memory. Furthermore, as more process and storage functions are compromised, the more overall written performance declines.

Additional research lends support to the importance of working memory in written expression. Researchers believe working memory is important to help writers juggle the many components of the composition process (McCutchen, 1994; Swanson & Berninger, 1996). Working memory plays a role in coordinating all the processes (planning, text generation, transcription, revising) and subprocesses that interact during writing.

Attentional Processes

Hooper, Swartz, Wakely, de Kruif, and Montgomery (2001) expanded the writing research to include additional executive functioning tasks that tapped into attentional and planning processes. Hooper and his colleagues compared fourth and fifth grade students with and without problems in written expression on various tasks measuring abilities to initiate, sustain, shift, and inhibit. They found that the children with writing problems performed more poorly on tasks tapping initiation and set shifting which are tasks more related to working memory and verbal organization. Tasks measuring sustaining approached significance; however, the effect sizes for all of the significant findings were in the small range. Moreover, the executive functioning tasks did not predict the written expression scores.

There are several hypotheses as to why Hooper et al. (2001) did not find the executive functioning tasks to be a strong predictor of written expression. First, this research used a non-standardized writing task in which the students completed a story. Second, they used nine different executive function tasks decreasing their power and some of the measures were redundant in the executive skills they were assessing. Finally, it is possible that the target age of this sample (fourth and fifth graders) lends the findings to show less strength. Areas of the brain contributing to executive functioning skills do not fully develop until approximately age 12 when students are attending middle school (Becker, Isaac, & Hynd, 1987; Denckla, 1994; Passler, Isaac, & Hynd, 1985). Students at the elementary age are all still developing these skills, whereas they should be closer to mastery by adolescence. This study may provide more support for previous models (Berninger & Swanson, 1994) that suggest neurodevelopmental skills underlying handwriting and spelling provide variance in writing skills across primary grade students.

Planning

To date there have not been any studies specifically looking at planning and organizing skills in writing through an executive functioning lens. Studies mentioned in the earlier section regarding updated writing models examined planning, but they used cognitive or instructional tasks to see how they could boost poor writers' planning processes. Besides Hooper et al. (2001) there has not been a published study attempting the use of an executive functioning task tapping into planning to find planning deficits and possible correlating writing deficits.

Metacognition

Some researchers have looked at metacognition and its role in writing. Metacognition consists of understanding the process of writing (declarative metacognition) and monitoring and controlling the processes involved (procedural metacognition) (Butterfield, Hacker, & Albertson, 1996). Procedural metacognition can also be described as executive functions and are closely linked to the planning and reviewing described in Hayes and Flowers model of writing. Adults monitor the writing process by allocating differing amounts of resources to a given task, monitoring performance, and use of metacognitive knowledge to find relationships between current and previous tasks in the writing assignment (Pressley et al., 1995). Englert, Raphael, Fear, and Anderson (1988) found that metacognitive knowledge affects executive functions that support the writing processes. These include knowledge about the writing process and knowledge of the organizational structures. Researchers have found that children with learning disabilities tend to have less mature metacognitions about writing and focus on more of the mechanical pieces of writing than planning or revising (Graham, Harris, MacArthur, & Schwartz,1991; Wong, Wong, & Blenkinsop, 1989). Finally, two kinds of metacognitive knowledge affect executive functions that implement, sustain, and monitor writing suprocesses: 1) knowledge about the writing process (planning, drafting, editing, revising), and 2) knowledge of organizational structures (compare/contrast, problem/solve, collection, explanation) (Englert, Raphael, Fear, and Anderson, 1988).

Written Expression Difficulties in Learning Disabilities

Students with learning disabilities have additional difficulties in writing than the normal developmental problems reviewed in the last section. Students with learning disabilities make significantly more spelling, punctuation, and capitalization mistakes than peers without learning disabilities (Deno, Marston, & Mirking, 1982; Moran, 1981) and more mistakes with word usage (Anderson, 1982; Poplin, Gray, Larsen, Banikowski, & Mehring, 1980). Students with learning disabilties produce shorter texts (Englert & Raphael, 1988; Graham, 1990; Montague, Graves, & Leavell, 1991; Newcomer, Barenbaum & Nodine, 1988; Wong, Wong, & Blenkinsop, 1989), have poorer handwriting (Graham & Weintraub, 1996), and produce overall poorer compositions (Graham & Harris, 1989; Newcomer & Barenbaum, 1991). They also seem to have less knowledge about the writing process as well as the ability to pull ideas form memory (Englert & Raphael, 1988).

Newcomer and Barenbaum (1991) reviewed articles written between 1980 and 1990 that concerned the writing abilities of children with learning disabilities. The research reviewed examined story writing, expository writing, and instructional practices. Most studies showed children with learning disabilities had more problems with writing mechanics (Anderson, 1982; Barenbaum, Newcomer, & Nodine, 1987; Graves, Montague, & Wong, 1990; Montague, Maddux, & Dereshiwsky, 1988; Poplin et al., 1980; Vallecorsa & Garriss, 1990) and verbal fluency and that these differences increase with age in comparison to their same-aged peers. Research also found problems with story cohesion and the lack of important story components (setting, character

development). Studies examining expository writing found problems with irrelevancies, redundancies, mechanical errors, early terminations, lack of coherence, organization, and planning strategies. (Englert , Raphael, Fear, & Anderson, 1988; Englert & Thomas, 1987; Moran, 1981; Thomas, Englert, & Gregg, 1987; Wong, Wong, & Blenkinsop, 1989).

Summary of Writing Research and Statement of the Problem

Many students find the transition from primary schools to secondary schools to be a drastic change academically and socially. Until middle school, it is possible that some children with writing deficits function with few academic problems throughout the primary grades. Some children with writing problems may not even be diagnosed due to their high intellectual abilities, parental involvement, or mild to moderate symptoms. During middle school, however, academic problems begin to emerge and become more salient due to the dramatic increase of tasks requiring higher-order cognitive skills or executive functions. Adolescents find the secondary classes contain more material, and longer assignments, as well as more in-depth and individual work. In addition, secondary schools expect students to demonstrate more cognitive and metacognitive strategies, to acquire information from lectures and printed material, and to express knowledge of information through writing and tests. These increases in academic demands can be overwhelming and dehabilitating to students with writing problems, especially if they have impairments in executive processes. Attention, working memory, planning, and metacognition play an integral part in thinking, problem solving, and other complex symbolic activities found in the academic setting. As a result of this role, a subject such

as writing may be problematic for children and adolescents with executive dysfunction. Possible support for explaining poor writing skills may come from examining neuropsychological functioning associated with the writing process.

Attention, working memory, planning, and metacognition provide skills that are necessary to write effectively (Berninger, 1999; Ellis, 1982; Gregg, 1991). Although, research has proposed a relationship between executive functions and written expression, research actually examining and describing this relationship is inadequate. Understanding the role of specific executive functions may help with not only diagnosis, but also the creation of appropriate interventions for children struggling with writing.

Description of Proposed Study

The purpose of this study was to examine the relationship between performance on executive function and written expression measures in students aged 12 to 14. In addition to establishing existing deficits, further support may be given to the cognitive and neuropsychological perspectives of written expression. It was hypothesized that there would be a direct positive relationship between executive function measure and the written expression measure for all participants. Based on the above literature review it was expected that working memory and attention would be most predictive of written language skills followed by planning and verbal fluency.

CHAPTER 3

Method

Researchers have suggested that students with executive dysfunction are more likely to experience academic difficulties than children with intact executive functions (Berninger, 1999; Ellis, 1982; Gregg, 1991). The purpose of this study was to determine the relationship between performance on executive function tasks and written expression. In this chapter the participants, procedure, measures, and data analyses are discussed.

Participants

Data for this investigation was randomly selected from a larger group of participants gathered for the purposes of norming the Woodcock-Johnson Tests of Cognitive Abilities – Third Edition and the Woodcock Johnson Tests of Achievement – Third Edition (WJ-III; Woodcock, McGrew, & Mather, 2001ab). The normative data for grades kindergarten through 12 consisted of 4783 students randomly selected within a stratified sampling design. This sampling design controlled for the following variables in attempt to represent the data reflected in 2000 U.S. census: census region, community size, sex, race, type of school, father's education, and mother's education.

Participants in the current study included 544 students between the ages of 12-14 years old and consisted of grades 5 through 9. Descriptive information regarding the current study's sample including age, ethnicity, and gender are provided in Table 4. The sample consisted of 292 males and 252 females. Thirty-five percent of the sample was twelve-years-olds, 32% was thirteen-years-olds, and 33% was fourteen years olds. The

Table 4

Sample Population Demographic Data (N=544)

Group	n	Percent (%)
Gender		
Male	292	54
Female	252	46
Age		
12	188	35
13	174	32
14	182	33
Ethnicity		
Caucasian	352	65
African American	79	15
Native American	12	2
Hispanic	61	11
Asian	40	7

sample consisted of 65% Caucasian, 15% African American, 2% Native American, 11% Hispanic, and 7% Asian. The original data used to norm the WJIII coded each participant with two separate race variables. One was race (White, African American, Native American, and Asian/Pacific Islander) and the other was Hispanic (Yes or No). The

current study combined the two variables into one race variable by coding the students who answered "yes" for Hispanic as Hispanic in the race variable. Students with less than one year of experience in regular English speaking classes were excluded as well as students receiving special education services.

Procedure

Data Collection

Subjects used in the WJ-III norming data were selected through three sampling stages: sampling of communities, sampling of schools, and sampling of participants. Communities were selected based on their geographic location, size of community, and SES features. School systems located in these locations were contacted and schools representative of the community were identified. In some cases more than one school was used in order to provide a better representation of the community. In addition to public schools, the sample also included private and parochial schools and home schooled students identified through home school associations. A project staff member contacted the schools and met with each principal to discuss the project and data collection. Using a table of random numbers, students were selected from each grade to be potential participants in the norming sample. Parents of these students received parent permission forms and information about the testing. Parents were instructed to give or not give consent for participation as well as completing demographic information about the participant. Approximately 224 research assistants were trained and assisted in conducting the testing for the national norming of the WJ-III Tests.

Measures

All measures were taken from the Woodcock-Johnson Tests of Cognitive Abilities – Third Edition and the Woodcock Johnson Tests of Achievement – Third Edition (Woodcock, McGrew, & Mather, 2001). The dependent variable measuring the student's writing skills is based on three subtests from the WJ-III Achievement which forms the Broad Written Language Cluster. The independent variables measuring executive function skills were subtests from the WJ-III Cognitive. Subtests scores and the Broad Written Language score are standard scores based on a mean of 100 and a standard deviation of 15. Subtest descriptions and norm data are found below under their corresponding variable. Split-half procedures corrected with the Spearman Brown formula were used to calculate the reliability for the Broad Written Language. The median reliabilities for each subtest can be found in Table 5.

TABLE 5

Reported Split-Half Reliability for Subtests in Participants in the 5 to 19 Age Range

Measure	r
Broad Written Language	.94
Spelling	.89
Writing Fluency	.92
Writing Samples	.91
Number Reversal	.86
Retrieval Fluency	.83
Planning	.75
Pair Cancellation	.80

Writing Performance

Writing performance was based on the Broad Written Language score consisting of three subtests: Spelling, Writing Fluency, and Writing Samples. For the Spelling subtest participants were required to write orally presented single letters or words. The examiner instructed the participant to spell a stimulus word, used the stimulus word in a sentence, and repeated the stimulus word for each item.

The Writing Fluency subtest is a measure of automaticity with writing. Participants had seven minutes to quickly develop and write simple sentences when presented with a picture and three words. To receive credit for an item the participant could not change the stimulus words and had to correctly use all three words in a complete sentence. Participants were not penalized for errors in punctuation, spelling, or capitalization on the Writing Fluency subtest.

The participant was also required to produce sentences that were evaluated with respect to the quality of expression on the Writing Samples subtest. Items increased with difficulty based on the demands of passage length, grammatical complexities, and level of concept abstraction. Individuals were not penalized for errors of punctuation or spelling. For this subtest the examiner used a scoring guide provided in the examiner manual. Each response received a rating of 0.5, 1.0, 1.5, 2.0, or no credit.

Planning

The Planning subtest found on the WJ-III Tests of Cognitive Abilities was used as a task to measure students' planning ability. For this subtest the examiner presented the students with figures of increasing complexity. Students traced the lines that make up the

figure without retracing any lines or picking up the pencil from the paper. Participants had to plan, determine, apply, and revise solutions for tracing each figure. The participant's score was based on number of errors or segments of the patterns untraced or traced more than once.

Working Memory

The Numbers Reversed subtest was used as a measure of working memory. For this subtest the examiner read aloud a series of numbers and the participant repeated the numbers back in the reverse order. Thus, the participant must retain the numbers in memory while performing the mental operation of reversing the numbers. Items increased in difficulty of two numbers to eight numbers.

Attention

The Pair Cancellation task was used as a measure of attention. This subtest required the participants to demonstrate sustained attention as well as avoid interfering stimuli. Participants were presented with a response booklet containing repeated rows of small symbols. The examiner instructed the participants to find a ball followed by a dog and circle the pair of symbols. Participants were given three minutes to locate and mark as many repeated symbols as possible, while avoiding other symbols.

Verbal Fluency

Retrieval Fluency, a subtest found on the WJ-III Tests of Cognitive Abilities, was used as a measure of verbal fluency or retrieval of verbal information from stored knowledge. For this task, the participant was given one minute to name as many items as

possible from a presented category. Participants completed this task for three different categories: things to eat or drink, first names of people, and animals.

Data Analyses

Hypothesis 1

Performance on executive functioning tasks measuring attention, working memory, planning, and verbal fluency will correlate statistically significant to performance on tasks measuring written language skills.

Hypothesis 2

Executive functioning tasks (attention, working memory, planning, and verbal fluency) will explain a statistically significant proportion of the variance to writing performances as measured by the Woodcock Johnson Test of Achievement – Third Edition.

Rationale

Although research specifically looking at executive functioning skills in students with poor writing skills is limited, the studies previously described have found executive functions to play important roles in the writing process. It was hypothesized that the executive functioning tasks will be correlated to writing ability and they will provide predictive ability for performance on a writing task.

Hypothesis 3

Performance on working memory and attentions tasks will be more important in explaining performance on the writing task with the other variables in the analysis controlled.

Rationale

Very few studies have examined the level of contribution specific executive functions provide to writing skills. Examination of each independent variable's contribution will provide information about writing skills as well as which measures are helpful to further explore.

Data Analysis

A multiple regression analysis was conducted to determine how much of the variance in written expression is explained by a combination of the four variables (Verbal Fluency, Pair Cancellation, Planning, and Number Reversal). A simultaneous regression method was used in which all predictor variables were entered into the analysis at the same time. In order to determine how much each task contributes to written expression, the standardized regression coefficient of each variable was examined.

CHAPTER 4

Results

The present investigation was developed to lend further support to cognitive and neuropsychological theories of written expression. This study examined the relationship between adolescents' performance on executive function tasks and writing skills. This chapter discusses the results of the analyses presented in Chapter 3. The first section focuses on descriptive data. This section is followed by the results for the research hypotheses. The final section of this chapter provides a summary of the results from the analyses. Analyses were conducted using statistical software SPSS 10.0 for Windows (released in 1999).

Descriptive and Preliminary Analyses

Descriptive statistics are presented in a Table 6 and includes means, standard deviations and number of participants for the entire sample. Statistics are presented for Broad Written Language Skills, Number Reversal, Retrieval Fluency, Pair Cancellation, and Planning. Table 7 shows descriptive statistics according to gender, race, and age on Broad Written Language. Preliminary analyses were conducted to determine the presence of significant differences between participants (gender, race, and age) and their performances on Broad Written Language Skills. An ANOVA did not show a significant difference between participants' performances on the written language task according to gender ($\underline{F}(1,543) = 3.161, \underline{p}<.076$) or age ($\underline{F}(2, 543) = .111, \underline{p}<.895$). A statistically

significant difference was found between races on the Broad Written Language score ($F(4,543) = 14.96$, $p<.001$).

TABLE 6

Means and Standard Deviations of Total Sample

Measure	n	M	SD
Broad Written Lang.	544	103.30	14.04
Number Reversal	544	102.93	15.33
Retrieval Fluency	544	102.20	14.91
Planning	544	100.11	12.21
Pair Cancellation	544	102.41	15.81

TABLE 7

Means and Standard Deviations of Broad Written Language Scores by Gender, Race, and Age

	n	M	SD
Gender			
Male	292	100.41	13.84
Female	252	106.65	13.55
Race			
White	352	105.43	13.26
African American	79	96.08	14.82
Native American	12	97.17	13.63
Hispanic	61	96.92	12.67
Asian American	40	110.43	12.20
Age			
12	188	103.05	14.10
13	174	103.76	14.80
14	182	103.13	13.28

Pairwise comparisons found Asian American participants performed significantly better than African Americans, Native Americans, and Hispanics and Caucasian participants

performed significantly better than the African American and Hispanic participants. Pairwise comparisons were corrected with the Bonferroni statistic so as to decrease the probability of a Type 1 error.

Analyses were performed to determine if the data met assumptions necessary to conduct the above ANOVA analyses and a multiple regression analysis. Variables were found to be normally distributed, error variances across variables were found to be equal, and the relationship between the dependent and independent variables was linear. Due to the correlation between some of the executive function measures multicollinearity was checked in order to address possible problems. Correlations between these variables were not above .80, tolerance levels were close to 1, and all variance inflation factor values were less than 2, thus reducing the chance of multicollinearity.

Results of Test of Hypotheses

Hypothesis 1 predicted that in the entire sample, the executive function measures would significantly related to the Broad Written Language score. Intercorrelations between the variables are presented in Table 8. A correlational analysis found statistically significant correlations between Broad Written Language Skills and Number Reversal (r=.448, p<.001), Broad Written Language Skills and Retrieval Fluency (r=.371, p<.001), Broad Written Language Skills and Planning (r=.189, p<.001), and Broad Written Language Skills and Pair Cancellation (r=.433, p<.001). Significant correlations were also found between the executive function measures. Number Reversal was found to be significantly correlated with Retrieval Fluency (r=.240, p<.001), Planning (r=.229, p<.001), and Pair Cancellation (r=.235, p<.001). Pair Cancellation was found to be

significantly correlated to Retrieval Fluency (r=.327, p<.001) and Planning (r=.184, p<.001). Gender was significantly correlated with broad written language (r=.221, p<.001), Retrieval Fluency (r=.166, p<.001), and Pair Cancellation (r=.206, p<.001). Significant correlations were statistically significant at the .001 level, though some were small and would be considered weak correlations.

TABLE 8
Intercorrelations between variables

	Broad Written Language Skills	Gender	Number Reversal	Retrieval Fluency	Planning	Pair Cancellation
Broad Written Language Skills	----	.222**	.448**	.371**	.189**	.433**
Gender		----	-.016	.165**	-.020	.204**
Number Reversal (working memory)			----	.240**	.229**	.235**
Retrieval Fluency (verbal fluency)				----	.100*	.327**
Planning (planning and organization)					----	.184**
Pair Cancellation (attention)						----

** Correlation is significant at the .001 level, * Correlation is significant at the .01 level

The variables Retrieval Fluency, Planning, Pair Cancellation, Number Reversal, and gender were entered simultaneously as predictors of written expression in a multiple regression equation. It was hypothesized that executive function measures and gender would significantly predict written language skills. The overall equation was found to significantly predict Broad Written Language Skills for this sample (F (5,543) = 63.00,

p=<.001), as shown in Table 9. The variables gender and executive functions accounted for 37% of the variance in Broad Written Language Skills scores.

TABLE 9

Simultaneous Regression Analysis for Variables Predicting Broad Written Language Skills (N=544)

	B	SEB	Beta
Gender	4.119	.995	.146
Number Reversal	.308	.033	.336
Retrieval Fluency	.167	.035	.177
Planning	.004	.032	.051
Pair Cancellation	.295	.043	.256

Note. R^2 = .369

T-tests of the standardized multiple regression coefficients were significant for Number Reversal (*B*=.336, *t*=9.188, *p*=.001), Retrieval Fluency (*B*=.17, *t*=4.785, *p*=.001), Pair Cancellation (*B*=.256, *t*=6.799, *p*=.001), and Gender (*B*=.146, *t*=4.141, *p*=.001). Planning was not found to be significant in this model (*B*= .051, *t*=1.426, *p*=.154). Measures assessing working memory, attention, and verbal fluency made a contribution to predicting Broad Written Language Skills, while Planning did not contribute significantly. Hypothesis 3 predicted that attention and working memory measures would be more important in explaining the variance on performance of Broad Written Language Skills. An examination of these results revealed tasks measuring working memory (Number Reversal) and attention (Pair Cancellation) contributed more variance than the other executive functioning tasks and thus better predictors for this sample.

CHAPTER 5

Discussion

The results of the present study are summarized and discussed in this chapter. In addition to examining the results in relation to the hypothesis, findings are discussed with respect to previous research concerning executive functions and written expression. The relevance of the findings to cognitive and neuropsychological theories of written expression are also discussed, as well as clinical implications for assessment and intervention of writing skills. Finally this chapter discusses the study's limitations and recommendations for future directions of research.

Summary and Explanation of Results

Previous researchers (Abbott & Berninger, 1993; Bereiter, Burtis, & Scardamalia, 1988; Berninger, Cartwright, Yates, Swanson, & Abbott, 1994; Berninger & Colwell, 1985; Berninger & Rutberg, 1992; Berninger & Swanson, 1994; Berninger, Yates, et al., 1992; Hayes and Flower, 1980; Scardamalia & Bereiter, 1986) have studied the basic underlying skills of composition, the developmental phases of writing, differences between good and poor writers, and explanations for difficulties in written expression. The purpose of this research was to examine the relationship between executive functions and written expression in typically developing adolescents, aged 12 to 14. Previous research is limited in this area and especially limited with this age group. Although research using younger participants found differences on executive function tasks

between good and poor writers, the performance on executive function tasks were not found to predict the students' performance on a written expression task (Hooper et al., 1996). Research examining the development of executive function skills has determined these skills are intact between the ages of 12-14, but continue to develop at a slower rate (Becker, Isaac, & Hynd, 1987; Denckla, 1994; Passler, Isaac, & Hynd, 1985). The present sample was limited to 12 to 14 years age range in order to evaluate whether executive functions would predict written language skills.

Results found that race and age did not significantly predict written expression scores so these variables were consequently dropped from the equation. This study did find a significant difference between races on the written expression task, but race did not predict written expression scores. Asian participants performed significantly better than African American, Native American, and Hispanic participants on the written expression task. Also, Caucasian performed better than African Americans and Hispanics in this sample. It should be noted that the sample did not include the same amount of participants representing each race. It is possible that with the inclusion of more participants representing different races, this variable would significantly predict written expression scores.

Similar to previous research (Berninger & Fuller, 1992; Berninger & Rutberg, 1996) significant differences were not found between males and females on the written expression task, but there was a trend towards significance (p=.076). The overall mean for females' performance on the written expression task was higher than the mean for males. Gender was found to be a significant predictor for Broad Written Language Skills.

Gender and the four executive functioning tasks were entered in the regression equation and found to significantly predict written expression in the sample of 544 students; however, the planning measure was not found to be a significant predictor. Numbers Reversed, a measure of working, memory accounted for the most variance, followed by Pair Cancellation (attention) and Retrieval Fluency (verbal fluency). This finding supports previous research examining the contribution of working memory to written expression in children and adolescents (Berninger, Cartwright, et al., 1994; Berninger, Whitaker, et al., 1996; Berninger, Yates, et al., 1992). Planning was the only executive functioning variable entered that did not reach significance. Further exploration of the planning scores revealed the performances on the other three executive measures showed more variance across the sample.

Previous research (Bereiter, Burtis, & Scardamalia, 1988; Bereiter & Scardamalia, 1987; Graham, Harris, MacArthur, & Schwartz, 1991; MacArthur, Harris & Graham, 1994; McCutchen, 1995; Perfetti & McCutchen, 1987; Scardamalia & Bereieter, 1986; discovered that planning is one of the last processes of writing to develop, thus it is possible that the executive function planning is not an appropriate predictor for this age group. There does not appear to be much variance across the sample for planning to differentiate the participants in this sample. Additionally, it is possible that the planning subtest from the W-JII was not an adequate measure for the purposes of this study. This finding will be discussed in more detail under the sections entitled theoretical relevance and limitations of present study.

The planning task was the only executive function task not found to significantly predict writing scores in the 12 to 14 year-old sample. In addition to developmental arguments discussed above, planning may have not been a significant predictor because the Planning subtest from the WJIII was not sensitive enough for the purposes of this study. Solutions on the planning task draw primarily on visuo-spatial thinking ability, and do not tap into language skills necessary for planning out a written composition. Although the planning tasks from the WJIII require sustained effort, it may not represent comparable effort used in writing sentences or a paragraph.

Theoretical Relevance and Implications for Research and Practice

Researchers (Berninger & Swanson, 1994; Hayes, 1996; Hayes & Flower, 1980; Kellogg, 1996; McCutchen, 1996; Scardamalia & Bereiter, 1986) have proposed both cognitive and neuropsychological theories to explain the phenomenon of written expression and recently began to integrate their work. The findings from the present study lend further support to both fields of psychology as well as the idea that combining these two theories can provide a better understanding of writing. To begin with, working memory was found to be a significant predictor of written expression in the current study, thus supporting several theoretical models suggesting it was an important part of the writing process (Berninger & Swanson, 1994; Hayes, 1996; Kellogg, 1996). Berninger and Swanson (1994) proposed that during the intermediate grades the expansion of working memory capacity emerges. Hayes depicted working memory as the central process in writing and argued that all the processes in the writing model must go through

working memory to carry out non-automatic tasks. Kellogg's (1996) model also included pieces of Baddeley's working memory model (1986) and applied them to each component in his writing model: verbal formulation, execution, and monitoring.

This investigation also found the task measuring attention, Pair Cancellation, significantly predicted students' performances on the Broad Written Language Skills. Although it did not contribute as much variance as working memory, the attention task should be noted as an important finding. Similar to working memory, deficits in attention may affect higher order writing skills such as planning and revision, however, attention deficits may also contribute to careless errors and poor self-monitoring exhibited in the lower order writing skills (Berninger, Mizokawa, & Bragg, 1991). Attention may play a more significant role in writing for elementary students, whereas working memory and planning may become more important for the middle school student. Attentional processes create a selective, more focused activity over a period of time, whereas planning processes assist in cognitive control, use of available knowledge, and even assist in self-regulation for goal attainment (Johnson & Bardos, 2002; Naglieri & Das, 1990). Elementary school students are focusing on the basic handwriting, spelling, writing conventions, mechanics, and vocabulary development. After these skills are developed, middle school students concentrate on theme development, organization of text and fluency. As the requirements for writing become more difficult students in middle school and high school must develop longer and higher quality assignments. These assignments require more use of variety of words, topic development, and revision. Also, adolescents are better at metacognition which is necessary in these steps. Therefore, it is possible that

not only do younger children not have strong planning skills, but they are not completing writing tasks that demand a great deal of planning. Following this rationale, planning may be a better predictor for older adolescents or student in high school.

These findings may be important for future research involving written expression and executive functions. Gender should continue to be an included in studies to determine if differences exist on this variable as well as its role in predicting writing performance. Also, results from this study suggest that developmental differences in executive functions need to be evaluated as well as written expression. Specific executive functions may contribute more or less variance in writing performance at different developmental stages.

The results of this investigation also suggest implications for psychologists practicing in the school setting. School psychologists may use these findings to assist in decisions regarding explanation of writing difficulties, recommendations for the struggling writer, or qualification for learning disabilities. Moreover, the school psychologist can find useful information within an intelligence test used to determine eligibility for special education services. The present study used subtests from the Woodcock Johnson Test of Cognitive Abilities – Third Edition. Thus the school psychologist could use this test for their primary cognitive measure and gather potentially helpful information regarding the student's executive functioning skills. Likewise a different cognitive measure could be used with the addition of selected subtests from the WJIII. If deficits are found on any of the subtests these deficits may help explain some of the writing difficulties. In addition to helping students with learning disabilities in the

area of written expression, this research may be helpful to students with writing problems but do not qualify for special education because they do qualify for a diagnosis of a learning disability. Furthermore with additional data supporting these results, school psychologists may be able to connect assessment with effective intervention and instructional programming.

Limitations of Present Study

The present study provided support to existing theories regarding written expression and the development of writing skills. These findings also provided support for the relationship between executive functions and written expression, however the study does have some methodological limitations that should be noted. Variables such as writing instruction or additional learning disabilities in other academic areas were not accounted for in this study. Since both the independent and dependent variables were not manipulated, there is a possibility that additional variables play a role in the significant results. Another limitation involves the students involved in this sample. Student participation in this data collection was voluntary and the students were compensated monetarily, thus performances by students tested in school referral cases may differ. The sample was also comprised primarily of Caucasian students and very few Latino and Asian American students. Due to the low sample size across races, it is difficult to generalize the results of this study across minority populations.

The quality of results is also dependent on the reliability and validity of the measures used in the research. Although the reliability and validity statistics for the

Written Expression subtest of the WJIII are respectable, there continues to be room for error due to the subjective nature of the scoring involved in this subtest. Some researchers may also feel that the WJIII written expression subtests do not adequately measure the students' ability to write an essay. The WJIII subtests requires students to write sentences given a prompt or picture, whereas other writing tests require the participant to write an entire essay given a prompt or picture. Students composing an essay with multiple paragraphs may require more planning abilities than some of the tasks on the measure used in the current investigation. Thus, it is possible a different writing task may find different results, including planning as a significant predictor of writing performance in middle school aged students.

Future Directions for Research

The findings from the present study provided further support that executive functions play some role in the development of writing skills. This study was restricted to students between the ages 12 to 14 to provide more support for development of executive functions. Future research should expand the sample to include elementary and high school age students to examine if executive functions predict writing skills differently across age groups. Planning was not found to significantly predict middle school students' writing skills, but perhaps it would be a significant predictor among high school students. Additional research should be completed with other planning tasks and writing measures to see if results are consistent. Furthermore, additional predictors should be included to determine what variables account for the remaining variance of scores.

Possible ideas for these predictors include visuo-spatial skills, visual-motor integration, motor skills, metacognition, motivation, socioeconomic status, oral language abilities, and writing experience.

Future research should also begin to look at how executive functions link to specific components of writing. Researchers should examine the written expression task for performance in the areas of mechanics, fluency and quality, conventions, vocabulary, organization, and theme development. Research should continue to provide support to the development of executive functions as well as the development of these writing skills. Understanding these relationships may help provide more appropriate interventions and specific recommendations for individuals with specific writing difficulties. As additional support is gathered showing the relationship between executive functions and written expression, intervention research should be developed to determine if targeting specific deficit areas in executive functions to improve written expression performance.

Conclusion

The present investigation found the tasks measuring the executive functions working memory, attention, and verbal fluency to significantly predict middle school students' writing performance. Although executive functions could only explain part of the model, these findings lend support to the theory that deficits in executive functioning may impair writing abilities. Executive dysfunction may impair basic underlying components of writing such as spelling and writing mechanics, as well as interfere with higher order writing skills of planning, translating, and revision. Further exploration of

this relationship may assist in the development of effective writing interventions targeting writing deficits and executive functions.

Appendices

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