EVALUATION OF A COMPUTER-BASED REVISION PROMPTING INTERVENTION FOR UNDERGRADUATE WRITERS WITH ACQUIRED BRAIN INJURY

by

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DISSERTATION ABSTRACT

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Title: Evaluation of a Computer-Based Revision Prompting Intervention for Undergraduate Writers with Acquired Brain Injury

People with acquired brain injury (ABI) present with impairments in working memory and executive functions, and these cognitive deficits contribute to difficulty self-regulating the production of expository writing. Cognitive processes involved in carrying out complex writing tasks include planning, generating text, and reviewing or revising text produced. Intervention targeting the process of revision during the writing process may contribute to improved self-regulation of expository writing for people with ABI, of which college undergraduates are a subset of writers experiencing challenges.

This study evaluated a computer-based revision prompting intervention for expository essay writing for undergraduate writers with acquired brain injury using a single-case, non-concurrent multiple-probe design across four participants. Primary outcome measures included number of revisions and quality scores. I used brief interviews to evaluate participants' writing knowledge at the start of the study, and a post-intervention questionnaire to evaluate participant perceptions of the intervention, and perceived changes in writing ability.

Visual inspection of data points plotted for Overall Quality Scores indicated a functional relation between the intervention and increased Overall Quality Scores compared to baseline, observed as a change in level at three distinct points in time across

three participants. Visual inspection of data points plotted for number of revisions revealed no increase from baseline to intervention phases. Results suggest that the computer-based revision prompting intervention has potential to improve expository writing in undergraduate writers with ABI, though mechanisms of improvement require clarification in subsequent studies. I discuss results in terms of potential mechanisms of improvement, including cueing of self-monitoring and prior knowledge, and stimulation of task schemas for self-regulation of expository writing.

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CHAPTER I

INTRODUCTION

Competent writing skills are important for both academic and professional achievement. Academic writing is a primary means of conveying complex topic knowledge and demonstrating competence with subject matter (Parr & Earl, 2010). Complex writing tasks at secondary and post-secondary levels demand increasing levels of complexity combined with critical analysis and synthesis of ideas. Given the importance of strong writing skills to success in post-secondary educational settings where academic tasks routinely require writers to describe, explain, persuade, and analyze, effective writing ability is critical.

Struggling writers are at a disadvantage compared to more skilled peers when seeking college entry and career opportunities (Graham & Perin, 2007; Taft & Mason, 2010). Despite the obvious importance of academic writing to college success, there is a paucity of research investigating writing intervention for lower performing college writers. While abundant research has shown that struggling writers have difficulty in both secondary and post-secondary educational settings, further research is needed to develop and evaluate interventions for struggling writers (Miller & McCardle, 2010). While some college writing educators have investigated intervention approaches targeting improved college-level writing (Feltham & Sharen, 2015; Hamman, 2005; Myhill & Jones, 2007; Riddell, 2015; Opnedacker & Van Waes, 2007), intervention research for improving writing for college students has focused on college writers in general, rather than specifically on college writers with disabilities.

College Writers With Acquired Brain Injury: A Neglected Population

Individuals with acquired brain injury (e.g., traumatic brain injury, sport-related concussion) are one of the populations enrolled in post-secondary education settings who frequently face academic struggle (Kennedy, Krause & Turkstra, 2008; Stewart-Scott & Douglas, 1998; Todis, Glang, Bullis, Ettel, & Hood, 2011). As a variety of cognitive processes may be impaired after brain injury (Sohlberg & Mateer, 2001), post-secondary writers with acquired cognitive impairments that impact higher level writing skills are likely to struggle with meeting the challenges of academic writing, as multiple cognitive processes are heavily involved in the writing process (Berninger, 2012; Graham, Harris & Olinghouse, 2007; Kellogg, 2008; Olive, 2012). There is a lack of evidence-based practice, and minimal to no information available in the literature describing the writing needs and challenges of this population, or documenting how these writers respond to targeted strategies and supports.

Cognitive impairments are common following brain injury and affect the writing process in multiple ways. Deficits in working memory and executive functions result in impaired ability to self-regulate academic tasks for individuals with ABI (Sohlberg & Turkstra, 2011; Anderson, 2002; Kennedy & Coelho, 2005). Of import, research specific to writing impairments in the ABI population is lacking. Despite prevalence and significance of writing impairments (Baker et al., 2009), there is virtually no empirical evidence specific to the ABI population to guide writing assessment and intervention. To date, only a single study has described writing difficulty after brain injury (Wheeler, Nickerson, Long and Silver, 2014). Faced with an absence of research, efforts at

determining how best to intervene to help college aged writers with brain injury must draw upon available intervention research conducted with other populations.

Intervention for College Writers

Strong theoretically based writing intervention research with the learning disabilities population has generated evidence-based intervention approaches built on theoretical models of cognitive processes and self-regulation in writing (Graham & Harris, 2012; Mason & Graham, 2008; Zimmerman & Risemberg, 1997). Across well known cognitive models of writing, researchers agree that writing involves interrelated dynamic, recursive processes that are mediated by the writing problem, the task environment, and individual differences (Berninger, 2012; Hayes & Flower, 1980a; Flower & Hayes, 1981; Hayes, 1996; Hayes, 2012a; MacArthur, 2012). Strategy instruction based on cognitive process theory has been demonstrated to be particularly effective in improving the writing of struggling writers (Baker et al., 2009; Gillespie & Graham, 2014; Graham & Perin, 2007; Rogers & Graham, 2008). Self-Regulated Strategy Development (SRSD; Graham & Harris, 1993), an evidence-based instructional approach grounded in cognitive process theory for teaching strategies for self-regulating writing, has produced large effect sizes when used as an intervention for struggling writers with learning disabilities and ADHD (Baker et al., 2009; Gillespie & Graham, 2014; Graham & Perin, 2007; Rogers & Graham, 2008). Studies investigating the use of SRSD with struggling adult writers have demonstrated positive results (e.g., MacArthur & Lembo, 2008). The SRSD instructional approach holds promise for improving the skills of struggling post-secondary writers with brain injury because it targets the self-

regulation of cognitive processes required for writing that are frequently associated with acquired cognitive impairments.

Research on intervention with struggling college writers is limited, and such research for writers with brain injury is non-existent. However, college writing instructors have recently completed studies noting the importance of intervening early on to improve the skills of undergraduate writers in general. This emerging body of literature suggests that college writing instructors are concerned and attentive to the complex needs of their students. For example, Riddell (2015) implemented and tested an intervention aimed at improving revision and essay quality in undergraduate writers in an undergraduate English course for which she served as instructor. The intervention program the author described aimed to engage writers metacognitively in a process of learning clear assessment criteria, providing feedback on others' performance, applying the feedback to their own performance, and revising based on feedback to improve the quality of the final written text. She noted that clear expectations, clear assessment criteria, and increased frequency of writing and feedback to inform revision are helpful for improving writing quality. In implementing the intervention, the author delivered three scaffolded exercises over the course of a semester in which she trained writers in her college English course to use a predetermined assessment process to evaluate essays from prior years' students who had volunteered their essays for the project. She then asked students in the class to use same criteria in rubric form to evaluate their own essays. She evaluated the efficacy of the study through obtaining both qualitative and quantitative student feedback about their experience in the course, with course grades serving as another outcome measure. Findings suggested that the intervention was helpful

in improving their writing skills. Other recent studies have also demonstrated the merits of delivering instruction for revision in post-secondary settings. Feltham and Sharen (2015) incorporated a variety of interventions into a college writing course, with some of the interventions specifically targeting revision, resulting in positive outcomes.

Further informing future intervention design is the growing literature on computerized intervention for writing. Of relevance, the growing popularity of computerized writing intervention programs looks to have created a demand for developing customized computer-based or computer-assisted interventions for efficient instruction or self-instruction of customized writing strategies for struggling college writers (Proske, Narciss & McNamara, 2012). Of specific interest to the current study is the potential for computer-based interventions to efficiently target the revision skills of struggling college writers with brain injury.

Is Revision the Key?

The literature points to a need for intervention research focused on revision. Early investigations of intervention for revision found that targeting revision in a brief, focused manner led to improved written text quality for undergraduate writers (Wallace & Hayes, 1991). More recently, prominent writing researchers have suggested that brief, theoretically driven interventions could serve to improve revision behavior (MacArthur, 2012). Of note, revision may be neither consistently nor adequately addressed by writing educators (Witte, 2013). Witte (2013) explored writing educators' reported practices for addressing revision in their courses. She found that writing educators reported numerous and diverse reasons for their general tendency to neglect revision instruction. On the other hand, those same educators tended to report demonstrating revision behavior when

engaged in their own writing tasks. Witte (2013) pointed to that discrepancy between writing educators' personal and professional practice with regard to revision, noting the importance for writing educators to "preach what [they] practice" (p.50) where revision is concerned. Effective revision as demonstrated by skilled writers is characterized by knowledge of task schemas for effective completion of complex academic writing tasks (Hayes, 2012a). Struggling writers have been shown to perform less well with revision tasks (Wallace & Hayes, 1991; Hayes, 2012a), perhaps due to lack of knowledge of task schemas. The revision behavior of struggling writers mainly consists of surface edits that fail to address macro-structure, micro-structure, and audience appeal (Hayes, 2012a).

Computer-based prompting targeting revision, if specific to text-macrostructure, micro-structure and consideration of audience perspective, may be able to help writers strategically use revision to improve the quality of their writing. Computer-based prompting has been investigated with positive results (Proske, Narciss & McNamara, 2012), suggesting this type of intervention could prove fruitful for struggling writers. Proske and colleagues (2012) found improved written text quality for college writers in response to computer-based prompting intervention that included feedback about writing with deliberate practice in writing tasks. They noted the need for external support for revision knowledge and strategies in less-skilled writers (Proske et al., 2012). Additional research with this type of intervention is still needed for college students who struggle with writing. This study has responded to the need for revision research by investigating whether computer-based prompting for revision can influence revision changes and positively impact essay quality for struggling writers.

The significance of this type of research is grounded in the need to address gaps in the intervention evidence base to identify interventions to assist struggling college writers with brain injury to better meet the academic demands of complex writing tasks. A primary research problem is to investigate whether efficient, computer delivered prompting will affect revision behavior and improve quality of the final written text. A reasonable hypothesis is that computer-based prompting for revision will increase the number and types of revision changes and result in greater numbers and more diverse types of revision changes that could be linked to improved quality of the final written text. Were this hypothesis upheld, it would be important for revision intervention because it would offer support that brief, computer-based prompting for revision could have the potential to improve writing performance. Given the time and effort constraints placed on writing educators to be able to deliver explicit instruction to target revision processes, the potential accessibility of revision-focused, computer-based interventions that college writers could feasibly access on their own for self-instruction would fill an unmet instructional need for the population of struggling college writers. Given the inadequacies of the Common Core State Standards for writing and the inconsistent use of evidence-based practices in secondary school writing classrooms (Troia & Olinghouse, 2013), that population seems likely to continue to grow.

Statement of Purpose

The purpose of this study was to evaluate a computerized revision prompting intervention for undergraduate writers with ABI who struggle with the writing process. Computer-based prompting for revision in writing could prove of benefit to writers experiencing pervasive, high-level writing challenges interfering with their educational

success. However, such interventions require development and testing of components through experimental research to evaluate their effectiveness at efficiently and expediently helping college writers grow their skills to better keep up with the expectations of post-secondary academic writing. This dissertation study aimed to address a gap in the writing intervention research literature by conducting an initial experimental evaluation of a computer-based revision prompting intervention delivered in a feasible, efficient format for college writers with high-level writing impairments associated with ABI.

Chapter II reviews the literature to explain the primary theoretical framework underlying the research proposed. After discussing cognitive processes involved in writing, the chapter presents information on cognitive processes impaired after brain injury and how those impaired processes impact writing. Following a review of writing intervention literature, the latter portion of the chapter focuses on revision to make a case for the current study. The chapter closes by presenting research questions, hypotheses, and expected findings.

Subsequently, Chapter III presents a description of the research methods, procedures and analyses for the study. The chapter describes the experimental design, participant characteristics, and details research procedures before delineating the experimental intervention, describing outcome measures, and presenting methods of analyses for answering the research questions. The chapter ends with a description of methods for determining social validity of the intervention. Chapter IV presents study results. Chapter V presents a discussion of results relative to the literature review, describes study limitations, and proposes directions for future research.

CHAPTER II

REVIEW OF THE LITERATURE

Writing is a complex activity. Over the past thirty years, the field of cognitive science has informed the theoretical landscape providing a context for investigating writing, with developmental and social cognitive perspectives contributing further theoretical grounding. The ensuing literature review endeavors to summarize and integrate the current theoretical landscape in order to inform the design of a proposed study of computerized prompting for revision for college writers with acquired brain injury. The chapter begins with a review of cognitive process theory and associated models, then relates this primary theoretical framework to cognitive developmental theory as related to writing. Following a discussion of cognitive processes implicated in writing, including revision processes, the chapter then presents information on cognitive processes impaired after brain injury and how those impaired processes affect writing. Following a review of writing intervention literature, the remainder of the chapter focuses on revision to make a case for the proposed study. The chapter ends with a presentation of proposed research questions, associated hypotheses, and a brief presentation of anticipated findings.

Cognitive Process Theory

In seminal theoretical work, Hayes and Flower (1980a) proposed a cognitive process model of writing comprised of three component processes: planning, translating and reviewing. The planning component includes goal setting, generating and organizing; the translating component refers to producing written text (i.e., translating ideas into sentences); and reviewing includes evaluating and revising. In particular, reviewing

consists of reading the text produced to diagnose the need for revisions, then carrying them out. Hayes (2012a) explained that a monitor function included in this original version of the model was intended to account for individual differences among writers in terms of how they carry out writing tasks, including revision. Figure 1 features an illustration of the model (Flower & Hayes, 1981).

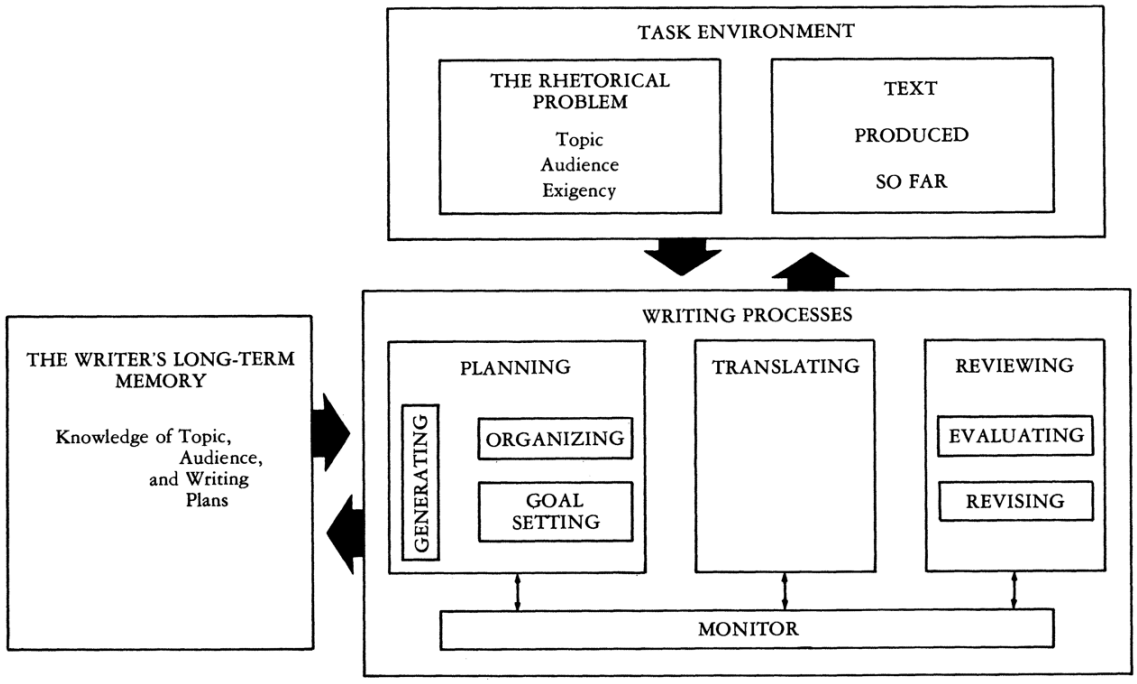

Figure 1

Cognitive Process Model of Writing (Flower & Hayes, 1981)

As represented in the model, writing occurs in the context of a task environment. The task environment is comprised of the rhetorical problem (i.e., topic, audience, and exigency) and "text produced so far," or text the writer creates while writing (Flower & Hayes, 1981, p.370). The authors advised that the model should be viewed as dynamic and recursive, warning against thinking of its components as discrete, sequenced stages. According to the model, writers alternate between global and local focus while engaged

in the writing process, tapping the various component processes and sub-processes embedded hierarchically within the model. Flower and Hayes (1981) explained that, while writing, writers engage in frequent switching of their focus from local tasks like text generation (translating) to global tasks like planning and reviewing. Responding to a writing task (rhetorical problem) requires manipulation in working memory of content knowledge, along with task schema knowledge about how to write (Hayes, 2012a), while simultaneously acting within multiple constraints. Writers must operate within multiple constraints to plan, generate, review and revise text while also considering purpose for writing, audience, grammar, spelling, and punctuation. Hayes (1996) clarified that working memory is central to the model, and also stressed the importance of motivation and affect in writing, which he reiterated in a later update to the model (Hayes, 2012a), discussed in the following sub-section.

An updated model. Hayes (2012a) updated the original cognitive process model of writing to emphasize the importance of transcription and transcribing technology, and to highlight the individual differences among writers and the role of motivation in the writing process. He also specified how the model explains revision. The author noted the continued usefulness of the model for representing the writer and the task environment, text produced so far (TPSF; Hayes, 2012b), long-term memory, and interaction among sub-processes (Hayes, 2012a). Observing how the research of his colleagues influenced the evolution of the model, he elaborated on four notable changes to it. Figure 2 depicts the updated cognitive process model Hayes (2012a) described**.**

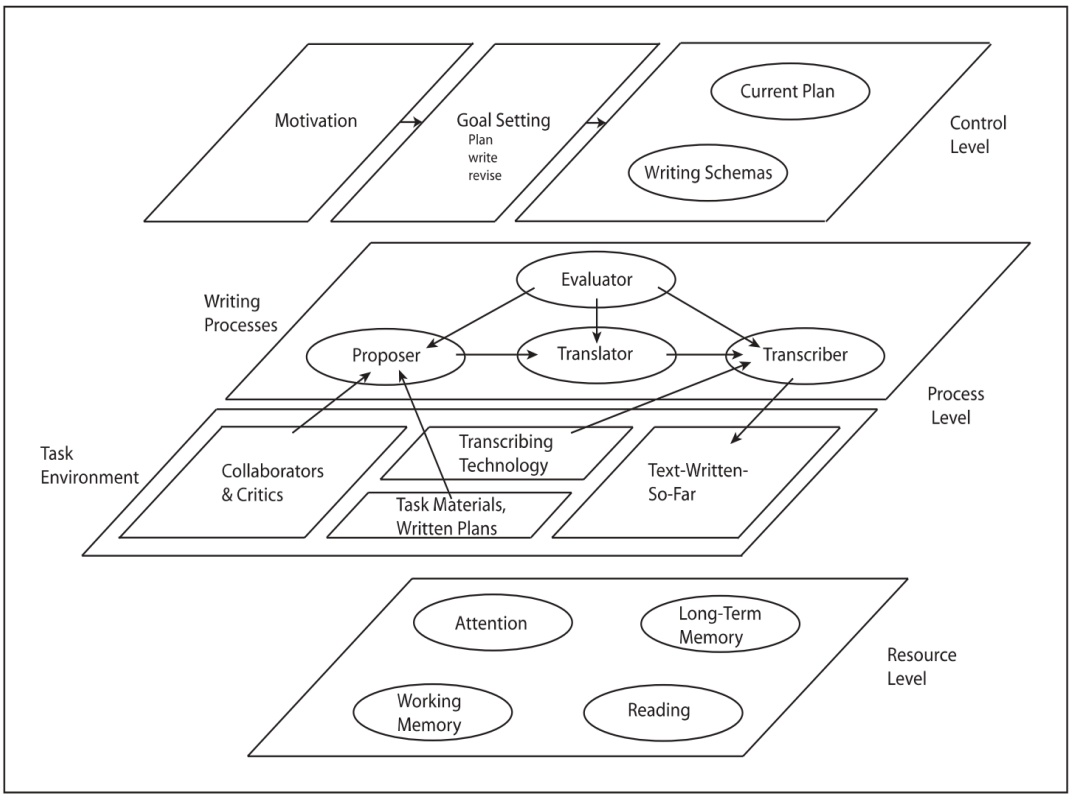

Figure 2

Updated Cognitive Process Model of Writing (Hayes, 2012a)

Role of transcription and transcribing technology. Citing his earlier work with a colleague, Hayes (2012a) observed that even adults can experience slowed transcription in the presence of reduced verbal working memory (Hayes & Chenoweth, 2006), thus transcription was included in the updated model. Transcribing technology, he added, comprises part of the task environment when writing, and is now included in the model to account for differences in transcription skills writers demonstrate depending on whether they write with pen, keyboard, or while using external aids to transcription (Hayes, 2012a).

Role of motivation. Hayes (2012a) expressed that whether, how, and how much people decide to write depends at least to some degree on motivation. The updated version of the model includes motivation in an effort to at least generally account for its impact on how writers set goals for writing (Hayes, 2012a). Less skilled college writers have been found to pay less attention to instructional materials and training sessions targeting writing compared to higher-skilled college writers (Hayes, Schriver, Hill, & Hatch, 1990, as cited in Hayes, 2012a). Describing his experience with earlier think-aloud protocol analysis, Hayes (2012a) also noted that writers revise during the translation process before even transcribing text, and that they may be more likely to make changes to their proposed language when they are more motivated to produce text of high quality. The overall suggestion is that when writers perceive a purpose for writing that they care about, they may be more motivated to write.

Removal of the monitor. Interestingly, the monitor function in the original model, Hayes (2012a) reported, was not intended to represent overall control over writing processes, but rather to represent individual differences in how writers approached carrying out writing tasks. Citing earlier work he completed with colleagues (e.g., Wallace & Hayes, 1991) the author explained how such individual differences have to do with how writers utilize task schemas to guide their carrying out of writing tasks. Task schemas may vary according to goal, scope or procedure for carrying out revisions (Hayes, 2012a).

How planning and reviewing fit into the updated model. Importantly, Hayes (2012a) explained that the intent of both the original and current models has been to determine how different sub-processes of the larger writing process interact to complete a

writing task. The original planning component is essentially now integrated into the goal setting component of the updated model. Additionally, the process of reviewing and revision is no longer considered a separate process, but rather a specialized application of the writing model. Revision involves detecting a problem in the text, diagnosing the nature of the problem, and determining how to solve it. The translator then formulates the language needed and writes the words replacing the original text.

Summary. The cognitive process theory of writing (Hayes & Flower, 1980a, 1980b; Flower and Hayes, 1981; Hayes, 1996; Hayes, 2012a, 2012b) provides a viable and well-established theoretical framework for discussing and investigating the writing process. Hayes' (2012a) updated cognitive processes model of writing now represents revision as a specialized application. That specialized application involves detecting problems in text, diagnosing them, and determining solutions to propose to the translator to transform into language for the transcriber to write into the text. This refinement to the original model more specifically captures what happens during revision. As such, it informs the design of interventions targeting revision behavior and provides a framework for evaluating how and to what extent such interventions prove efficacious for improving revision behavior.

Because the role of development is an important consideration when designing interventions, the next section discusses cognitive developmental theory and how it relates to the primary theoretical framework, cognitive process theory.

Cognitive Developmental Theory

Writing processes mature and become more refined through childhood and adolescence into adulthood (Bereiter & Scardamalia, 1987; Kellogg, 2008). In typical

development, writers become more efficient at allocating cognitive resources to higher level writing tasks as skills like handwriting and spelling become more automatic with age and schooling. Bereiter and Scardamalia (1987) explained how developing writers progress through stages referred to as knowledge-telling (writing to tell what you know) to knowledge-transforming (writing to transform what you know to present to the reader). Expanding upon Bereiter and Scardamalia's (1987) work, Kellogg (2008) proposed that very experienced, skilled writers may eventually reach a stage he called "knowledge-crafting" (Kellogg, 2008, p. 4) as expert or professional writers.

Kellogg (2008) illustrated important differences between the knowledge-telling and knowledge-transforming stages. Knowledge-telling means writers simply state their own thoughts and ideas without considering audience, genre, or purpose for writing. Knowledge-transforming, in contrast, is characterized by a more mature use of planning, translating (i.e., thoughts into written language) and reviewing processes with purpose and audience in mind. For example, writers in the knowledge-transforming stage read over (review) and revise the TPSF (Hayes, 2012b).

Relevance to the current study. Cognitive developmental theory provides a context within which to discuss typical writing, and within which to consider the cognitive processes underlying writing that Hayes and Flower (1980a, 1980b) and Hayes (1996) proposed in their writing model based on cognitive process theory, and Hayes' (2012a) updated version of the model. Recognizing writers as demonstrating knowledge-telling or knowledge-transforming characteristics (Bereiter & Scardamalia, 1987; Kellogg, 2008) within a developmental cognitive perspective should inform the design of interventions for revision. Because writers in the knowledge-telling stage may not

effectively transform their content knowledge with the audience in mind (Bereiter & Scardamalia, 1987; Kellogg, 2008), interventions targeting revision for these writers should aim to support that skill.

As studying revision requires an understanding of the cognitive processes implicated in writing, the following section reviews research describing how cognitive processes are involved in the writing process.

Cognitive Processes Implicated in Writing

Writing processes depend heavily upon activation of interrelated yet separable cognitive domains (Berninger & Richards, 2012; Olive, 2012). Cognitive writing research for the past 30 years has focused on investigating how attention, working memory, executive functions and self-regulation are involved in planning, translating and reviewing processes (Berninger, 2012; Graham & Harris, 2012; MacArthur, 2012; Olive, 2012). This section describes the role of cognitive domains in typical writing for comparison with impaired cognitive processes after brain injury, discussed in the subsequent section.

Attention and working memory. A number of experimental studies have helped elucidate the role of both verbal and visuospatial working memory in the writing process, and the components of working memory implicated in writing. For example, using Baddeley's (2002) well known model of working memory as their theoretical framework, Vanderberg and Swanson (2007) examined components of working memory involved in writing processes. In an effort to determine the role of working memory in predicting writing abilities, they administered a standardized writing test, an expository essay writing task, and a battery of working memory measures to 160 high school students. For

the writing task, they measured essay quality using a 5-point rubric, planning using a 5-point rubric, essay components, revision (i.e., product after 30 minutes allotted for revision; not type and number of revisions), and syntax (i.e., number of clauses and complexity of clauses in the first 100 words written). Confirmatory factor analyses supported three highly correlated components of Baddeley's model (i.e., phonological loop, visuospatial sketchpad, and central executive) as expected. Results indicated that only the central executive component of WM predicted planning, translating and revision macro-structure components of writing. Results also revealed that the central executive predicted micro-structure components of writing (e.g., grammar, spelling, vocabulary and punctuation). Vanderberg and Swanson's (2007) findings align with cognitive process theory of writing, supporting the complex role of working memory in writing processes.

In an effort to clarify the role of verbal, visual and spatial working memory in the writing process, Olive, Kellogg and Piolat (2008) conducted two experiments. In the first, undergraduates completed verbal, visual and spatial tasks alone and while writing argumentative essays. The researchers measured number of arguments, essay quality, and accuracy and response time for concurrent tasks, finding slower writing fluency in concurrent conditions and with more arguments produced in the no-task condition. Writing fluency was better in the spatial than in the verbal condition. Quality was reported as equal across conditions. The authors concluded that writing primarily taps verbal and visual working memory, and that spatial working memory is minimally involved. Olive and colleagues (2008) replicated their first experiment rule out presentation modality as a confound. Task accuracy was lower in a verbal condition, but unchanged in a spatial condition. They concluded that the writing process makes high

demands on both verbal and visual working memory, but fewer demands on spatial working memory.

In related research, Le Bigot, Passerault and Olive (2009) investigated undergraduates' memory for location of words in text in two experiments. In the first, writers wrote a one-page text offering pro and con arguments on one of two topics without knowing they would be asked to recall words from the text after writing. After participants finished writing, a template was placed over the text produced to separate the page into nine sections. A researcher then said nine words aloud to be located in each section of the text. Participants wrote each of the nine words on a separate blank sheet of paper in the locations where they recalled writing the words in the original text they composed. In the guessing condition, participants simply guessed the location of nine words an experimenter read aloud taken from other participants' texts. The researchers compared simulated recall scores to scores in production and guessing conditions. In a second experiment, undergraduate writers recalled location of words from a text written while completing concurrent verbal and visuospatial tasks. Responses from concurrent tasks were compared to responses from a no-task condition. Given results from both experiments, Le Bigot and colleagues (2009) found that writers located words from text at a level better than chance after writing a text, and that memory for words location in text was supported by mental representation of the text. They found lower recall of word location in text when completing a visuospatial task while writing, but better recall of words location when participants completed a verbal concurrent task. They concluded that completion of a concurrent visuospatial task while composing, disrupted recall of words location, suggesting that visuospatial text representation supports memory for

words location in written text, thus implicating spatial working memory in the writing process.

The findings of these two groups of researchers are mutually supportive. Le Bigot and colleagues' (2009) extended the findings of Olive and colleagues (2008), adding evidence supporting the notion of visuospatial representations of text as important to the writing process. Given results of their two experiments, Olive and colleagues (2008) concluded that writing essays makes greater demands on verbal working memory and visual working memory, but fewer demands on spatial working memory. Le Bigot and colleagues' (2009) concluded that visuospatial text representation supports memory for words location in written text given evidence that completing concurrent visuospatial tasks while composing disrupted recall of words location in text. These studies help to clarify the relative roles of verbal, visual and spatial working memory in the writing process. Kellogg (2008) also noted how working memory heavily in writing. He highlighted the importance of working memory to the knowledge-transforming stage of writing, emphasizing the slower maturation of working memory.

Overall, the research reviewed above illustrates the substantial role of verbal, visual and spatial aspects of working memory. Experimental findings suggest that minimizing demands on working memory to support allocation of cognitive resources while writing should be considered when developing interventions for struggling writers.

Executive functions. Both education and cognitive science researchers have discussed the role of executive functions in writing. Graham, Harris and Olinghouse (2007) defined executive functions as "conscious, purposeful, and thoughtful activation, orchestration, monitoring, evaluation and adaptation of strategic resources, knowledge,

skills and motivational states to achieve a desired goal (p. 217).” Coordination and flexible application of cognitive resources for analysis, decision-making, and planning is involved in completing writing tasks (Graham et al., 2007). Deficits in these abilities adversely impact planning, translating and reviewing.

Kellogg (2008) also emphasized the role of executive functions for orchestrating planning, translating and reviewing processes to self-regulate writing, proposing “cognitive apprenticeship” (Kellogg, 2008, p. 19) as an approach for helping writers build and advance their skills. He described the approach as involving guided participation with the help of an individual serving as a coach or mentor. Citing Vygotsky’s (1978, as cited in Kellogg, 2008) well-known research with the zone of proximal development, Kellogg described social learning as providing writers a supportive context wherein they can expand upon existing skills to progress toward a more advanced level, given instructive feedback and deliberate practice in self-regulation of writing.

Self-regulation of writing. Self-regulation of writing has been heavily researched in the cognitive science and social cognitive writing literature over the past three decades (Boekaerts & Rozendaal, 2007; Ferrari, Bouffard & Rainville, 1998; Graham & Harris, 1997; Graham & Harris, 2000; Graham & Harris, 2012; Harris, 1990; Kaplan, Gorodetsky & Lichtinger, 2009; Kaplan, Lichtinger & Margulis, 2011; Zimmerman & Kitsantas, 2002; Zimmerman & Risemberg, 1997). Early social cognitive theoretical work with self-regulation in writing aimed to account for different aspects of self-regulation, with particular relevance to writing performance (Graham & Harris, 1997; Graham & Harris, 2000; Harris, 1990). For example, Graham and Harris (2000) reviewed

experimental studies of self-regulated writing, concluding that research supported four predictions they had made about self-regulation of writing. First, they predicted that skilled writers are more self-regulated than less-skilled ones. Secondly, they predicted that developing writers improve ability to self-regulate with age. Third, self-regulation differences predict individual differences in writing. Fourth, they predicted that instruction in strategies for self-regulating writing should improve writing performance for both developing and struggling writers.

A relevant model of self-regulated writing grounded in social-cognitive theory is that of Zimmerman and Risemberg (1997). Their three-part model included environmental processes, or self-regulation of physical and social settings; behavioral processes for self-regulating motor activity in writing; and personal processes comprised of beliefs and affective states related to writing. Reciprocal relationships among environmental, behavioral and personal processes, as well as beliefs about self-efficacy and performance characterize the model. The authors explained that a writer's self-efficacy—their ability to plan and carry out writing tasks to achieve a desired level of performance—underlies the three components of the model (Zimmerman & Risemberg, 1997). A critical instructional implication associated with the model is the use of self-monitoring and a personal feedback loop through which writers engage their metacognition as they learn to self-regulate the writing process (Zimmerman & Risemberg, 1997). Zimmerman and Risemberg (1997) described their self-regulatory model of writing as focused on *performance*, distinguishing it from the cognitive processes model of Hayes and Flower (1980a) that Zimmerman and Risemberg (1997) claimed was more focused on writing *competence.*

Generally supportive of the model, Graham and Harris (1997) pointed out four caveats relative to the Zimmerman and Risemberg (1997) model. First, they observed that other theoretically based descriptions of self-regulation are possible. Second, they noted that the role of self-regulation in writing may be more modest than emphasized in the model. Third, they held that successful writing performance requires not only self-regulation, but also domain-specific knowledge, strategy knowledge, and motivation. Finally, they observed that self-regulation will not always be successful, as self-regulated efforts may produce a product that fails to respond to the writing task in question.

The Zimmerman & Risemberg (1997) model of self-regulation in writing can be reconciled with the cognitive process model of writing, and with Hayes' (2012a) ideas on task schemas for revision, individual differences in carrying out writing tasks, and the important role of motivation in writing. Self-regulation is only one of the skills required for proficient writing. Graham and Harris (1997) noted that it is possible to effectively self-regulate performance on a writing task but still fail to produce a quality written product. Being able to self-regulate successfully, they added, is not sufficient for producing quality writing that successfully addresses the expectations of the task. Fully responding to a rhetorical problem also requires knowledge of task schemas for how to produce writing that a given audience can understand and appreciate (Hayes, 2012b). Knowing whether the message will be received successfully requires that the writer understand audience expectations, which in turn demands transforming knowledge to meet those expectations (Kellogg, 2008). Beyond self-regulation, efficient and effective management of the multiple constraints (Hayes & Flower, 1980b) involved in completing a complex writing task requires both working memory (Kellogg, 2008) and motivation

(Hayes, 2012a), or a purpose for engaging the task (Kaplan, Gorodetsky & Lichtinger, 2009; Kaplan, Lichtinger & Margulis, 2011).

The cognitive process model of writing (Hayes & Flower, 1980a; Hayes, 1996; Hayes, 2012a) can account for self-regulatory processes as modeled by Zimmerman and Risemberg (1997). The personal processes component of the Zimmerman and Risemberg (1997) model refers to how individual writers engage and manage writing tasks. Similarly, Hayes (2012a) described the monitor function included in the original cognitive process model as accounting for individual differences among writers, and pointed out the importance of knowledge of task schemas for revision. Of note, motivation, goal-setting and task schemas for writing are all accounted for at the control level of the updated cognitive process model (Hayes, 2012a). The task environment (Hayes & Flower, 1980a, Hayes, 2012a) component of the cognitive process model accounts for environmental processes (Zimmerman & Risemberg, 1997) external to the writer that the writer must manage when carrying out a writing task, including audience, materials and TPSF (Hayes, 2012b). Zimmerman and Risemberg (1997) described behavioral self-regulation as "adaptive use of a motoric performance strategy (p. 78)." They further described behavioral processes for self-regulation as including self-monitoring to track performance during writing, self-consequences such as offering oneself rewards for completing a writing task, and self-verbalization to aid the writing process. The cognitive process model partially accounts for these behavioral aspects of self-regulation in that the transcriber process represents online production of written text, and motivation and goal-setting are included in the model at the control level (Hayes, 2012a). Essentially, all components included in Zimmerman and Risemberg's (1997)

model of self-regulation in writing are identifiable to some degree in Hayes' (2012a) updated cognitive process model. While Zimmerman and Risemberg (1997) indicated that Hayes' & Flower's (1980a) original cognitive process model was more competence- than performance-oriented, Hayes' (2012a) updated model serves to adequately explain writing performance as well as competence.

Knowledge of task schemas, as well as the provision of models and feedback may also influence self-regulation of writing. For example, Ferrari, Bouffard and Rainville (1998) asked good and poor college writers to complete an expository writing task. They measured time spent before starting to write, activity during pauses, final revision to text, and time spent writing, and analyzed final written texts for surface changes, revisions to text structure, changes to form and content, and use of comparative discourse. They found that poor writers introduced more errors into their writing, while good writers exhibited better knowledge of text structures. The authors suggested that good writers may possess better rhetorical and linguistic knowledge and may more carefully consider audience perspective. Implicit in this observation is that examining writers' knowledge of task schemas (Hayes, 2012a; Wallace & Hayes, 1999) may be one key to understanding differences between competent and struggling writers. In a study of modeling and feedback for self-regulated writing, Zimmerman and Kitsantas (2002) examined how modeling and social feedback influenced performance on a revision task for undergraduate writers. Writers who observed a coping model demonstrate gradual improvement on completing a sentence-combining revision task performed better on measures of self-regulation and writing skill than those exposed to a mastery model. Also, writers observing a mastery model performed better than writers in a no-model

condition. The authors reported that social feedback during performance assisted writers in all groups to acquire self-regulation and writing skills.

Summary. Cognitive writing research has linked working memory and executive functions to processes important to the self-regulation of complex writing tasks, and has emphasized the role of both motivation and knowledge of task schemas for writing. Research reviewed in this section highlights the crucial role cognitive processes play in writing, making it important to recognize how impairments in cognition might interfere with individuals' ability to carry out complex writing tasks, and to effectively carry out revision during the writing process.

The following section explains how attention, working memory, executive functions and self-regulation are impaired after brain injury, and describes the impact of impaired cognitive processes on academic performance.

Cognitive Processes Impaired After ABI

People with ABI commonly present with cognitive impairments in attention, working memory, and executive functions (Anderson, 2002; Conklin, Salorio & Slomine, 2008; Kennedy et al., 2008; Sohlberg & Mateer, 2001; Sohlberg & Turkstra, 2011). They experience difficulty self-regulating academic tasks (Sohlberg & Turkstra, 2011; Ylvisaker et al., 2001) and challenges keeping up with the academic demands of college (Kennedy, Krause & Turkstra, 2008; Stewart-Scott & Douglas, 1998). Frontal lobe injuries adversely impact working memory and metacognition (Anderson, 2002; Kennedy & Coelho, 2005; Sohlberg & Mateer, 2001; Sohlberg & Turkstra, 2011). Understanding the academic struggles people with brain injury face requires an understanding of the

cognitive processes impaired after brain injury, and how those impaired processes impact performance.

Attention and working memory. Attention and working memory impairments are common after ABI (Sohlberg & Mateer, 2001; Sohlberg & Turkstra, 2011; Ylvisaker, 2001). People with attention deficits after ABI exhibit difficulty with focusing and sustaining attention, selectively attending to relevant information while suppressing irrelevant stimuli, and alternating, or switching, their attention among stimuli within a task environment (Sohlberg & Mateer, 2001). In addition, working memory deficits make it difficult for individuals with ABI to hold information in mind long enough to manipulate it and act upon it for an intended purpose (Sohlberg & Mateer, 2001; Conklin et al., 2008). Working memory is important for managing newly received information, manipulating it for transfer into long-term storage as well as for later retrieval when needed. Working memory functions are critical for the selection and organization of information from long-term storage to be used during the production of complex academic tasks like writing.

Executive functions and self-regulation. People with ABI present with impairments to executive functions that adversely affect performance on academic tasks (Hibbard et al., 2001; Ylvisaker, 2001). Impaired executive functions interfere with self-regulation of routine and academic tasks, impacting ability to set and work toward goals (Kennedy et al., 2008; Kennedy & Coelho, 2005). Deficits in goal-setting, initiation, planning, organizing, and shifting among tasks frequently present challenges for students with ABI (Ylvisaker, Hibbard & Feeney, 2007). Self-regulation has been described as "a set of dynamic relationships between metacognitive beliefs and knowledge, ongoing self-

monitoring or self-assessment during activities, and self-control" (Kennedy & Coelho, 2005, p. 242). Kennedy & Coelho (2005) further characterized self-regulation as involving dynamic relationships among metacognition, self-monitoring, self-control, and strategy execution in the context of activities. Ylvisaker, Hibbard and Feeney (2007) described the impact of impaired self-regulation in students with brain injury. They observed that students with brain injury have difficulty with initiating activities, setting goals, monitoring and evaluating their performance, thinking and acting strategically, problem-solving, and shifting among activities, thoughts or strategies. These challenges adversely affect academic performance, including writing.

Summary. Cognitive domains impaired after brain injury are the same cognitive domains writers heavily depend on and frequently tap during the writing process. The interrelated yet separable cognitive domains of attention, working memory, executive functions and self-regulation are critical for completing complex academic tasks like writing. Impairments to any of these functions following brain injury have the potential to interfere with planning, coordinating and executing the sort of dynamic, goal-directed activity that characterizes the writing process.

The following section aims to describe the types of challenges writers with ABI face, and to explain how impaired cognitive processes may impact components of the cognitive process model of writing (Hayes & Flower, 1980a, 1980b; Hayes, 1996; Hayes, 2012a)

Writing Challenges in ABI

There is a paucity of empirical data about writing performance after brain injury. Understanding factors contributing to writing difficulty must presently rely on knowledge

of cognitive impairments and how such impairments may logically be expected to disrupt the writing process. Working memory and executive functions are cognitive processes heavily involved in writing (Berninger, 2012; Kellogg, 2008; Olive, 2012; Vanderberg & Swanson, 2007). Deficits in these domains would be likely to negatively affect writing processes for writers with ABI. Additionally, writers must activate executive functions for initiating, planning, organizing, generating and revising while writing (Graham, Harris & Olinghouse, 2007; Olive, 2012), making it logical that writers with ABI would experience difficulty during the writing process.

Experimental research. A search of the University of Oregon Libraries' databases using the key words "brain injury," "TBI," and "writing" yielded only a single study describing how writing is impacted after brain injury. In that study, Wheeler, Nickerson, Long and Silver (2014) examined components from different measures of text to characterize expressive writing disorders for writers with learning disabilities (LD) and TBI using principle components analysis (PCA). Other aims of their study were to examine whether the two populations differed on identified components, and to identify cognitive predictor variables for expressive writing disorder (EWD). Participants were 28 adults with TBI a documented coma of at least two weeks and no history of LD, and 28 adults with a documented history of LD with an Individual Educational Plan (IEP) in their school history. Average full scale IQ reported was 92-93 for both groups. Previously collected 10-minute paragraph-writing samples were analyzed using a computer software package called RightWriter to determine level of expressive writing skill. The software was reported to analyze for total words, grammatical errors, the Flesch-Kincaid index of readability, converted to standard scores for comparison to participants' Wechsler Adult

Intelligence Scale scores from prior testing. The authors described using the difference between scores on the two measures to determine a written language index, with negative scores suggesting expressive writing disorder when compared to intellectual ability. The PCA results suggested that four components from text measures characterized EWD for both populations under study: reading ease, sentence fluency, grammar and spelling, and paragraph fluency. They reported no significant difference between the TBI and LD groups on components identified through PCA, suggesting that writers with TBI may experience challenges similar to those of writers with LD. They reported that neuropsychological measures of spatial perception, visual memory, verbal intelligence, and working memory were the best predictors of writing skills for both groups. The authors recommended intervention focused on setting goals for writing, as well as "general academic skill training" (Wheeler et al., 2014, p. 35). The researchers' findings suggested that working memory was a notable predictor of writing skills for writers with both LD and TBI, which is consistent with research on working memory in writing (e.g., Vanderberg & Swanson, 2007). Their recommendation that intervention focus on setting goals for writing is consistent with components of approaches like SRSD (Harris & Graham, 1999) and instructional recommendations for using the approach (Mason & Graham, 2008), as well as with recommendations for self-regulation instruction after brain injury (Kennedy & Coelho, 2005).

While Wheeler and colleagues (2014) completed the only experimental study of writing after brain injury, it should be noted that at least one review from the pediatric brain injury literature has referred specifically to writing difficulty as one of the many challenges students may experience when returning to school after injury (Savage,

DePompei, Tyler & Lash, 2005). Together, the small amount of research pointing to difficulty with writing after brain injury is important because it supports the existence of writing challenges in the ABI population. Further experimental research is needed to document writing difficulty after ABI.

Clinical observations. In spite of the lack of formal research documenting writing difficulties for college students with ABI, clinical observations point to writing difficulties in the population. Observations in the context of studies with purposes indirectly related to academic writing elucidate challenges of writers with ABI. For example, in a study piloting an e-mail program for supporting people with brain while using e-mail, researchers observed participants to experience challenges with the writing process while writing email messages (Sohlberg, Ehlhardt, Fickas, & Sutcliff, 2003). Writers in that study presented much difficulty detecting repeated sentences and missing text when writing, and difficulty generating messages. Other problems included omitted message components, missed details, and failure to review. Such errors map to difficulty with planning, translating, and reviewing described by Hayes and Flower (1980a, 1980b). Findings offer support for the need to develop interventions for writing targeting revision behavior for writers with ABI.

Given the known involvement of attention, working memory, executive functions and self-regulation in the writing process (Olive, 2012; Kellogg, 2008) and the known deficits people with ABI experience in these cognitive domains (Hibbard et al., 2001; Kennedy & Coelho, 2005; Ylvisaker, 2001) it is reasonable to conclude that such impairments adversely affect the planning, translation and reviewing processes of writing in individuals with ABI.

Writing Intervention for ABI and LD

Numerous writing intervention studies have focused on empirically evaluating strategy instruction approaches for improving the writing of school-aged, adolescent writers (Cook & Bennett, 2014; De Smet, Brand-Gruwel, Leijten, & Kirschner, 2014; Gillespie & Graham, 2014; Graham & Perin, 2007; Mason & Graham, 2008; Rogers & Graham, 2008; Taft & Mason, 2010). Self-regulated strategy development (SRSD; Harris & Graham, 1999) is one of the most heavily researched, evidence-based interventions for struggling school-aged writers, with multiple experimental studies and meta-analyses documenting its effectiveness (Gillespie & Graham, 2014; Graham & Perin, 2007; Mason & Graham, 2008; Rogers & Graham, 2008; Taft & Mason, 2010). While few investigations of strategy instruction have included college students or adults, a limited number of studies with positive findings have been reported. In one such study, Stoddard and MacArthur (1993) instructed middle school students in use of peer-editing strategies for revision. Analyzing revisions using a taxonomy developed by Faigley and Witte (1981), Stoddard and MacArthur (1993) found an increase in the number of revisions improving quality of the final text following instruction. Additionally, Berry and Mason (2010) found a functional relation between SRSD instruction and improved expository writing for four adults with writing difficulties preparing for the General Educational Development® test (GED® Testing Service, 2012).

Although no intervention studies have examined writing intervention for individuals with ABI, SRSD (Harris & Graham, 1999) is comprised of instructional components which, when properly implemented (Mason & Graham, 2008), align with components of self-regulation instruction for people with brain injury. Kennedy and

Coelho (2005) characterized self-regulation as involving dynamic relationships among metacognition, self-monitoring, self-control, and strategy execution in the context of activities, defining self-regulation as "a set of dynamic relationships between metacognitive beliefs and knowledge, ongoing self-monitoring or self-assessment during activities, and self-control (p. 242)."

Explicit teaching of procedures for goal setting and self-monitoring, along with scaffolding, guided practice, use of customized strategies and provision of support to facilitate generalization and maintenance are all recommended for improving the self-regulation of writing tasks (Mason & Graham, 2008). Other authors have made similar recommendations. For example, Kennedy and Coelho (2005) recommended instructing individuals with ABI in self-regulation of learning by ensuring accurate internal feedback (self-monitoring); training accurate self-feedback for strategy decisions; explicitly teaching the connections between self-monitoring and strategy use; and providing frequent practice of strategies across varied contexts and conditions. Consistent with support from meta-analyses and systematic reviews, cross-population data reviewed above support use of SRSD as an evidence-based intervention approach for individuals with ABI who struggle with writing.

The following section reviews relevant literature to define revision, present revision models, describe revision measurement, and discuss factors influencing revision. The section also identifies components of intervention approaches potentially applicable to intervention with writers with brain injury.

Revision: A Potential Key for Helping Writers with ABI

Revision is clearly important to producing quality writing, and has already

received a fair amount of attention from researchers. However, intervention to improve writing revision in the brain injury population has yet to be investigated. This section reviews relevant literature to present a definition and model of revision, to highlight factors influencing revision, to describe how revision has been measured, and to identify instructional components useful in revision intervention.

Defining and measuring revision. Research on revision has focused on examination of both the effects of revising and the possible reasons for writers' decisions to revise (Faigley & Witte, 1981). Compelled by the need for a way to classify revision changes and their effects, Faigley and Witte (1981) reviewed earlier literature on revision and proposed what they described as a "simple, yet robust, system for analyzing the effects of revision changes on meaning (p. 401)." Their resulting taxonomy of revision changes, which they tested in two studies (Faigley & Witte, 1981), subsequently became widely cited and used (e.g., Bonk & Reynolds, 1992; Daiute, 1986; Hayes et al., 1986; Stoddard & MacArthur, 1993), and remains a resource for measurement in revision research (e.g., Crawford, Lloyd & Knoth, 2008; Myhill & Jones, 2007).

Faigley and Witte (1981) based their taxonomy on the distinction that some revisions affect meaning while others do not. For example, *surface changes* are those changes that do not add or remove content from the text. In contrast, *meaning changes*, also known as *text-based changes*, refer to adding or removing information to change the meaning of the text (Faigley & Witte, 1981). Either broad type of revision change (surface changes or meaning changes) can be classified as one of six different specific types of revision (Faigley & Witte, 1981). *Additions* refer to any content added to the text. *Deletions* refer to content removed from the text. *Substitutions* consist of replacing

content with different content. *Permutations* involve rearranging elements of text. *Distributions* refer to instances of breaking apart single units of text into two or more units. *Consolidations* consist of combining two or more units of text into a single unit. Additions, deletions, substitutions, permutations, distributions and consolidations are considered text-based, meaning-changing revisions if they alter the meaning of either the *microstructure* or *macrostructure* of the text. In contrast, these six specific revision types are considered surface changes whenever they do not result in alterations to the meaning of the content revised (Faigley & Witte, 1981)

Macrostructure changes involve substantial revisions to the larger structure of the text, such that were one to summarize the text, the summary would change as a result of any revisions to macrostructure (Faigley & Witte, 1981). An example of a macrostructure change could be rewriting paragraphs based on alterations to a thesis statement; such a change would alter the summary of the work. *Microstructure change*s operate at a smaller scale in that they only alter the meaning of smaller portions of text, but would not result in a need to summarize the text differently (Faigley & Witte, 1981). An example of a microstructure change could be the addition of a supporting sentence to back up the main idea of a paragraph. Such an addition would clarify or elaborate on existing content, but not to the point of altering a summary of the written work.

Faigley and Witte (1981) reported on two studies they conducted to analyze and compare the revisions of six inexperienced undergraduate writers, six advanced undergraduate writers, and six expert writers using the taxonomy described above. They recruited the inexperienced writers from a writing lab intended for struggling writers, and the advanced writers from an upper level elective expository writing class known to

attract stronger writers. Expert writers were professional writers in the community with journalism experience. They conducted the study over three days. On the first day, they gave writers a topic asking them to describe a location in the city unfamiliar to readers from out of town for publication in a local paper. They asked writers to think about the topic and make notes if desired. On the second day, writers wrote the essays for the assigned topic. The authors collected and photocopied the essays and used the taxonomy to analyze changes writers made while writing. On the third day, they returned first drafts to the writers so they could then write a second draft. The authors then collected and analyzed the revisions changes to both drafts, reporting the use of different colors of ink to distinguish day 2 from day 3 revisions. They found that skilled writers regularly reviewed their written text to identify needed changes and make revisions while writing, whereas inexperienced writers were less likely to make text-based changes and instead focused mainly on surface edits (Faigley & Witte, 1981).

MacArthur (2012) indicated that most researchers operate within a broad definition of revision, including considering revision as changes that can occur in the mind during the planning stage before starting to write the text (Hayes & Flower, 1980b), not just on the page. For example, in work on cognitive processes in revision, Hayes, Flower, Schriver, Stratman, and Carey (1987) proposed an operational model of revision, defining revision as a goal-directed problem solving process for evaluation, strategy selection and making changes to text. Hayes (2012a) presented and discussed a redrawn version of the model, depicted in Figure 3.

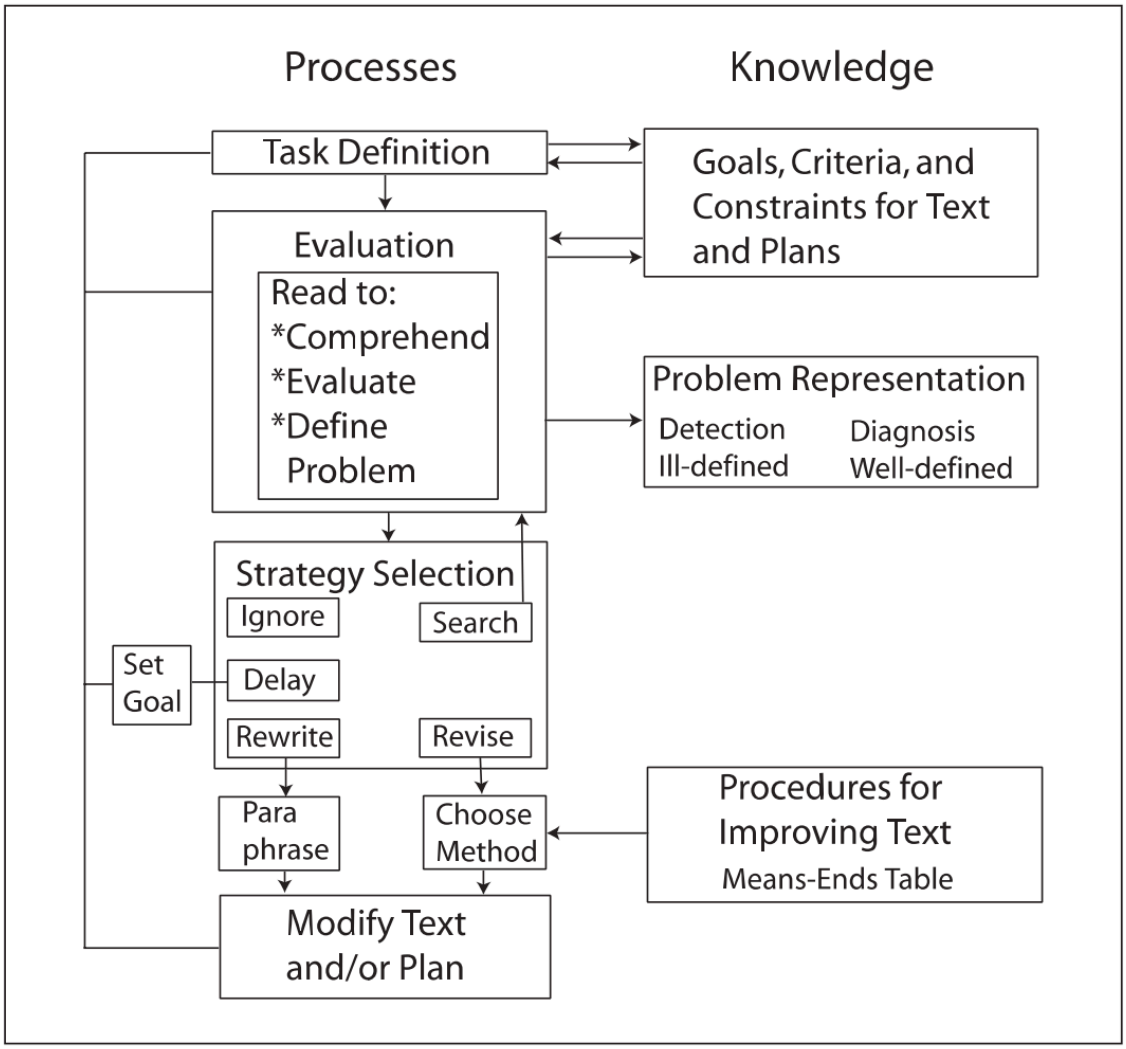

Figure 3

A Model of Revision (Hayes, 2012a)

A model of revision. The revision model presented in Figure 3 represents revision components that align with the broad definition of revision described by MacArthur (2012). The model accounts for both detected and diagnosed representations of a writing problem that writers could aim to resolve either through rewriting or through selecting revision strategies, represented in the model as a "means-ends table" (Hayes et al., 1987, p. 24; Hayes, 2012a, p. 374). The strategies a given writer opts to use for

revision may depend to some extent on the writer's task schema (Wallace & Hayes, 1991; Hayes, 2012a) for the writing problem. Writing schemas are represented in the updated cognitive processes model for writing as part of the control level (Hayes, 2012a; see Figure 2). Of note, Hayes (2012a) indicated that individuals' writing schemas can be modified through instruction. Thus, an important aim of interventions designed for targeting revision would be to provide the writer access to explicit instructions for detecting and resolving diagnosed problems in the TPSF (Hayes, 2012b).

Factors affecting revision. Several researchers investigating cognitive processes in writing have stressed the importance of revision in the writing process (Flower, Hayes, Carey, Schriver & Stratman, 1987; Hayes, 2012a; MacArthur, 2012; Wallace & Hayes, 1991). MacArthur (2012) identified a variety of factors influencing revision processes. He cited contextual factors, including task, audience, and goals, and noted the need to consider other writing processes.

Regarding the task of revision, Wallace and Hayes (1991) found that the way in which writers define the task of revision influences the quality of revisions. Moreover, training in defining revision tasks leads to improved quality of the final text (Wallace & Hayes, 1991). MacArthur (2012) advised studying revision in relation to its effects on quality of final written product, stressing that more revision will not always result in a better final product. He added that researchers should examine revision at word, sentence, and paragraph levels, and in relation to other processes (MacArthur, 2012). Finally, MacArthur (2012) advised consideration of individual factors, including revision schema, content knowledge, and goals. Individual differences among writers in terms of how they revise will be discussed in the following subsection.

Revision process differences among writers. How writers engage the process of revision varies to some extent by writer according to style and preference (Galbraith, 1996; Hayes, 2012a; MacArthur, 2012). At least two approaches to revising exist. In the first, writers with a preference for freewriting tend to write to explore ideas first, and may revise multiple drafts (Galbraith, 1996). It could be that time constraints may limit writers who prefer that style, putting them at a disadvantage when timed (e.g., as with the SAT writing test). In a different approach to revision, writers demonstrate the use of an automatic editing style, which Hayes (2004, as cited in MacArthur, 2012) described as "reflective review of larger segments of text (p. 477)." Also, revisions can occur during the planning stage before starting to write the text (Hayes & Flower, 1980a), and style differences could conceivably impact that sort of revision behavior. The role of the TPSF (Hayes, 2012b) is also of interest in terms of how writers interact with it during revision. Hayes (2012b) explained that Kaufer, Hayes and Flower (1986) found that adult writers interact with the TPSF while writing, and observed that the TPSF helps generate ideas and make associations with previously written content, suggesting that the TPSF plays a role in revision behavior. These points may be especially important for writers with impaired cognitive processes. Studies of revision should aim to consider writer preference and style when aiming to answer research questions about revision. Completing interviews or questionnaires with writers to gather data about preference and style could be useful for that purpose.

Intervention for revision. Evaluation and revision are important components of a cognitive theoretical perspective, and revision is an important target for writing instruction (Hamman, 2005; MacArthur, 2012; Myhill & Jones, 2007). Yet little research

has focused primarily on improving revision. Given that, some of the studies reported in this section are studies of high school or middle school writers. The purpose of reviewing these studies is to evaluate whether aspects of the approaches could be integrated into computer-based interventions focused on improving revision behavior.

In early work that serves as a foundation for research on revision intervention, Bereiter and Scardamalia (1983) described a strategy called "compare, diagnose and operate." The purpose of the strategy was to improve revision by teaching writers to review their text for problems, determine how to resolve the problem, and to carry out revisions to fix the problem. A few years later, Hayes and colleagues (1987) described how writers detect, diagnose and select strategies for revising problems in their writing.

When asked to revise, inexperienced college writers tend to make surface edits rather than strategic revisions to the larger text structure at a global level, a problem that Hayes (2012a) suggests can be addressed through directly targeting how these writers view revision. Brief, targeted instruction in the specifics of how stronger writers go about revising to improve text quality may be a viable and efficient means of helping college writers improve their academic writing skills. For example, Wallace and Hayes (1991) tested the effect of task definition on the revising behavior of first-year undergraduate writers. They provided 8 minutes of instruction to one group of first-year undergraduate writers, and simply asked the other group to make the text better. Writers in the experimental group produced significantly better quality text and significantly more global revision. Findings suggest that writers' task schema knowledge for how to carry out revision is modifiable through targeted instruction. This work is important to research focused on developing interventions for improving revision because it suggests that

minimal amounts of targeted instruction in how to revise can quickly result in marked improvements to text quality.

Instructional components. MacArthur (2012) observed that inexperienced and developing writers engage in little revision behavior, which consists primarily of surface changes. Further, asking these writers to simply complete more revisions may not lead to improved quality of the final product. Improving revision requires instruction and guidance on how to evaluate and solve writing problems (MacArthur, 2012). Instructing writers to evaluate and solve problems in their writing, according to MacArthur (2012), should involve teaching evaluation criteria along with practice in applying it, which can be taught effectively through strategy instruction. Given that willingness to write and revise depends at least to some degree on motivation (Hayes, 2012a), it would also be important for instruction to address motivation and purpose for engaging in writing tasks.

Other authors have recommended instructional components for inclusion in intervention to improve revision behavior. The recommendations are generally consistent with MacArthur's (2012) recommendations for revision instruction as well as Hayes' (2012a) emphasis on motivation. For example, in a study of writing beliefs, self-regulatory behaviors, and epistemology beliefs of student teachers, Hamman (2005) reported findings of a positive relationship between enjoyment of writing and perceived learnability of it, as well as between writing enjoyment and writing self-assessment. In follow-up analyses, she found that students who considered writing less learnable also reported beliefs in fixed ability and that learning should happen quickly. Interestingly, she also found that students reporting higher writing enjoyment reported greater levels of self-regulation. Importantly, the author reported a relationship between knowledge of

cognition and belief in fixed ability, suggesting that those less knowledgeable of cognitive processes may be less inclined to believe that they can improve their writing ability. Hammann's (2005) instructional recommendations included obtaining information about writing experiences, learning behavior and beliefs; providing explicit instruction in strategies for self-regulating writing; and paying attention to the role of motivation in writing. Similarly, Myhill & Jones (2007) completed a qualitative study of comments high school writers made about their revision processes, finding that over half of the writers reported making no revisions, and nearly half reported revising for "making it better" or "sounding better (p. 332)." The authors made three instructional recommendations. First, they suggested thinking of revision as occurring throughout the writing process, rather than merely as making corrections to a completed draft. Second, they recommended focusing instruction on facilitating metacognitive understanding of revision processes. Finally, they encouraged engaging writers in explicit discussion of how text and language structures affect meaning in order to raise awareness of options available when revising.

Findings that over half of writers made no revision and nearly half were focused on revising to make general versus specific improvements (Myhill & Jones, 2007) are consistent with MacArthur's (2012) observation that less experienced writers make fewer revisions comprised mainly of surface changes. Because revising more in general will not necessarily improve quality of the final text (MacArthur, 2012), the recommendation to consider revision as a process rather than as post-hoc corrections to a draft (Myhill & Jones, 2007) is crucial to revision instruction. Importantly, research reviewed here points to a critical recommendation for explicit instruction in how to evaluate and solve

problems during writing by teaching and providing practice in how to apply evaluation criteria (Hamman, 2005; MacArthur, 2012; Myhill & Jones, 2007). These components of instruction seem especially relevant for writers who experience difficulty with the revision process related to uncertainty about how to effectively and efficiently engage it (Hamman, 2005; Myhill & Jones, 2007). Recommendations for facilitation of metacognition to raise awareness of revision processes and to teach strategies for making specific changes to text and language structures (Hamman, 2005; Myhill & Jones, 2007) may help struggling writers engage revision more effectively. Finally, addressing writers' beliefs about their ability to improve their writing, along with attending to motivation (Hamman, 2005), are consistent with Hayes' (2012a) recommendations to consider motivation, suggesting the need for interventionists to address purpose for engaging writing tasks. Of note, instructional recommendations reviewed in this section generally align with those for instructing self-regulation after brain injury (Kennedy & Coelho, 2005) and with instructional recommendations for the SRSD writing intervention approach (Mason & Graham, 2008) reviewed earlier.

To explore the degree to which instructional components have been integrated into computer-based approaches, the following section presents information on types of computer-based interventions for writing found in the literature, focusing specifically on how computer-based interventions have addressed revision.

A Case for Computer-Based Prompting for Revision

Studies of computer-based writing intervention consist of at least three types: 1) older studies from the 1980s and 1990s investigating whether simply writing using word

processing programs would affect the quality of students' written text; 2) studies of web-based writing environments investigating whether such systems positively affect text quality; and 3) studies of computer-based prompting or scaffolding programs. Because few intervention studies have focused on college students, studies including secondary school aged students are also reviewed in this section.

Word processing. Several studies in the 1980s and 1990s focused on the possible positive effects of word processing on writing quality, and word processing has been found in meta-analyses to have small to moderate effect sizes for improving writing (Bangert-Drowns, 1993; Graham & Perin, 2007). Word processing is now widely used for writing, but some of the early studies are notable for findings relative to revision. For example, Daiute (1986) investigated whether writers wrote more effectively using a computer word processor instead of a pen, and also examined whether use of the computer word processor was more effective than use of a revision prompting program. She found that writers using the revision prompting program engaged in better revision than those using only a word processing program. This positive finding lends support for the use of revision prompting to improve revisions, suggesting that specifically prompting revision is a useful component for inclusion in computer-based intervention.

Web-based and electronic writing environments. Opdenacker and Van Waes (2007) described the development and implementation of an online writing environment. In what the authors described as an "integrated writing environment (Opdenacker & Van Waes, p.252)," college writers engage in a recursive process of drafting and revising, either alone or in collaboration with peers, giving and receiving feedback about their reading. They are expected to integrate peer feedback into subsequent drafts, as well as to

document their own writing processes. The authors emphasized their intent to facilitate metacognitive understanding of the writing process by providing exposure to writing problems solved by experts and expert commentary on peers' writing, as well as videotaped think-alouds of peers solving writing problems.

In a study of electronic outlining, De Smet, Brand-Gruwel, Leijten and Kirschner (2014) examined organization of planning, translating and reviewing for two writing tasks for high school students. They found that electronic outlining improved argument structure, but no effect on overall text structure. While total processing time increased, how writers utilized planning and reviewing was unaffected. Repeated strategy use reportedly improved writing fluency. Interestingly, the authors reported greater numbers of revision on the second writing task, but did not report analysis of type or quality of revisions.

Automated feedback. In the first study evaluating whether automated feedback delivered through the use of Project Essay Scoring (PEG; Page, 1996, as cited in Wilson Olinghouse, & Andrada, 2014) improves writing quality, Wilson and colleagues (2014) examined improvements across multiple revisions (ranging from within an hour to across several days) in response to a writing prompt for writing samples ranging across genres (expository, narrative, and persuasive) from nearly 1000 writers in grades 4-8. They found that use PEG was associated with an improvement in writing quality, measured using the PEG overall score, with small gains documented across revisions. Noting the potential usefulness of automated feedback for writing instruction compared to earlier research, the authors also acknowledged limitations. An important limitation of automated feedback relevant for the proposed study is that automated feedback provides

task-level feedback instead of feedback targeting the writing process or strategy use. Automated feedback tends to focus on product instead of process, failing to provide specific, qualitative feedback (Vojak et al., 2011). Lack of feedback relative to the process of writing may be less useful for assisting writers in producing a quality final written product (Vojak et al., 2012). Moreover, intervention during the process has the potential to prevent problems in the final text, thus enhancing quality (Deane et al., 2012; Klobucar et al., 2012). Second, automated feedback, as Wilson and collegues (2014) observed, is constrained to feedback on surface aspects of text production (Vojak et al., 2012). Finally, MacArthur (2012) questioned the usefulness of that feedback to writers for helping them improve their writing. In summary, automated feedback is neither customized nor targeted to addressing complex processes struggling writers must harness in order to exercise strategic control and adjust their approach to produce quality final text (Deane et al., 2012; Klobucar et al., 2012). Design of computer-based intervention aimed at improving revision should therefore attempt to specifically address the process writers engage *while producing* a draft, rather than simply offering feedback to stimulate post-hoc corrections to a draft (Myhill & Jones, 2007).

Computer-based prompting. Few studies have examined computer-based prompting interventions for writing. Bonk and Reynolds (1992) used a generative-evaluative computer-based prompting intervention to investigate middle school writers written texts over a period of six weeks. The rationale for their study was that making writers aware of the link between generative and evaluative aspects through prompting of each aspect would result in better quality written product. Generative prompts targeted fluency, flexibility, originality, and elaboration, whereas evaluative prompts targeted

relevancy, logic, assumptions, and conclusions, as well as overall structure of the written product. Of note, students were trained how to use the prompting program and had to initiate use of the prompts (prompts did not appear unsolicited). The authors found minimal positive effect of the prompting program on writing performance. The authors reported findings from earlier work in which they had found improved revision and quality of final product in college writers using the same intervention program (Reynolds & Bonk, 1990a, as cited in Bonk & Reynolds, 1992).

More recently, a study of computer-based scaffolding of writing activity found improved written text quality for college writers who participated in a computer-based prompting intervention (Proske, Narciss & McNamara, 2012). The aim of the study was to provide external support for writing through a computer-based scaffolding program. The purpose of the program was to generate feedback about writing and to provide deliberate practice in writing tasks. The authors compared writing performance in the computer-based prompting condition to performance in an unsupported, practice-only condition. Writers also completed a post-test condition in which they wrote without support. The authors found that the supported group wrote essays of better comprehensibility than the practice-only group. They reported that the supported group spent more time pre-writing. Writers in the supported condition had access to considerable amounts of information accessible via tabs they could click to read more about how to complete the writing task. The additional time spent prewriting suggests engagement with the writing task. Of relevance to the proposed study, the authors identified revision as necessary to producing successful academic writing, and noted the

need for external support to make less-skilled writers aware of knowledge and strategies to aid revision (Proske et al., 2012).

The sub-section that follows reports on a pilot study completed to evaluate the use of a computerized writing log for assessing the writing process of writers with brain injury (Ledbetter, Fickas, & Sohlberg, 2014). The pilot study results add a modicum of evidence about writing challenges college students with brain injury might experience, and raise questions about revision.

Pilot study. Ledbetter, Fickas and Sohlberg (2014) conducted a pilot study to validate the use of a computerized writing log tool for assessing the writing process. Three writers with ABI and three matched controls used the interface to write essays in response to expository prompts. Using a directed retrospection protocol (Ericsson & Simon, 1980), the tool delivered on-screen prompts to collect self-reported samples of writing process activity (planning, translating, reviewing) and activity unrelated to writing every 90 seconds (+/- 15 seconds). Results suggested writers with ABI exhibit fewer self-reported responses for planning and reviewing processes when writing, with more activity unrelated to writing compared to controls. Further, patterns of time-stamped writing process activity self-reported through directed retrospection suggested controls showed more evidence of dynamic, recursive use of planning and reviewing than writers with ABI. This finding suggests a need for research on revision processes for writers with ABI to examine whether writers with ABI will strategically alter revision behavior in response to computer delivered prompts, leading to improved text quality.

Summary. Several computer-based writing interventions have been tested in recent decades. Investigations of the effect of word processing on writing quality were

completed in the 1980s, with web-based and electronic writing environments, automated feedback and computer-based prompting studies in the 1990s, 2000s and 2010s tending to demonstrate a degree of positive influence on writing performance for secondary school aged and college writers. At least four themes have emerged from the literature on computer-based writing intervention to inform future intervention design, including the need for specific feedback on the process of revision, explicit information about how to carry out the writing task and solve problems in writing using evaluative criteria, the importance of raising metacognitive awareness of writing processes, and the usefulness of tapping motivation by creating an engaging environment for writing. To varying degrees, studies reviewed in this section addressed or included the recommended instructional components (Hamman, 2005; Hayes, 2012a; MacArthur, 2012; Myhill & Jones, 2007) described earlier. Data from a pilot study involving computer-based prompting offer support for future research examining intervention for computer-based prompting of revision for writers with ABI (Ledbetter, Fickas & Sohlberg, 2014).

Rationale for the Current Study

MacArthur (2012) called for research to study separate components of instructional approaches targeting revision, stating that,"brief, theoretically motivated interventions have confirmed the theoretical importance of task schema for improving revision (pp. 479-480)." Computer delivered prompting targeting revision, if specific to text-macrostructure, would likely result in improvements to writers' strategic use of revision to improve the quality of their final text. Revision research has demonstrated and emphasized the importance of knowledge of task schemas to successful revision behavior linked to improved text quality (Wallace & Hayes, 1991; Hayes, 2012a), and providing

brief, specific, and targeted revision instruction has been shown to result in positive outcomes (Wallace & Hayes, 1991). Additionally, both explicit modeling and prompting for self-regulated writing (Mason & Graham, 2008) and computer-based prompts aimed at improving writing have led to improved text quality (Bonk & Reynolds, 1992; Proske et al., 2012). Importantly, MacArthur (2012) pointed out that viewing revision as a process is crucial to revision instruction. Several authors have recommended explicit instruction in evaluation criteria and providing practice in applying it (Hamman, 2005; MacArthur, 2012; Myhill & Jones, 2007). Writers who have difficulty effectively and efficiently engaging a process of revision would likely respond positively to instruction aimed at raise awareness of revision processes (Hamman, 2005; Myhill & Jones, 2007). Were such instruction delivered efficiently by computer during the writing process, it may have the potential to lead to positive changes in revision behavior that could be linked to improved text quality.

Research Questions

Four research questions drove this study:

1. Is there a functional relation between a computerized revision prompting intervention for expository essay writing and the quality of the written product as measured by quality rubric scores assigned using the Oregon Department of Education (ODE) *Official Scoring Guide*, *Writing*?

For the first research question, I hypothesized a functional relation between the computerized revision prompting intervention and increased overall quality scores as evidenced through visual analysis of number of overall quality scores, revealing an observable change in level from baseline to treatment phase at 3 points in time.

2. Is there a functional relation between a computerized revision prompting intervention for expository essay writing and changes in writing behavior as measured by number of revision changes produced in response to revision prompts?

For the second research question, I hypothesized a functional relation between the computerized revision prompting intervention and changes in writing behavior as evidenced through visual analysis of number of revision changes produced, revealing an observable change in level from baseline to treatment phase at 3 points in time.

3. When struggling writers receive prompts instructing revision behavior during expository essay writing, will they make revision changes specific to the prompts' suggestions as measured by type of revisions produced in response to revision prompts?

For the third question, I hypothesized that revision changes produced would be specific to the computerized revision prompt suggestions. Further, I hypothesized that data would reveal specific types of text-based revisions to both macro-structure and micro-structure in the specific prompting condition as measured using the Faigley & Witte (1981) revision taxonomy.

4. What is the perceived benefit and acceptability of the prompting intervention as measured by a post-intervention questionnaire?

For this question, I hypothesized that participants would report perceived benefit from the intervention in the form of perceived improvements to their writing, and that they would report finding the intervention to have an acceptable level of usability.

CHAPTER III

METHOD

This chapter provides a description of the research methods, procedures and analyses for the study. The first section presents the experimental design. Participant characteristics are described in the second section. Subsequent sections detail research procedures, delineate the experimental intervention, describe outcome measures, and present methods of analyses for answering each research question. The chapter concludes by specifying procedures for evaluating social validity of the intervention.

Experimental Design

The study design was a multiple probe, single-case design (C. H. Kennedy, 2005) with baseline, treatment and maintenance phases, replicated across 5 participants. A minimum of 3 data points was included in the baseline phase, with 3 data points in the treatment phase and one data point in the maintenance phase. Implementation of the experimental intervention was staggered over time across participants, with each successive participant held in baseline phase until the experimental intervention was implemented with the previous participant.

The decision to include a minimum of three data points per phase is supported in the writing research literature. A recent meta-analysis of single-case studies of writing interventions for high school students reported that only one of the fourteen studies included in the meta-analysis included 5 data points per phase (Cook & Bennett, 2014). The data suggest that few researchers using single-case methodology to examine writing have met the design standard of a minimum of 5 data points per phase that Horner and colleagues (2005) recommended. Ten of the fourteen studies were completed after 2005,

but the only one reporting 5 data points per phase was a study conducted by Hoover, Kubina and Mason (2012). The failure of many studies to meet the recommended design standard of 5 data points per phase is noteworthy. One possible rationale for researchers making the design decision to use fewer than 5 data points per phase is that researchers strategically chose to sacrifice that particular design standard in order to reduce potential practice effects caused by repeated writing. Practice effects could interfere with establishing experimental control. Another possibility is that researchers wanted to reduce the amount of writing participants would be expected to complete for the study, with the understanding that participants with writing challenges may be less inclined to engage in multiple writing sessions and would feel burdened by these demands. Both of these concerns influenced the decision for this study to replicate earlier single-case writing researchers and not require 5 data points per phase criterion for studies involving complex writing tasks.

Participants

Four first-year, undergraduate writers aged 18-21 with acquired brain injury (ABI) participated in the study. Participants included in the study had a documented diagnosis of ABI resulting from trauma, or disease (e.g., brain tumor) or an anoxic event as documented by medical records. Participants demonstrated an expressed awareness of their own difficulties with the writing process and an expressed interest in participating in intervention targeting the writing process.

Additional criteria for study inclusion were:

1. Acquired impairments in attention, working memory, and/or executive functions as measured by at least one fluid cognition subtest score 15 or more points lower than a

crystallized cognition measure (composite or picture vocabulary) on the NIH Toolbox Cognitive Measures (National Institutes of Health and Northwestern University, 2012)

2. Average crystallized cognition score (or picture vocabulary score) as measured by assessment with NIH Toolbox Cognitive Measures
3. Native speakers and writers of English
4. Basic computer navigation skills
5. Able to read text on computer screen

Exclusionary criteria included:

1. Reported history of language disorder, learning disability or other developmental disability
2. Motoric impairments affecting keyboarding ability or mouse use
3. Uncorrected vision impairments that interfere with reading
4. Deteriorating health or neurodegenerative disorder

Recruitment. I recruited potential participants' through flyer and social media postings in university, college and community settings in accordance with the research protocol approved by the Institutional Review Board. Procedures for participant screening are described in the following section. Five participants indicated interest.

Screening and initial interview. I screened each of the five potential participants by phone or email (participant's choice) by asking the participants to confirm that they met the inclusion and exclusion criteria listed above. If the phone or email screen suggested that a participant was eligible for the study, I scheduled an initial interview at which time I again presented inclusion and exclusion criteria and asked the participant to

confirm, and also invited their questions. Four potential participants met criteria and wished to participate in the study. One potential participant did not meet criteria because he clarified in the initial interview that he had a prior learning disability. I did not consent that person for the study and thanked him for his time. I presented the four participants who met criteria and wished to participate with consent forms, an explanation of risks and benefits associated with the study, and an opportunity to ask questions prior to giving their consent to participate. Participants were paid $25 for each writing session. Table 1 presents participant characteristics.

Table 1

Participant Characteristics

Participant	Age	Sex	Reported diagnosis
P1	19	F	Multiple concussions
P2	21	M	TBI
P3	20	M	Multiple concussions
P4	18	F	Concussion

Note. All participants sustained injury greater than six months before starting the study, spoke English as a first language, and reported no prior learning difficulties.

Cognitive testing. Each consented participant completed initial cognitive testing using the *NIH Toolbox Cognitive Measures* (Weintraub et al., 2014). The instrument, developed by the National Institutes of Health in collaboration with Northwestern University, serves as a nationally normed and standardized comprehensive cognitive battery to evaluate cognitive performance for individuals aged 3-89. Fluid cognition subtests evaluate performance in working memory, inhibitory control, cognitive shifting, processing speed, and episodic memory domains. Crystallized cognition subtests evaluate

performance on picture vocabulary and oral reading recognition tasks. The instrument constitutes an hour-long, computerized battery of cognitive measures with fair psychometrics delivered in an adaptive format. An advantage of the instrument is its sensitivity to working memory, processing speed and executive function deficits. Research supporting the reliability and validity of the NIH Toolbox Cognitive Measures provides data for test-retest reliability as well as convergent and discriminant validity (Weintraub et al., 2014).

The program generates a score report using only an ID number with no name or other identifying information associated with the scores. Scores were entered into a score report protocol labeled with the participant ID number and placed in the participant's numerically identified file and retained for the duration of the study. The scores were used to confirm the presence of cognitive impairments for each participant.

This link provides complete description and video demonstration of the NIH Toolbox Cognitive Measures: http://www.nihtoolbox.org/WhatAndWhy/Assessments/E-learning%20files/player.html.

Table 2 shows participants' cognitive scores.

Table 2

Participants' Cognitive Scores from the NIH Toolbox Cognitive Battery

	Participant 1		Participant 2		Participant 3		Participant 4	
Assessment	AASS	PR	AASS	PR	AASS	PR	AASS	PR
Picture Vocabulary	108.74	71.90	89.87[a]	24.80[a]	100.33	50.80	108.83	72.20
Pattern Comparison	116.46	86.40	64.63	1.00	108.47	71.20	147.48	99.90
Oral Reading Recognition	123.61	94.20	DNT[a]	DNT[a]	109.52	73.60	94.08	34.80
Flanker Inhibitory Control & Attention	75.64	5.30	88.01	21.20	113.46	81.60	111.11	77.00
List Sorting Working Memory	94.33	35.20	89.14	23.60	94.89	36.70	76.81	6.10
Dimensional Change Card Sort	86.81	18.90	91.60	28.80	109.40	73.60	116.31	86.20
Picture Sequence Memory	112.44	79.70	74.52	4.50	108.79	72.20	72.88	3.50
Cognition Fluid Composite	89.35	23.90	68.28	1.70	115.41	84.80	112.61	79.90
Cognition Crystallized Composite	120.79	91.80	NA[a]	NA[a]	105.08	63.30	101.42	53.60
Cognition Total Composite	109.13	91.80	NA[a]	NA[a]	119.18	90.00	114.14	82.60

Note. NIH Toolbox: Cognitive Battery (National Institutes of Health and Northwestern University, 2012). AASS = age-adjusted scaled score; PR = percentile rank. DNT = did not test. NA = not available

[a]Participant 2 did not complete Oral Reading Recognition because severe dysarthria interfered with oral reading ability. Accordingly, no Crystallized and Total Cognition Composites are available, but Picture Vocabulary score suggests low average crystallized cognition.

Writing knowledge interview questions. Prior to completing any writing sessions, participants answered five knowledge questions about writing and revision. Table 3 lists knowledge questions with participants' responses to each.

Table 3

Responses to Writing Knowledge Questions

	Participant			
Question	P1	P2	P3	P4
How do you revise your writing?	I usually just go through it again after I type it all out and make sure it makes sense.	Grammatical revisions and paragraph structure revisions, for example each of my paragraphs I want to start with a topic sentence, followed by two body sentences, and end with a conclusion.	I revise it usually by just reading it right after I write it—the whole thing….and then I'll go individually into each paragraph and focus on my sentences first--make sure they're all complete sentences and that they make sense, which usually, if I'm writing fast, they tend not always make sense. So they'll go in and fix those issues and then check for spelling and grammar and do that with each paragraph through, and then do a clean sweep to make sure it all flows together.	I revise my writing…typically I start with, uh…and correct like spelling or …., um word choice and I would typically kinda start from the bottom of the essay so I don't overlook anything, and then I would probably start from the beginning and make sure everything sounds fluent. Yeah.
If you were going to back and strengthen your writing, what would that look like for you?	I don't know.	I struggle with coming up with topics to write about.	I think generally just simple grammar would help strengthen my writing a lot. Something I just struggle generally in school with and I don't know why. Or spelling, which luckily I mean we have computers now that help us spell, but having I think just better diction over all would advance my writing.	To strengthen my writing, I would probably have a peer edit it and then I would go back and make those changes and make it sound more like my writing and revise it that way to make sure it's fluent and it flows well.

Table 3 continued

Question	P1	P2	P3	P4
What is a thesis statement?	A thesis statement is…um….basically like the main argument that the author is trying to get across.	Introduction or a conclusionary statement at the beginning of a paragraph.	A thesis statement is essentially a sentence that tells the reader or tells your paper essentially what the rest is going to be about. So it should be what the rest of your paper—what the paper's focus is or main idea of the paper...	A thesis statement is the sentence or part of the introduction that outlines, uh…. the reason for...the reason….the…. idea....behind the….research?
How do you know if your main ideas connect to and support your thesis statement?	If they're….the same thing like…the same topic	I'm not sure.	I mean your topic sentence essentially is your thesis statement so whatever you say you're going to talk about in that---if you can't link your paragraphs to that statement, then it's going to go along with your paper. So …if your topic is like, dogs and how they affect people's emotions, you shouldn't all the sudden talk about cats or…some other thing, so just staying near that topic and examples.	So, can you repeat that? [repeats.] Um, I would know by just re-checking my work and my writing to make sure that the ideas would connect and relate to each other and the infomation I provide would be uh…related to the thesis.

Research Procedures

This section delineates the research protocol for the study.

Essay sessions. All essay sessions were 59 minutes in length, as determined by the sum of the 7-minute intervals preceding the delivery of each of the 7 prompts (49 minutes), followed by a 10-minute interval that the final prompt required. A timer set for 59 minutes ensured all essay sessions were of equal length. All participants completed their essays within the 59-minute time allotted. For consistency with intervention phase

sessions, all baseline and maintenance sessions were also timed for 59 minutes.

Participants wrote all intervention essays using the computer-based revision prompting program, run by Chrome browser on a computer with keyboard and mouse. Baseline and maintenance essays were written using the word processor mode with the prompt mode turned off. Given the design requirement that each subsequent participant be held in baseline until the prior participant began the intervention, the first participant wrote 7 essays, the second wrote 8, the third wrote 8, the fourth wrote 9, and the fifth participant wrote 9 essays to complete the study.

Topic selection and equivalency. A bank of 40 expository topics representative of those typically used on the state writing test was employed (see **APPENDIX A** for the list of topics). Topics were either drawn from or developed based upon those historically used on state writing tests as determined through review of information available at the state department of education website (Oregon Department of Education/Office of Assessment, 2009). From the bank of 40 topics, 20 topics were randomly selected for each participant using a random number generator. During the first session, each participant was presented with the 20 topics and asked to read and rate each topic using a 1-6 scale for both familiarity and interest (see **APPENDIX B** for scales). Topics the participant rated as 3 or 4 for familiarity and interest were selected for use for that same participant. If there were not a sufficient number of topics rated 3 or 4 on both dimensions for a given participant, I generated an additional 10 topics and presented them for rating. The procedure was repeated until a given participant rated enough topics 3 or 4 for that participant's essay sessions (ranging from 7 to 9).

Experimental intervention. A computer-based revision prompting program constituted the independent variable manipulated in the study. The basic prompting system was developed for the pilot study (Ledbetter, Fickas & Sohlberg, 2014) described in the literature review. This early study revealed high usability and feasibility of the prompting interface. The computer-based revision prompting program is a web application created using Google's Appspot. All information stored on the server can easily be viewed from the data page. At this webpage, the researcher views anonymous essays, identified only by the non-unique user ID number and the time the essay was begun. Each time a computer-based revision prompt is delivered, the written text produced up to that point, including every significant keystroke the user makes, is stored in the server as a snapshot of text. Researcher review of snapshots of TPSF (Hayes, 2012b) allows for analysis of revision changes produced in the time elapsed following delivery of the previous revision prompt.

Specific, sequenced revision prompts were delivered at 7-minute intervals over the course of the 59 minutes alloted for writing an essay. Given that the target population was undergraduate writers with ABI who reported writing challenges, the 59-minute time limit was justifiable for the task under investigation as it allowed writers extra time to revise. The computer-based revision prompting program recorded snaphots of TPSF at 7-minute intervals aligned with delivery of each revision prompt. Table 4 (next page) presents the sequenced revision prompts delivered by the computer.

Table 4

ComputerBased Revision Prompts

Prompt	Time	Target	Type[a]	Rationale	Support
1. Check to make sure your first paragraph includes a thesis statement. Revise if needed.	07	Create a thesis statement	Specific	Introducing a thesis statement is addressed in writing intervention studies, including use of the term "thesis statement" during instruction	De La Paz (2001); Lienemann, Reid & The Iris Center (2009); Berry & Mason (2010)
2. Check to make sure any paragraphs you have written contain main ideas that support your thesis. Revise if needed.	14	Create cohesion across paragraphs	Specific	Including main ideas to support the thesis statement is addressed in writing intervention studies	De La Paz (2001); Lienemann, Reid & The Iris Center (2009)
3. Check to make sure you've included supporting sentences in your paragraphs to back up each main idea. Revise if needed.	21	Add support for main ideas	Specific	Including support for main ideas is addressed in writing intervention studies	De La Paz (2001); Lienemann, Reid & The Iris Center (2009);
4. Check to make sure supporting sentences within paragraphs are in a clear order for the reader. Revise if needed.	28	Clearly organize ideas for the reader	Specific	Writing intervention studies address organization of ideas and making ideas clear to the reader	De La Paz (2001); Lienemann, Reid & The Iris Center (2009); Wallace & Hayes (1991)

Table 4 continued

Prompt	Time	Target	Type[a]	Rationale	Support
5. Check to make sure any paragraphs you've written are in a logical order for the reader. Revise if needed.	35	Organize paragraphs within essay	Specific	Writing intervention studies address organization of ideas and making ideas clear to the reader	De La Paz (2001); Lienemann, Reid & The Iris Center (2009); Wallace & Hayes (1991
6. Check to make sure you've written a conclusion for your essay. Revise if needed.	42	Conclude the essay	Specific	Including a conclusion is addressed in essay writing intervention studies	De La Paz (2001); Berry & Mason (2010)
7. You have 10 minutes left to read over your paper out loud or to yourself. Revise if needed	49	Review to diagnose need for revisions	General, non-specific	Reviewing to determine need for revisions, a characteristic of skilled writers, is addressed in writing studies	Myhill & Jones (2007); Mason & Graham (2008)

[a] Specific prompts provide details for task execution, whereas general, non-specific prompts alert individuals to monitor performance (Boyd & Sautter, 1993).

Three principles informed prompt development. First, the sequenced prompts together comprise a brief, focused intervention aimed at stimulating revision behavior (MacArthur, 2012). Second, prompts were theoretically grounded in research showing that brief instruction in task schemas for revision can result in improvements to revision behavior and text quality (Hayes, 2012b; Wallace & Hayes, 1991). Third, prompts were aimed at assisting the writer in self-regulation (Kennedy & Coelho, 2005; Mason & Graham, 2008) of the revision process *while* writing (Myhill & Jones, 2007), versus after producing a draft.

Three additional parameters were applied to prompt development. First, the prompts targeted writing behaviors and specific essay elements addressed in the writing

literature (Berry & Mason, 2010; De La Paz, 2001; Lienemann, Reid & The Iris Center, 2009; Mason & Graham, 2008; Myhill & Jones, 2007; Wallace & Hayes, 1991). Second, I designated prompts as either specific or general/nonspecific, consistent with Boyd and Sautter's (1993) prompt classification when instructing people with brain injury. Third, I wrote the prompts to include clear, concise and accessible wording while also using terminology consistent with that used in writing intervention research (Berry & Mason, 2010; De La Paz, 2001; Lienemann, Reid & The Iris Center, 2009; Mason & Graham, 2008).

The computer program delivered revision prompts chronologically every 7 minutes in the numbered sequence presented in the table. Each prompt appeared at the top of the screen without blocking the text and remained in place for 7 minutes and then began to blink, then minimize, upon delivery of the subsequent prompt. In other words, writers were able to view each prompt at the top of the screen for 7 minutes until the subsequent prompt replaced it. When the subsequent prompt appeared, each previous prompt remained accessible if the writer later wished to view a given prompt again by clicking a back arrow.

Schedule. Participants completed the study in three phases: baseline phase, intervention phase, and maintenance phase, as described below.

Baseline phase. During a brief interview conducted at the start of the first baseline session, participants responded to the following five questions about their writing and revision behavior:

1. How do you revise your writing?

2. If you were going to back and strengthen your writing, what would that look

like for you?

3. Is revision something you do while you're writing, or after you finish writing?

4. What is a thesis statement?

5. How do you know if your main ideas connect to and support your thesis statement?

The purpose of these questions was to elicit qualitative baseline data on the participants' knowledge and perceptions of their revision behavior. To establish a stable baseline for expository essay writing, participants completed between three and five baseline essay sessions during which the participant wrote using a basic interface identical to the interface used in the experimental intervention, but with no computer-based revision prompts delivered. Additional baseline sessions were conducted for successive participants who were held in baseline phase until the previous participant began intervention. In other words, implementation of the intervention occurred for each participant before a subsequent participant entered the intervention phase. Procedures for analyzing the essays are described below under Outcome Measures. Note that given anticipated practice effects from writing multiple essays, the baseline phase contained a minimum of 3 essays rather than the minimum 5 data points per phase widely accepted as the standard for single-case research (Horner et al., 2005).

Intervention phase. All participants completed three essays in the computer-based prompting condition. Each successive participant began the intervention after having been held in baseline phase beyond the session in which the prior participant began the intervention. Before participants wrote their first intervention phase essay using the computer-based revision prompting intervention, I manually demonstrated example

revisions made in response to a revision prompt. A script for the revision demonstration procedure with examples included is available in **APPENDIX B**.

Maintenance phase. All participants completed one maintenance phase essay in a no-prompting condition one week following completion of the final intervention phase essay. As in the baseline phase, participants wrote using a basic interface with no computer-based revision prompts delivered.

Outcome Measures

The study included measures of number and type of revision changes and direct measures of writing quality. To measure revision changes, the study used a revision taxonomy originally developed and validated by Faigley and Witte (1981). To measure quality, the study employed the *Oregon Department of Education Writing Scoring Guide*, a measurement tool commonly used in the state public education system. Each measure is described in detail in sub-sections that follow.

Revision changes. The primary dependent variable measure at the discrete, ratio level of measurement was total number of revision changes as measured by coding with a widely used revision taxonomy (Faigley & Witte, 1981). This taxonomy has been frequently used in revision research (e.g., Bonk & Reynolds, 1992; Crawford, Lloyd & Knoth, 2008; Daiute, 1986; Hayes et al., 1986; Myhill & Jones, 2007; Stoddard & MacArthur, 1993). The frequency and way in which writers alter their written text during the writing process is important to comprehensive measurement of writing, but measures of the revision process are typically absent from intervention studies (e.g., Berry & Mason, 2010; Mason et al., 2009; MacArthur & Lembo, 2008; Mason & Shriner, 2007; Delano, 2007; Chalk et al., 2005). The study addressed that gap by using the revision

taxonomy for measuring text-based revisions (additions, deletions, substitutions, permutations, consolidations, distributions) in the TPSF as captured in snapshots of text taken each time the computer program delivered a revision prompt. Inter-observer agreement procedures for recording revision changes are described below.

Essay quality. Essay quality was scored using a rubric available from the Oregon Department of Education (see *ODE Official Scoring Guide, Writing* in the Appendix) for assessing quality with a value assigned to each essay ranging from 1 to 6 across the following six domains: ideas and content; organization; voice; word choice; sentence fluency; and conventions. The rubric scores served as a categorical dependent variable measure. Scores across the six domains were summed for an overall quality score (possible range from 6 to 36) plotted for visual inspection. Inter-scorer agreement procedures are described below.

The validity of measures of a written product may depend to some degree upon whether dependent variables are directly or indirectly measured (Tindal & Parker, 1989). Direct measures of operationally defined, countable items are frequently used (e.g., De La Paz, 2001; Delano, 2007; Mason et al., 2009; Jacobsen & Reid, 2010; MacArthur & Lembo, 2008; Berry & Mason, 2010), but do not capture the complexity of writing (Tindal & Parker, 1989). Quality measures may better capture the complex nature of writing, but require strong operational definitions combined with training of scorers to high levels of inter-scorer agreement (Engelhard, 1992). The process used for scoring quality is also used by the state of Oregon, the site of this study. The state requires a minimum score of 4 to meet competency on traits assessed by the *Official Scoring Guide, Writing* (Oregon Department of Education, 2016).

Evidence from the literature supports the validity and reliability of quality measures, and several investigations of writing intervention have employed quality rubrics (Brunstein & Glaser, 2011; Chalk et al., 2005; De La Paz, 2001; Mason et al., 2006; Mason et al., 2009; Jacobsen & Reid, 2010; and MacArthur & Lembo, 2008). Holistic judgments of writing serve as a form of direct assessment with stronger content validity than indirect methods (Tindal & Parker, 1989). Common practices for establishing inter-scorer agreement include training observers in rubric use by defining rubric points and clarifying criteria, as well as providing anchor papers for each rubric level.

Scoring. I scored each essay for quality and number and type of revision changes. I completed descriptive analysis of snapshots of TPSF (Hayes, 2012b) to characterize participant response to revision prompts. Inter-scorer agreement procedures for quality and response to revision prompts are detailed in the following sub-section.

Inter-scorer agreement procedure. I completed an inter-scorer agreement procedure for overall quality scores and descriptive analysis of response to revision prompts. I trained an independent scorer uninformed of the study's purpose in use of the quality rubric scoring criteria and descriptive analysis for coding response to revision prompts.

The unaware scorer independently scored 50% of the essays. I defined overall quality scores the unaware scorer assigned as in adequate agreement with my own when they fell within 2 points of scores I assigned. For example, I determined an overall quality score of 24 (6 to 36 possible) to be in adequate agreement with a score of 22. I calculated inter-scorer agreement by summing the number of identified agreements for a

given outcome measure then dividing the total by the total number of possible agreements. I multiplied that result by 100 to yield percent agreement. The goal for both quality scores and response to revision prompts was inter-scorer agreement of 85% or greater.

The unaware scorer independently analyzed 15% of intervention phase essay snapshots to determine response to revision prompts. I calculated agreement using the same procedure described for essay quality scores.

Analyses

Research Question 1. Is there a functional relation between a computerized revision prompting intervention for expository essay writing and the quality of the written product as measured by quality rubric scores assigned using the Oregon Department of Education (ODE) *Official Scoring Guide*, *Writing*?

For the first research question, I hypothesized a functional relation between the computerized revision prompting intervention and increased overall quality scores as evidenced through visual analysis of number of overall quality scores, revealing an observable change in level from baseline to treatment phase at 3 points in time.

Answering my first question consisted of primary and secondary analyses, as overall quality scores comprise the sum of the six dimensions of quality scored using the ODE rubric. For primary analysis, I used visual data analysis to determine the presence of a functional relation for overall quality scores through visual inspection of level, trend, variability, immediacy of effect, degree of non-overlap, and consistency across phases (Horner et al., 2005). I plotted data obtained for the metric described above on a graph for visual analysis for each phase of the study (i.e., baseline, intervention, and post-

intervention follow-up). For secondary analysis, I completed the same procedure for each of the six dimensions of quality.

To augment visual analysis, I completed primary statistical analysis of difference between baseline and treatment phases (effect size) for overall quality scores using Tau-U (Parker, Vannest, Davis, & Sauber, 2011). The Tau-U statistic integrates nonoverlap between baseline and treatment conditions with intervention phase trend, and also corrects for baseline trend. For secondary analysis, I completed this procedure for any of the six dimensions of quality for which visual analysis revealed a functional relation. All Tau-U analyses were completed using a publicly available online calculator, accessible at singlecaseresearch.org (Vannest, K.J., Parker, R.I., Gonen, O., & Adiguzel, T., 2016).

Research Question 2. Is there a functional relation between a computerized revision prompting intervention for expository essay writing and changes in writing behavior as measured by number of revision changes produced in response to revision prompts?

For the second research question, I hypothesized a functional relation between the computerized revision prompting intervention and changes in writing behavior as evidenced through visual analysis of number of revision changes produced, revealing an observable change in level from baseline to treatment phase at 3 points in time.

To answer my second question, I used an approach to visual analysis identical to that for my first question. I also coded revisions produced in each snapshot of the TPSF (Hayes, 2012b) using the Faigley and Witte (1981) taxonomy in order to enumerate and describe revisions.

Research Question 3. When struggling writers receive prompts instructing revision behavior during expository essay writing, will they make revision changes specific to the prompts' suggestions as measured by type of revisions produced in response to revision prompts?

For the third question, I hypothesized that revision changes produced would be specific to the computerized revision prompt suggestions. Further, I hypothesized that data would reveal specific types of text-based revisions to both macro-structure and micro-structure in the specific prompting condition as measured using the Faigley & Witte (1981) revision taxonomy.

To answer my third question, I analyzed revisions coded using the Faigley and Witte (1981) revision taxonomy relative to the corresponding computer-based prompt delivered on screen at the time the program recorded a snapshot of text. I examined the revisions produced in each snapshot of the TPSF (Hayes, 2012b) in order to determine whether revisions responded directly to the intent of each on-screen prompt. First, I determined whether the prompt delivered was in fact necessary for the writer by examining the text to see whether the writer had already addressed the target at the time of the prompt. For example, prompt #1 targeted thesis statements. In examining the first snapshot of text, if a thesis statement was present, I coded that prompt as not necessary (NN) for that writer. If the writer had not yet included a thesis statement at the time of the prompt, I then analyzed the subsequent snapshot to determine whether the writer included a thesis statement in the 7 minutes following delivery of the target prompt. If so, I coded that prompt with a plus sign (+) to indicate that the writer had responded positively to the

prompt. If not, I coded that prompt with a minus sign (-) to indicate that the writer had not responded to the prompt.

Research Question 4. What is the perceived benefit and acceptability of the prompting intervention as measured by a post-intervention questionnaire?

For this question about feasibility and social validity of the intervention, I hypothesized that participants would report perceived benefit from the intervention in the form of perceived improvements to their writing, and that they would report finding the intervention to have an acceptable level of usability.

I assessed the feasibility and social validity of the intervention through the use of a participant questionnaire designed to gather data on participants' perceptions of their revision skills and experience with the intervention at the end of the study (see *Post-Intervention Questionnaire* in **APPENDIX D**). I tallied questionnaire results in table form for descriptive analysis.

CHAPTER IV

RESULTS

This chapter presents the analyses conducted to answer the four research questions. Analyses consist of (1) data plotted for visual inspection in single-case design graphs for measures of essay quality across study phases; (2) statistical analyses of intervention effects; (3) descriptive analyses of number and type of revisions produced in computer-based snapshots of essay text produced at time of revision prompt delivery; and (4) descriptive analysis of post-intervention questionnaire data on feasibility and social validity of the intervention.

Research Question 1. Is there a functional relation between a computerized revision prompting intervention for expository essay writing and the quality of the written product as measured by quality rubric scores assigned using the Oregon Department of Education (ODE) *Official Scoring Guide*, *Writing*?

In answering research question one, I first transformed scores to a 0-100 scale from the original 1-6 scale for the six quality dimensions and overall quality score scale of 6- 36 for ease of comparison in both visual and descriptive analysis. The score transformation also allowed for ease of comparison of average scores across phases to identify when participants demonstrated improvement to a passing level in the intervention phase. Passing in the state of Oregon was a score of 4 on the 1-6 scale; a score of 24 on the 6-36 scale; or a score of 60 when transformed to a 0-100 scale. See Table 5 for mean transformed quality scores across all dimensions and mean transformed overall quality scores by phase for each participant.

Table 5

Mean Transformed Quality Scores by Phase

	Participant 1			Participant 2			Participant 3			Participant 4		
Dimension	B	I	M	B	I	M	B	I	M	B	I	M
Ideas and content	46.67	**66.67**	60.00	30.00	46.67	60.00	80.00	80.00	80.00	32.00	53.33	60.00
Organization	40.00	**60.00**	60.00	30.00	46.67	60.00	60.00	66.67	80.00	28.00	46.67	40.00
Voice	60.00	66.67	60.00	55.00	**80.00**	80.00	70.00	80.00	80.00	52.00	**60.00**	60.00
Word choice	60.00	66.67	60.00	40.00	**80.00**	80.00	60.00	73.33	80.00	40.00	53.33	60.00
Sentence fluency	60.00	60.00	60.00	35.00	53.33	40.00	60.00	66.67	80.00	40.00	**60.00**	60.00
Conventions	60.00	66.67	60.00	40.00	53.33	40.00	60.00	60.00	60.00	56.00	**60.00**	60.00
Overall quality score	54.33	**64.33**	60.00	38.25	**60.00**	60.00	65.00	71.33	77.00	41.40	56.67	57.00

Note. B = baseline phase; I = intervention phase; M = maintenance phase. A transformed score of 60.00 or greater meets passing criteria. Bold scores indicate improvement to passing level in intervention phase.

Inter-scorer agreement results. Without correction, overall initial agreement for quality scores was 76.5% (within two points). The scorer and I met in person and through discussion resolved disagreements, thus increasing inter-scorer agreement to 94%. One factor accounting for disagreement was the unaware scorer's professional training in evaluating writing for English language learners by looking specifically for adherence to a formulaic 5-paragraph structure. The scorer noted her own tendency to rate organization lower when it did not adhere closely to the 5-paragraph formula. Subsequently, the scorer recalibrated scoring on organization and other quality dimensions, resulting in 94% agreement.

According to single-case design standards, I used visual inspection to determine the presence of a functional relation by analyzing level, trend, variability, immediacy of effect, degree of non-overlap, and consistency across phases (Horner et al., 2005). I plotted the transformed scores on a graph for visual analysis of each phase of the study (i.e., baseline, intervention, and post-intervention follow-up). See Figure 4 for a graph of overall quality scores.

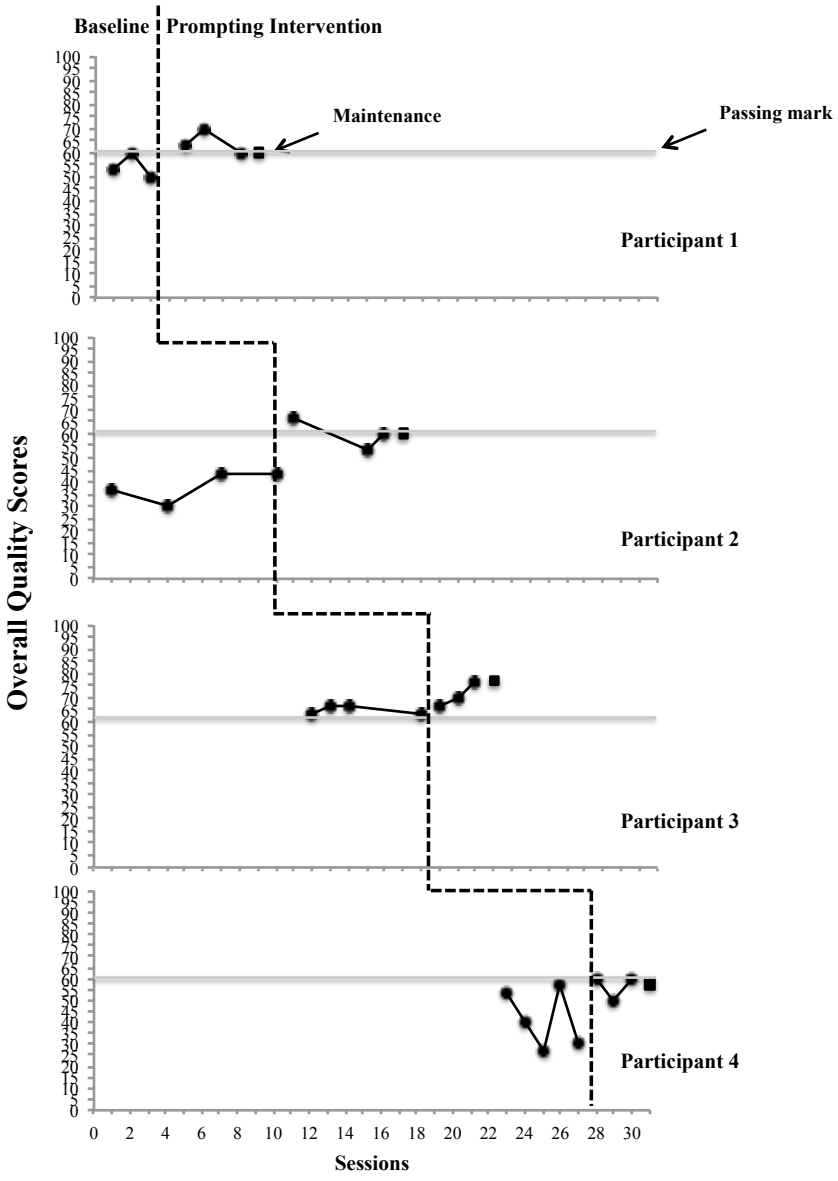

Figure 4.

Overall Quality Scores across baseline, intervention and maintenance phases

Visual inspection of the data plotted for Overall Quality Scores (OQS) above reveals evidence of a functional relation between the computer-based revision prompting intervention and improved OQS, as indicated by a shift in level from baseline to intervention at three points in time across participants. Non-overlap between baseline and intervention phases is most apparent for P2, with lesser degrees of non-overlap for the other participants. Immediacy of effect is apparent for P1, P2 and P4, whereas P3 shows a trend of increasing scores in intervention. All participants maintained increase over baseline at follow-up one week after completing the intervention phase.

In addition to visual analysis, I completed statistical analysis of difference between baseline and treatment phases (effect size) using Tau-U (Parker, Vannest, Davis, & Sauber, 2011). As described earlier, the Tau-U statistic integrates nonoverlap between baseline and treatment conditions with intervention phase trend, and also corrects for baseline trend. See results presented in Table 6. I corrected baseline trend for all participants. Tau-U analyses yielded results on the cusp of statistical significance for participants P1 and P4 at $p = .05$.

Results of both visual and quantitative analyses are summarized in Table 6.

Table 6

Visual and Quantitative Analyses of Overall Quality Scores

	Visual Analysis			Quantitative Analysis	
Participant	I phase *M* > B phase *M*	Increasing I phase trend	Immediacy of effect	Tau-*U*[a]	*p* value
P1	yes	no	yes	1.00	.05
P2	yes	no	yes	0.75	.11
P3	yes	yes	no	0.83	.08
P4	yes	no	yes	0.87	.05

Note. B = baseline; I = intervention; M = mean; Tau-U (Parker, Vannest, Davis, & Sauber, 2011). Baseline trend corrected for all participants.

*a*Alternate analysis with Tau yielded negligible differences, so I report Tau-U here.

I plotted transformed scores for each of the six dimensions of quality (Ideas and Content; Organization; Voice; Word Choice; Sentence Fluency; and Conventions) on a graph for visual analysis for each phase of the study (i.e., baseline, intervention, and post-intervention follow-up). See Figures 5-10 for data plotted for visual inspection for each dimension of quality.

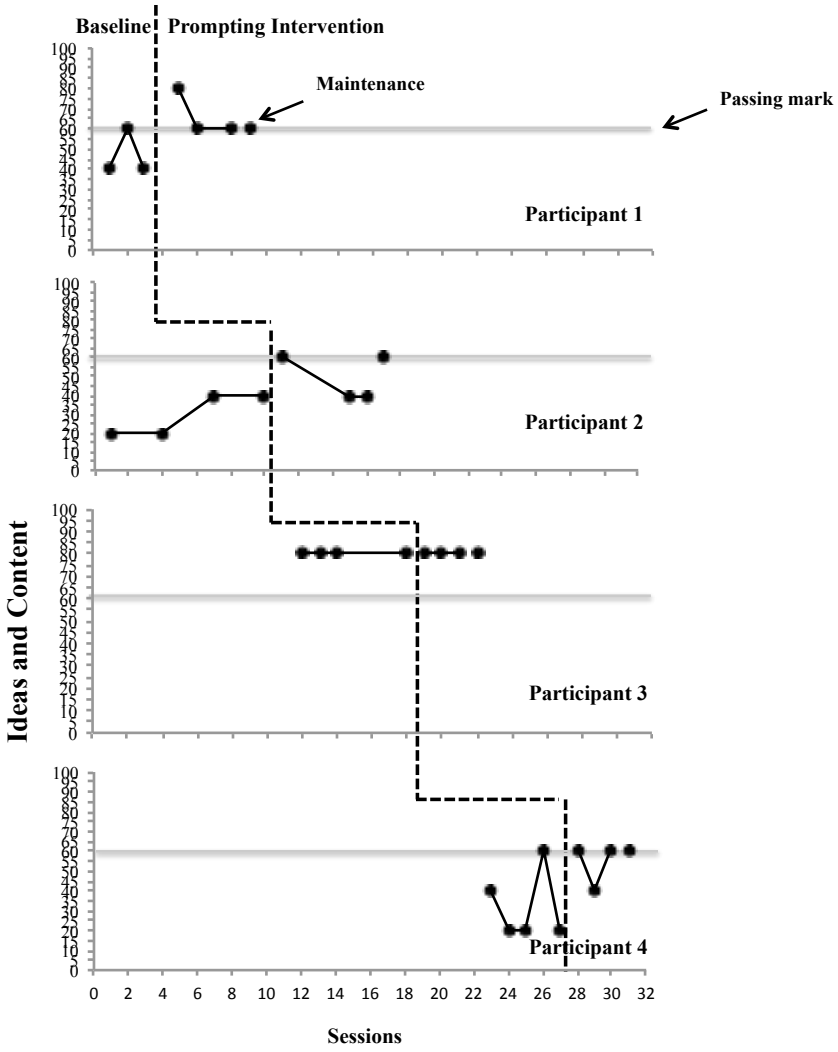

Figure 5

Ideas and Content across baseline, intervention and maintenance phases

Visual inspection of the data plotted for Ideas and Content (IC) above reveals evidence of a functional relation between the computer-based revision prompting intervention and improved IC as indicated by a slight shift in level from baseline to intervention at three points in time across participants P1, P2 and P4. Despite the shift in

level, overlapping data points between baseline and intervention phases are apparent for P1, P2 and P4. Immediacy of effect is apparent for P1, P2 and P4 upon implementation of the intervention. Data plotted for P3 show no change from baseline to intervention. All participants maintained increase over baseline at follow-up one week after completing the intervention phase, with P2 demonstrating an increase in score at follow-up to match that of the first intervention phase data point.

Statistical analysis of effect size using Tau-U (Parker, Vannest, Davis, & Sauber, 2011) yielded no statistically significant results for any of the participants for Ideas and Content at $p < .05$.

Table 7 summarizes results of both visual and quantitative analyses for IC.

Table 7

Visual and Quantitative Analyses of Ideas and Content Scores

	Visual Analysis			Quantitative Analysis	
Participant	I phase *M* > B phase *M*	Increasing I phase trend	Immediacy of effect	Tau-*U*[a]	*p* value
P1	yes	no	yes	0.78	.13
P2	yes	no	yes	0.33	.48
P3	no	no	no	0.00	1.00
P4	yes	no	yes	0.73	.10

Note. B = baseline; I = intervention; M = mean; Tau-U (Parker, Vannest, Davis, & Sauber, 2011). Baseline trend corrected for all participants.

[a]Alternate analysis with Tau yielded negligible differences, so I report Tau-U here.

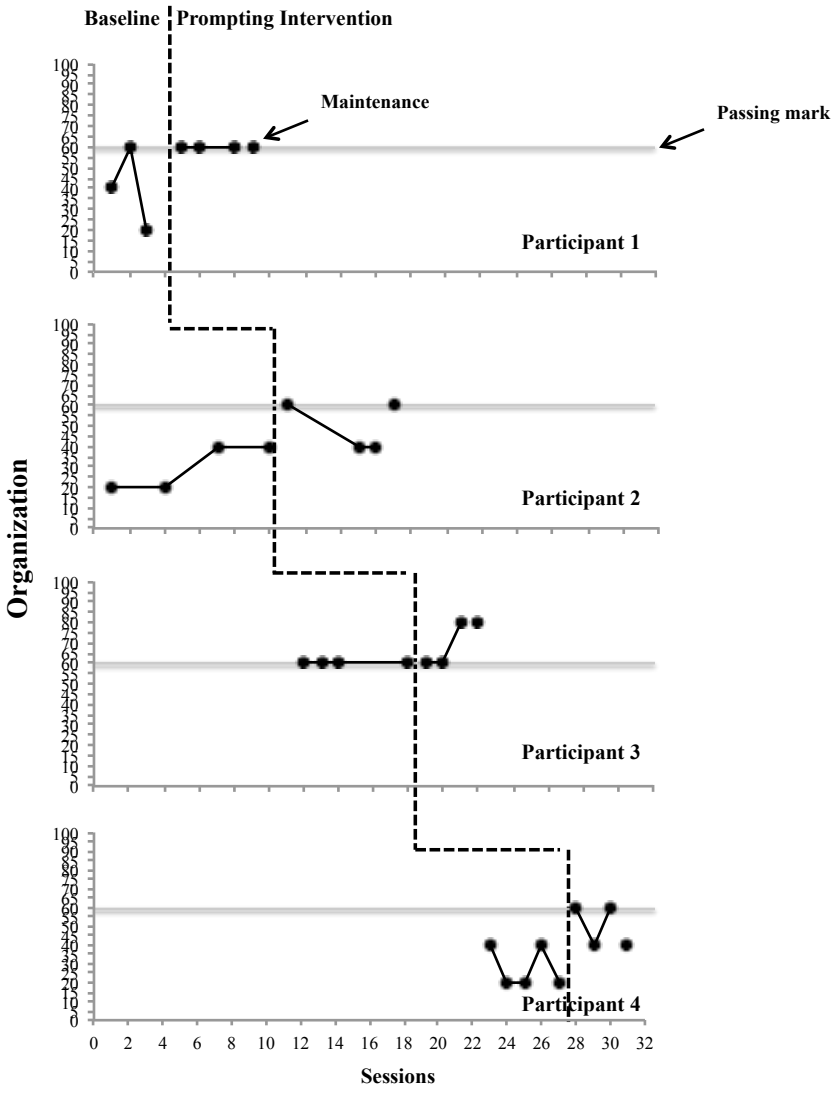

Figure 6

Organization scores across baseline, intervention and maintenance phases

Visual inspection of the data plotted for Organization above reveals evidence of a functional relation between the computer-based revision prompting intervention and improved Organization as indicated by a shift in level from baseline to intervention at three points in time across participants P1, P2 and P4. Despite the shift in level,

overlapping data points between baseline and intervention phases are apparent for P1, P2 and P4. Immediacy of effect is apparent for P1, P2 and P4 upon implementation of the intervention. Data plotted for P3 appear to show a delayed intervention effect, though a number of overlapping data points call this basic effect into question. Participants P1 and P3 maintained increase over baseline at follow-up one week after completing the intervention phase, with P2 demonstrating an increase in score at follow-up to match that of the first intervention phase data point. Participant P4 did not maintain increase over baseline for Organization at follow-up.

Statistical analysis of effect size using Tau-U (Parker, Vannest, Davis, & Sauber, 2011) yielded statistically significant results for participant 4 for Organization at $p < .05$. Table 8 summarizes results of both visual and quantitative analyses for Organization

Table 8

Visual and Quantitative Analyses of Organization Scores

	Visual Analysis			Quantitative Analysis	
Participant	I phase *M* > B phase *M*	Increasing I phase trend	Immediacy of effect	Tau-*U*[a]	*p* value
P1	yes	no	yes	0.78	.13
P2	yes	no	yes	0.33	.48
P3	yes	no	no	0.33	.48
P4	yes	no	yes	1.00*	.03*

Note. B = baseline; I = intervention; M = mean; Tau-U (Parker, Vannest, Davis, & Sauber, 2011). Baseline trend corrected for all participants.

*a*Alternate analysis with Tau yielded negligible differences, so I report Tau-U here.

* $p < .05$

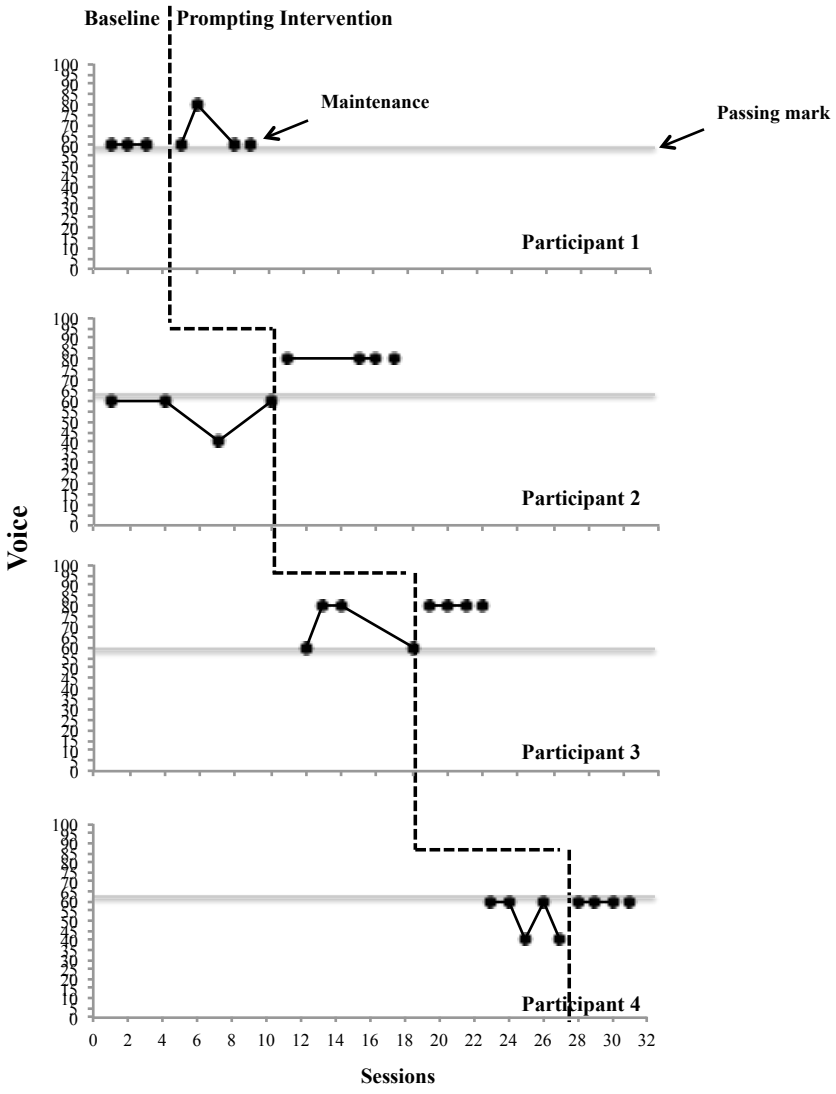

Figure 7

Voice scores across baseline, intervention and maintenance phases

Visual inspection of the data plotted for Voice above does not reveal evidence of a functional relation between the computer-based revision prompting intervention and improved Voice. There is a shift in level from baseline to intervention with immediacy of effect for participants P2 and P3, but multiple overlapping data points preclude

determining a basic effect for P1 and P4. All participants maintained increase over baseline at follow-up one week after completing the intervention phase. I did not complete statistical analysis given negative findings from visual analysis for this dimension of quality.

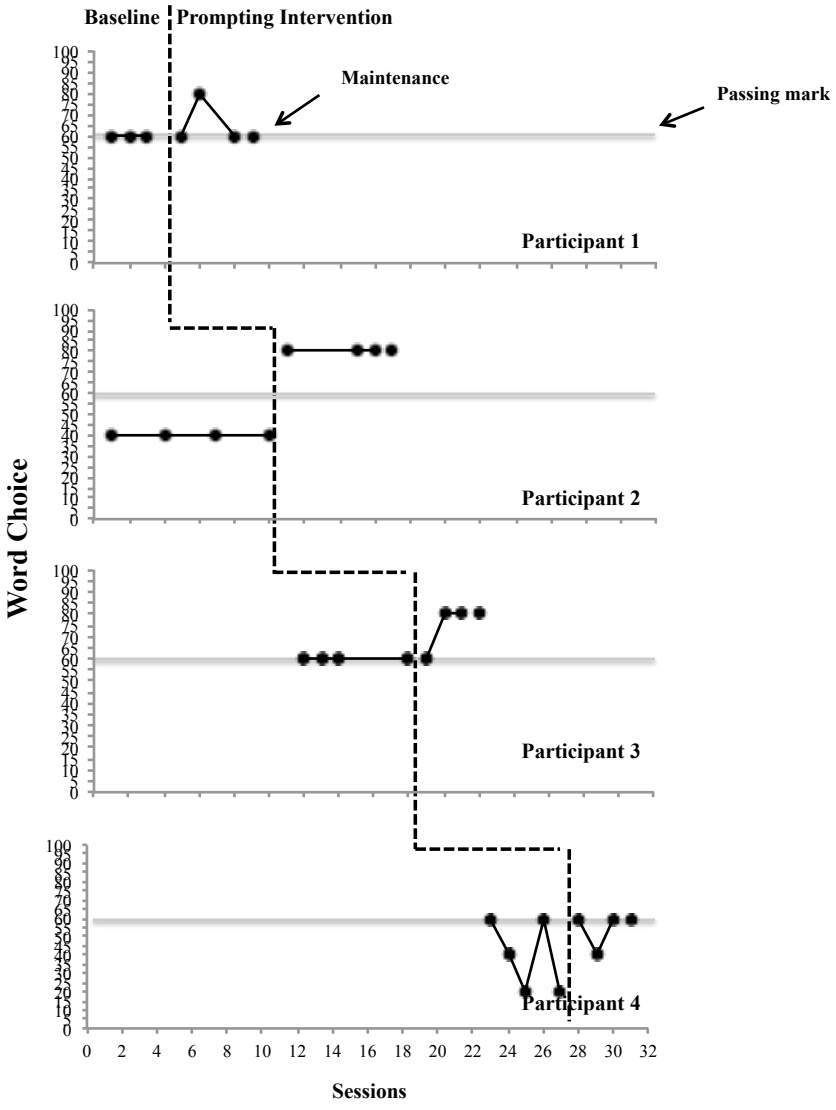

Figure 8

Word Choice scores across baseline, intervention and maintenance phases

Visual inspection of the data plotted for Word Choice above does not reveal evidence of a functional relation between the computer-based revision prompting intervention and improved Word Choice. There is a shift in level from baseline to intervention for participants P2 and P3, but multiple overlapping data points preclude determining a basic effect for P1 and P4. All participants maintained increase over baseline at follow-up one week after completing the intervention phase. I did not complete statistical analysis given negative findings from visual analysis for this dimension of quality.

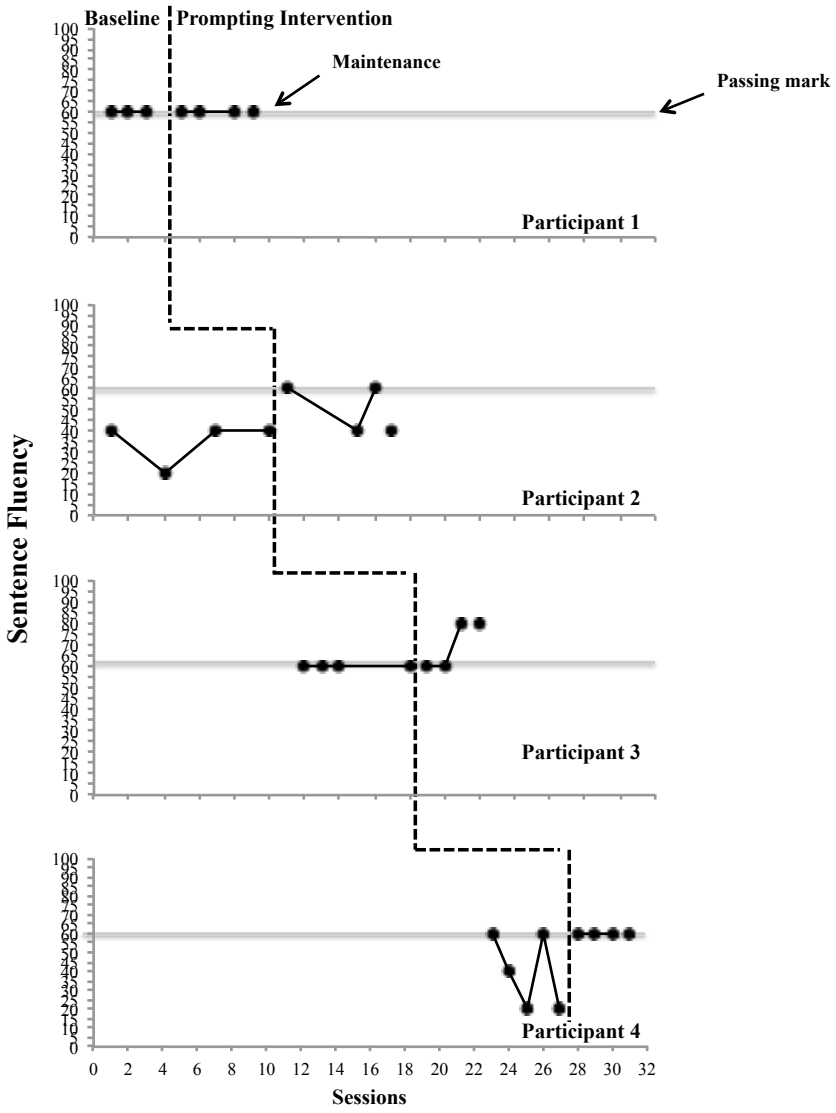

Figure 9

Sentence Fluency scores across baseline, intervention and maintenance phases

Visual inspection of data plotted for Sentence Fluency reveal no evidence of a functional relation. Despite posituve shift in level for participants P2 and P4, no change from baseline to intervention for P1 and multiple overlapping data points for P3 preclude basic effect. Participants P1, P3 and P4 maintained increase over baseline at follow-up,

but P2 did not. I completed no statistical analysis given negative findings for this dimension.

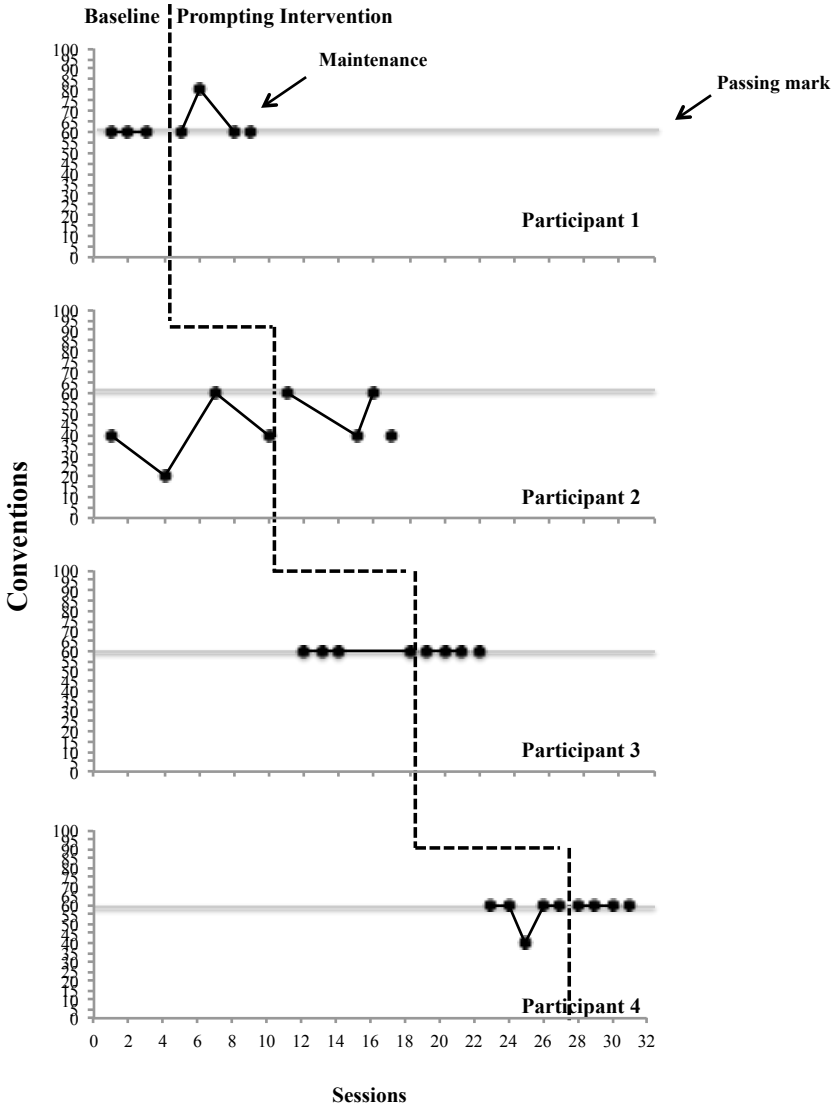

Figure 10

Conventions scores across baseline, intervention and maintenance phases

Visual inspection of the data plotted for Conventions reveal no evidence of a functional relation. No change from baseline to intervention for P3 and multiple overlapping data points for other participants preclude basic effect. Participants P1, P3 and P4 maintained increase over baseline at follow-up, but P2 did not. I completed no statistical analysis given negative findings for this dimension of quality.

Research Question 2. Is there a functional relation between a computerized revision prompting intervention for expository essay writing and changes in writing behavior as measured by number of revision changes produced in response to revision prompts?

To answer my second question, I coded all revisions participants completed for each essay using the Faigley and Witte (1981) revision taxonomy. Tables 9-12 present number and type of revisions to macro-structure, micro-structure and surface level for all essays each participant completed during the study.

Table 9. *Number and Type of Revisions by Essay for Participant 1*

	Macro-structure							Micro-structure							Surface							Total						
Essay #	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Addition	1	0	0	0	0	0	0	7	10	7	6	3	3	10	0	0	0	1	0	1	3	8	10	7	7	3	4	13
Deletion	0	0	0	0	0	0	0	2	1	1	1	0	0	2	4	0	1	3	2	0	2	6	1	2	4	2	0	4
Substitution	0	0	0	0	0	0	0	9	6	6	18	3	7	21	1	2	3	2	0	0	3	10	8	9	20	3	7	24
Permutation	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Distribution	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consolidation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	0	0	0	0	0	0	18	18	14	25	6	10	33	5	2	4	6	2	1	8	24	20	18	31	8	11	41

Note. Participant 1 completed 7 essay sessions, including 3 baseline sessions, 3 intervention sessions, and one maintenance session. Bottom row tallies total number of macro-structure, micro-structure and surface level revisions for each essay. Right hand column tallies total number of revision types across text levels for each essay.

Table 10. *Number and Type of Revisions by Essay for Participant 2*

	Macro-structure								Micro-structure								Surface								Total							
Essay #	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Addition	0	0	0	0	0	0	0	1	3	0	2	1	2	1	2	0	0	0	0	0	0	0	0	0	3	0	2	1	2	1	2	1
Deletion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substitution	0	0	0	0	0	0	0	0	2	1	1	0	0	3	1	1	4	2	1	0	0	0	0	0	6	4	3	0	0	3	1	1
Permutation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consolidation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	1	5	1	3	1	2	4	3	1	4	2	1	0	0	0	0	0	9	3	4	1	2	4	3	2

Note. Participant 2 completed 8 essay sessions, including 4 baseline sessions, 3 intervention sessions, and one maintenance session. Bottom row tallies total number of macro-structure, micro-structure and surface level revisions for each essay. Right hand column tallies total number of revision types across text levels for each essay.

Table 11. *Number and Type of Revisions by Essay for Participant 3*

	Macro-structure								Micro-structure								Surface								Total							
Essay #	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Addition	0	0	0	0	0	0	0	0	1	3	2	0	0	3	3	1	0	0	0	0	0	0	0	0	1	3	2	0	0	3	3	1
Deletion	0	0	0	0	0	0	1	0	1	1	3	0	1	2	5	1	0	0	0	0	0	0	0	0	1	1	3	0	1	2	6	1
Substitution	0	0	0	0	0	0	0	0	3	8	8	2	4	7	2	1	12	0	2	1	0	0	0	1	15	8	10	3	4	7	2	2
Permutation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consolidation	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total	0	0	0	0	0	0	1	0	5	12	13	2	6	12	10	3	12	0	2	1	0	0	0	1	17	12	15	3	6	12	11	4

Note. Participant 3 completed 8 essay sessions, including 4 baseline sessions, 3 intervention sessions, and one maintenance session. Bottom row tallies total number of macro-structure, micro-structure and surface level revisions for each essay. Right hand column tallies total number of revision types across text levels for each essay.

Table 12. *Number and Type of Revisions by Essay for Participant 4*

	Macro-structure									Micro-structure									Surface									Total								
Essay #	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Addition	0	0	1	1	0	0	0	0	0	8	11	10	11	8	7	10	3	4	2	0	0	0	0	0	1	0	0	10	11	11	12	8	7	11	3	4
Deletion	0	0	0	0	2	0	0	0	0	4	3	3	8	2	1	1	3	0	0	2	1	1	0	0	1	1	1	4	5	4	9	4	1	2	4	1
Substitution	0	0	1	0	0	0	0	0	0	29	13	21	21	28	17	18	22	5	2	0	3	1	2	1	1	0	0	31	13	25	22	30	18	19	22	5
Permutation	0	0	0	0	0	0	0	0	0	0	1	2	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	2	1	0	2	1	1	0
Distribution	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consolidation	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Total	0	0	2	2	2	0	0	0	0	41	27	36	41	38	26	29	29	9	4	2	4	2	2	2	4	1	1	45	29	42	45	42	28	33	30	10

Note. Participant 4 completed 9 essay sessions, including 5 baseline sessions, 3 intervention sessions, and one maintenance session. Bottom row tallies total number of macro-structure, micro-structure and surface level revisions for each essay. Right hand column tallies total number of revision types across text levels for each essay.

Number and type of revisions varied across participants and across essays, with no clear pattern or trend of increase or decrease noted from baseline to intervention phases observed across individual data points. Mean number of revisions per phase, however, decreased from baseline to intervention for all participants. Participants made few revisions to macro-structure. The greatest number of revisions were micro-structure substitutions, most frequently word level substitutions, but also substitutions of phrases, and occasionally sentences. Micro-structure additions were somewhat less frequent, and micro-structure deletions were the third most frequent type of revision.

Research Question 3. When struggling writers receive prompts instructing revision behavior during expository essay writing, will they make revision changes specific to the prompts' suggestions as measured by type of revisions produced in response to revision prompts?

Based on examination of TPSF (Hayes, 2012b) when completing analyses for this research question, I noted the need for a post-hoc addition to the analysis as described in the Methods chapter. In examining a given writer's response to a given prompt, I reviewed the TPSF from the snapshot immediately subsequent to that taken at the time of prompt delivery. For example, to determine writer response to prompt #1, I reviewed snapshot #2. In reviewing the snapshots, I identified the need to consider whether the TPSF in that snapshot included the element the prompt addressed, even if that portion of the text did not constitute a revision change previously coded using the Faigley & Witte (1981) taxonomy as part of my analysis for my second research question. If, upon review, I determined that the writer's TPSF in the snapshot immediately subsequent to delivery of a given prompt had responded to the prompt, I entered a plus sign (+) in the table to indicate the writer had responded positively to the prompt, even though that response did not constitute an observable revision change from prior TPSF snapshot. The rationale for coding response to prompts in this way is based on the premise that revision behavior may occur in mind rather than on the page, as writers may generate ideas for writing, then make changes during the translation process before transcribing into text (Hayes & Flower, 1980a; Hayes, 2012a). In adding this approach to analysis for the third research question, the purpose was to ensure that I captured any evidence in the TPSF that the writer may in fact have responded to the prompt, with the caveat that the writer may have

intended to produce that portion of text despite the prompt. I discuss limitations to this approach in the following chapter.

Analysis of TPSF snapshots relative to the seven computer-based revision prompts across all intervention phase essays for the four participants revealed that 52% (44/84) of the prompts were not necessary for writers at the time they were delivered. In other words, at the time 52% of the prompts were delivered, the writers' TPSF had already addressed elements the prompts aimed to target. In all cases, writers responded with revisions following delivery of prompt #7, "You have 10 minutes left to read over your paper out loud or to yourself. Revise if needed." When prompts were determined necessary for the writer, specific responses to the prompts (+) made up 68% (27/40) percent of the responses. Table 13 summarizes participants' response to revision prompts across intervention phase essays.

Inter-scorer agreement results. I obtained inter-scorer agreement data on coding of response to revision prompts for 15% of the snapshots. Initial inter-scorer agreement on response to revision prompts was 79%, increased to 93% through discussion.

Table 13. *Participants' Response to Revision Prompts*

	Intervention phase essays											
	1				2				3			
Prompt	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4
1. First paragraph includes thesis statement	NN	+	NN	+	NN	+	NN	+	NN	NN	NN	+
2. Paragraphs contain main ideas that support thesis	NN	+	+	NN	NN	-	NN	+	NN	+	+	-
3. Supporting sentences in paragraphs back up each main idea	NN	+	NN	NN	NN	-	NN	+	NN	NN	NN	-
4. Supporting sentences within paragraphs in clear order	NN	NN	NN	NN	NN	-	-	NN	NN	+	+	NN
5. Paragraphs in logical order	NN	NN	NN	NN	NN	-	NN	NN	NN	NN	NN	NN
6. Wrote a conclusion	NN	+	+	-	NN	-	NN	+	NN	-	NN	-
7. Read over/revise if needed (10 minutes remaining)	+	+	+	+	+	-	+	+	+	+	+	+

Note. P1 = Participant 1; P2 = Participant 2; P3 = Participant 3; P4 = Participant 4; + indicates specific response to prompt present; - indicates specific response to prompt absent; NN = prompt not necessary (prompt criteria already addressed).

Research Question 4. What is the perceived benefit and acceptability of the prompting intervention as measured by a post-intervention questionnaire?

Descriptive analysis of post-intervention questionnaire response data suggested that participants found the intervention acceptable in its usability, and also perceived it to have benefitted their writing. Participants' responses to items seeking feedback on perceived improvements to their writing or perceived helpfulness of the prompts averaged 4.00 to 4.5 on a 1-5 scale.

Feasibility responses with high consistency included that all participants reported attending to the prompts when they were presented and found the presentation of the prompts acceptable. None of the participants reported confusion about how to respond to the prompts, and none reported disliking the prompt experience or being bothered by prompt interruptions.

Social validity responses with high consistency included all four writers reporting no difficulty understanding what the prompts meant, and reporting that prompts reminded them of things they could change to improve their writing. There was moderately high consistency for responses indicating that prompts reminded writers of things they sometimes forget to do when writing despite prior knowledge, the belief that the intervention helped writers learn something to help them write better, and the belief that the intervention helped writers organize their essays.

Table 14 reports participants' questionnaire responses.

Table 14. *Post-Intervention Questionnaire Responses*

Items	Participants			
	P1	P2	P3	P4
Feasibility				
I noticed the reminders when they changed at the top of the screen.	5	4	4	5
The reminders at the top of the screen distracted me.	3	2	2	1
I disliked this experience because I kept getting interrupted.	1	1	1	2
It was hard to focus on my writing.	2	1	2	4
I was confused about what to do.	1	1	1	2
I had trouble deciding what to revise.	1	2	1	4
I like the presentation of the reminders at the top of the screen.	4	5	4	5
Some of the writing topics were easier than others.	3	5	3	3
Social validity				
I feel like the revision reminders helped me write better essays.	5	3	4	4
The reminders made me think of things I could change to make my writing better.	4	5	4	4
I wasn't sure what some of the reminders meant.	1	1	1	1
The reminders reminded me to do things I already know but sometimes forget to do.	5	5	3	4
I feel like I learned something that helped me write better.	4	5	4	3
I thought revision was something I should do after I finish writing.	4	1	4	4
The reminders helped me organize my essay.	5	5	3	5

Note. 1 = Not at all; 2 = A little bit; 3 = Some; 4 = A lot; 5 = Almost always; Instructions: "Please rate each of the following statements using the scale above. When you respond, think about whether the statement is true of your experience with the computer-based revision intervention.

CHAPTER V

DISCUSSION

This study evaluated a computer-based revision prompting intervention for improving essay writing in undergraduate writers with ABI who expressed having difficulty with writing after injury. I hypothesized that overall essay quality would improve with computer-based revision prompting, that number and type of revisions would increase, that writers' revisions would respond specifically to prompts' suggestions, and that participants would find the intervention acceptable. This study, to my knowledge, was the first to investigate computer-based intervention for improving writing after brain injury. One earlier experimental study aimed to describe the characteristics of writing after brain injury in comparison to the writing of those with learning disabilities (Wheeler et al., 2014), opening the way for future intervention studies. The primary purpose of this study was to evaluate the effect of computer-based revision prompting designed based on a cognitive processes model of writing (Hayes & Flower, 1980a, 1980b; Hayes, 1996; Hayes, 2012a) on both essay quality (product) and revision behavior (process). To evaluate feasibility and social validity, I used a post-intervention questionnaire to gather data on participants' perceptions of benefit and acceptability of the intervention.

This chapter begins with an analysis and interpretation of the results for each research question with respect to the corresponding hypotheses. This is followed by a discussion of the study limitations and suggestions for how to address those limitations in future studies. The chapter concludes with a discussion of the clinical implications of this study and proposed directions for future research.

Research Question 1: Relationship Between Revision Prompting and Writing Quality

I hypothesized that overall quality scores would improve in response to the intervention. Results revealed a moderate intervention effect on overall quality by simply prompting writers with ABI to consider revising their writing. Importantly, these results suggest that self-monitoring alone may have been sufficient to assist writers in tapping or activating their existing writing skills, and in so doing, improve the quality of their written product. Simple, but targeted computer-based prompting, appeared to be sufficient to help writers with ABI improve the quality of their expository essay writing from a non-passing score to one that passes criteria for state high school writing standards. To date, we have no data on essay writing performance after ABI and on how profiles may differ from the unimpaired population. We also do not have intervention data on methods to improve writing performance in people with ABI who exhibit writing impairments. These findings raise questions that encourage further research. For example, what may account for the improvements in quality scores? Also, what may account for the maintenance of increase over baseline given the short intervention? The sub-sections that follow discuss possible explanations for quality improvements, including possible reasons for maintenance of improved quality one week post.

Improved quality of macro-structure vs. micro-structure. Computer-based prompting may have differentially affected essay macro-structure compared to micro-structure of the essays participants produced. Improvements to overall essay quality were related to macro-structure rather than micro-structure, as evidenced by a functional relation between prompting and increased scores for Organization and Ideas and Content

dimensions during the intervention phase of the study. Four of the seven prompts (see Table 4 in **Method**) were designed to target organization, ideas and content at the macro-structure level (e.g., thesis, main ideas, paragraph order, conclusion). Two prompts were developed to target micro-structure (supporting sentences, sentence order in paragraphs). One prompt—the last—encouraged general review ("read over your paper"). All prompts ended with the statement, "Revise if needed." The prompting intervention may have affected macro-structure, resulting in positive changes to ideas, content, and organizational quality. In contrast, prompting seems to have had less effect on micro-structure elements in that micro-structure revisions were not linked to specific prompt suggestions (see also **Research Questions 2 and 3**, below). Relative to macro-structure, results suggest that perhaps prompting alone may be sufficient to assist writers in self-monitoring to tap their existing writing knowledge and thereby improve quality of the written product. Elements of micro-structure, however, may require customized prompting procedures or explicit teaching to lead to improved quality. Of interest, differential impact of prompts that targeted macro- versus micro-structure may perhaps account for corresponding improvements in quality dimensions as evidenced through findings of both visual and statistical analyses. I discuss those findings in the following sub-sections.

Dimensions of quality. In addition to primary analyses of overall quality, secondary visual and statistical analyses evaluated relative contributions of the six dimensions of quality the rubric scored. Visual inspection of data plotted for Ideas and Content and Organization dimensions supported a functional relation of each with the intervention. Analysis revealed a statistically significant effect for Organization for

participant P4, with no statistically significant findings for Ideas and Content or Organization for the other participants. Analyses suggested that the prompting had less effect on microelements like sentence fluency and conventions, yet prompting may have affected macro-structure, resulting in changes to organizational quality. In seeking to explain the finding that Organization and Ideas and Content domains improved, contributing to improved overall quality, it is important to consider the role self-monitoring may have played in improving these macro-structure elements.

Role of self-monitoring. As noted in the literature review, brain injury researchers and writing researchers have described similar conceptualizations of self-monitoring and self-regulation (e.g., Kennedy & Coelho, 2005; Mason & Graham, 2008; Zimmerman & Risemberg, 1997). In their study of error self-regulation, Ownsworth, Quinn, Fleming, Kendall and Shum (2010) describe self-knowledge, self-monitoring and self-regulation as integrated, but distinct aspects of metacognition. They defined self-knowledge as awareness of one's own performance ability and the need for strategy use. Self-monitoring was differentiated as an ongoing process of self-evaluation during task performance. Self-monitoring of task performance includes the ability to identify errors. Self-regulation was differentiated as the ability to make performance adjustments in response to the demands of a task. Also, in a scoping review of executive function, self-regulation and attribution in ABI, Hunt, Turner, Polatajko, Bottari and Dawson (2013) described self-regulation as a process for making adjustments to performance while working toward goals, with complex tasks requiring conscious effort at self-regulation. These conceptualizations of self-monitoring and self-regulation align with literature reviewed earlier on self-regulation after brain injury (Kennedy & Coelho, 2005) and self-

regulation as it pertains to writing performance (Graham & Harris, 2012; Mason & Graham, 2008; Zimmerman & Risemberg, 1997). Overall, the literature suggests that self-monitoring is an ongoing process of noticing performance, whereas self-regulation refers to modification of behavior based on the results of self-monitoring.

Prompting self-monitoring has the potential to facilitate improved self-regulation of performance for people with brain injury, and the role of self-monitoring in self-regulating performance may explain participants' improvements to writing quality in response to computer-based prompting (Kennedy & Coelho, 2005). As participants in this study wrote their essays, the computer-based revision prompts may have encouraged writers to self-monitor and review their writing more frequently in intervention than in the baseline phase of the study. Prompting these writers with ABI to review their work may have encouraged self-feedback (Kennedy & Coelho, 2005) and facilitated strategic control with their writing process, helping them make more strategic decisions while writing and ultimately led to self-regulation. Although no studies examining prompting of writing behavior after brain injury exist for comparison, other studies of self-monitoring after brain injury have examined interventions incorporating prompting techniques during complex tasks with positive results. For example, a study by Ownsworth, Fleming and colleagues (2006) examined a metacognitive intervention using a combination of specific and non-specific prompts to encourage self-monitoring in order to detect errors during a cooking task. They reported that the intervention yielded positive results. In a similar investigation, Ownsworth, Quinn and colleagues (2010) reported an increase in self-correction and decreased errors during cooking tasks with a metacognitive intervention. Certainly, cooking and writing are very different types of tasks. On the other hand,

cooking and writing are similar in that they are both complex tasks requiring individuals to operate within multiple constraints while self-monitoring and self-regulating their performance to meet the demands of the task. For the current study, prompting connections between self-monitoring and strategy use *while* writers were engaged in the process of writing may have helped them focus more successfully on the rhetorical problem (Hayes & Flower, 1980a) of responding effectively to the writing task. Conceivably, computer-based prompting to "revise if needed" supported self-monitoring, thereby contributing to these writers' improved self-regulation of writing (Mason & Graham, 2008) to produce better quality essays. Alternatively, the prompts may merely have served as a source of external encouragement for self-evaluation of writing as writers produced text while tapping task schema knowledge.

Role of task schemas. Writers employ task schemas for carrying out revisions when completing writing tasks. (Hayes, 2012a). Computer-based prompting may have helped writers in the current study tap task schemas—existing writing knowledge—more effectively during the writing process to help them improve the quality of their writing. Of relevance, Proske and colleagues (2012) found that writing quality improved for undergraduate writers in response to computer-based prompting, noting a need to externally support revision knowledge. Additionally, early research found that focused targeting of revision resulted in improved text quality for undergraduate writers (Wallace & Hayes, 1991). Those writers with difficulty were suspected to have performed less well with revision tasks because of lack of task schema knowledge (Wallace & Hayes, 1991; Hayes, 2012a). Further, Hayes (2012a) described revision behavior in those with writing difficulty as consisting primarily of surface edits that do not adequately address macro-

structure, micro-structure, or audience perspective. In the current study, writers self-reported different writing knowledge and abilities. The unexpected maintenance of increase over baseline following a brief intervention may be explained by writers' existing knowledge of task schemas. Since these writers had previously typical functioning prior to their brain injuries, they may have had foundational skills which were leveraged when they were supported to self-monitor. Access to prior knowledge of how to write, once tapped, may have helped these writers to self-regulate their writing beyond the intervention phase of the study.

Graham and Harris (1997) noted that producing a quality product involves more than the ability to self-regulate; writing also requires knowledge of how to produce writing with a given audience in mind. Writers must transform that knowledge to effectively meet the expectations of a writing task (Bereiter & Scardamalia, 1987; Kellogg, 2008). Because efficiently and effectively managing the multiple constraints involved in completing a complex writing task requires working memory (Kellogg, 2008), which is often impaired after ABI, the computer-based prompts activating existing writing knowledge may have proved the active ingredient for helping these writers improve the quality of their essays.

Pre-correcting existing writing knowledge. Writers' responses to writing knowledge questions at the outset of the study suggested that some of the writers more readily expressed their knowledge of how to write than others. For example, participant P3 offered more detailed responses to knowledge questions than did the other three participants. Interestingly, P3 also demonstrated higher baseline quality scores and more modest improvements in overall quality relative to baseline than other writers. Although

the prompting intervention did not appear to stimulate macro-revisions *during* writing, it may have changed how writers approached their process in future sessions. Conceptually, this notion of prompting could be thought of as akin to pre-correction techniques discussed in behavioral literature on academic problem behaviors. Pre-correction is way of prompting to focus an individual on a target behavior typically required or expected in a given context (DePry & Sugai, 2002). In the context of the current study, prompting, or pre-correcting, writers who possessed background knowledge to attend to macro-structure elements important for essay organization may have helped these writers achieve improved improved writing quality. Interestingly, this finding is the opposite of what was hypothesized—that prompting specifically to stimulate *revision* would be the key. Given that to date we have no data on writing performance and how to improve it for this population, these findings encourage further research.

Prompt saliency: modeling thinking aloud. Modeling how to think aloud about steps for how to carry out a particular writing task is an aspect of strategy instruction described in the writing intervention literature (Mason, Harris & Graham, 2011). In an intervention study with three adult writers, for example, MacArthur and Lembo (2008) included modeling of how to think aloud for strategy steps in instructing three adult writers in persuasive essay writing. They found that writers demonstrated improved quality in post-test sessions completed after an intervention phase comprised of 8-9 session of 60-120 minutes duration. For the current study, the prompting intervention was computer delivered during three 59-minute writing sessions completed during a period of 1-2 weeks for each writer. The intervention may have served to model the sort of thinking aloud writers may have needed in order to more successfully self-regulate the production

of subsequent essays and maintain at follow-up. The fact that all writers in the study were adults enrolled in college may mean that writers perhaps entered intervention with motivation and a purpose for engagement, which may have contributed to maintenance.

Research Questions 2 and 3: Relationship Between Revision Prompting and Writing Process

For my second and third questions respectively, I hypothesized (1) an increase in number and type of revisions in response to computer-based prompting, and (2) revision changes would be specific to prompt suggestions. Hypothesized revision behavior in response to prompts was not upheld for either question. The results did not support the hypothesis that writers would increase number of revisions with prompting, nor that they would respond specifically to prompts' suggestions. Interestingly, the mean number of revisions per phase decreased from baseline to intervention for all participants. In the following sub-sections, I discuss possible reasons for these outcomes.

Intervention phase decrease in mean number of revisions. The mean number of revisions decreased from baseline to intervention for all participants. This finding was unexpected, and the reasons for it are unclear. One possibility is that writers became more strategic in their use of revision in the intervention phase, but data on the types of revisions coded in the snapshot samples of TPSF do not appear to support this idea. For example, as discussed earlier, improvements to the quality of organization, ideas and content in intervention compared to baseline may link to improved macrostructure, yet few macrostructure revisions were observed. Strategic revisions aimed at improving organization, ideas and content seem likely to show up in the TPSF as macrostructure revisions, yet such revisions were not observed. It could be that quality improvements in

those areas were related to improved self-regulation of writing process through more efficient tapping of task schema knowledge, discussed earlier. Also, revisions may have occurred in mind but not on the page. On the other hand, it could perhaps be that measurement challenges limited capacity to observe strategic revisions to macro-structure that otherwise might have been captured in the TPSF. I discuss that possibility in the next subsection.

Measuring revision after ABI. Coding revisions in snapshots of TPSF (Hayes, 2012b) with the Faigley & Witte (1981) taxonomy did not reveal an increase in number of revisions with implementation of the prompting intervention, and it did not reveal revisions that responded specifically to prompts' suggestions. Although the hypotheses were based on available literature, most of the literature on revision in writing is based on studies with typical writers or writers described as less experienced. There are no studies of revision after ABI. It follows that my assumptions about revision behavior may have been inaccurate with respect to the ABI population. Hence, the revision taxonomy (Faigley & Witte, 1981) employed for categorization and measurement of revision may not have been adequate. Although I piloted the taxonomy by using it to code revisions in existing data from the earlier unpublished pilot study (Ledbetter et al., 2014), it had not been used in experimental research with the ABI population prior to this study. Moreover, the revision taxonomy has not been used for coding snapshots of TPSF in prior research. Development of a novel system for coding or describing revisions may prove useful, but would require pilot research to determine how best to develop and test it.

Response or no response? At times it was difficult to determine whether a writer may have responded to a given prompt. Two explanations may account for this uncertainty. First, analysis of the TPSF snapshots for evidence of writer response to a given prompt required comparing snapshots of text that the application captured simultaneously with delivery of each prompt. Each snapshot was taken 7 minutes later than the previous snapshot. The snapshots represented a sampling of TPSF essentially frozen in time. During the 7-minute interval between snapshot samples of TPSF, clearly participants continued to write, meaning that some ongoing revisions to TPSF may have been lost. Another way of clarifying the snapshots at 7-minute intervals could be to liken them to a writing sample that may not adequately represent a writer's capacity. The procedure for capturing snapshots was constrained to the prompt delivery interval, thus necessitating a compromise. A second explanation is that, in some cases, writers may have demonstrated a delayed response to the prompt, addressing the prompt suggestion later in the process of generating the essay, rather than responding with observable revisions to TPSF. For these reasons, the procedure used does not consistently allow for a determination about the impact of the prompt on revision behavior, and requires further study.

Adequacy of Prompts. Two potential factors are relevant in explaining the inadequacy of the specific prompts to stimulate revision: the delivery interval for the prompts and the specificity of the prompts. I discuss each in the following sub-sections.

Computer-based prompt delivery interval. Per a pre-determined schedule, computer-based prompts appeared on-screen at 7-minute intervals. Snapshots of TPSF (Hayes, 2012b) taken at each interval intended as a sampling of TPSF at the time of

prompt delivery may have failed to capture revisions writers typed in direct response to the prompt. Scheduling delivery of the prompts was a crucial decision point with respect to designing this intervention. The design challenge was to determine a reasonable interval at which to deliver the prompts on screen. In an earlier pilot study conducted to examine the use of directed retrospection prompts for assessing how writers allocated their time during the writing process (Ledbetter et al., 2014), the scheduled prompt delivery interval was 90 seconds based on the pilot study's purpose. The purpose of the current study being different, and with no study of similar purpose available upon which to base the prompt delivery interval, the decision to set the 7-minute interval was somewhat arbitrary. The intent was to allow enough time for writers to produce revisions in response to a given prompt while also spacing delivery of the seven prompts fairly evenly over the course of a writing session. Also, the application used for designing the intervention at this point in time imposed the necessary limitation that the snapshot be taken simultaneously with delivery of the prompt.

The effect of increased overall quality discussed above may not directly relate to revisions produced at the time the snapshot was taken, as most revisions were word or sentence-level additions or substitutions to micro-structure with no impact on organization and minimal or no impact on ideas and content. More likely, the computer-based prompts alerted writers of specific needs to address, such that, as they continued to write their essays, writers devoted more attention to those needs while generating their writing. The net effect, then, was that they did not produce identifiable revision changes that I would have been able to code in the TPSF using the Faigley and Witte (1981) taxonomy, but rather, they produced higher quality writing moving forward. A relevant

consideration here is the possibility that writers may in fact have engaged in revision in mind, but not on the page.

Prompt specificity. Another factor influencing adequacy of the prompts is that the intervention may have needed to instead employ different prompts, perhaps customized to individual writers' needs. Two of the prompts seemed more likely to have evoked revisions. The first, prompt #6, targeted writing a conclusion. Prompt #6 evoked revisions for the writers in more instances than the other task-specific prompts. Those revisions were typically additions or substitutions to micro-structure. The second prompt that tended to evoke revisions was the task-general prompt #7. Prompt # 7 precipitated micro-structure revisions for all participants.

Of relevance to this discussion of prompt adequacy is that a determination that a given prompt was "not necessary" should not necessarily suggest that the prompt was not useful for the writer in producing the rest of their essay. The designation "not necessary" indicates a judgement based on analysis of the TPSF corresponding to a given prompt for which the writer had already addressed the suggestion for revision in the *previous* snapshot.

Finally, addressing concerns about prompt adequacy requires further study of the specificity of prompts in relation to writing behavior. For example, facilitating self-selection of goals for writing before developing customized computer-based prompts based on those goals may prove more helpful for some writers.

Research Question 4. Feasibility and Social Validity

All participants perceived benefit from the intervention and found its design and delivery acceptable. I discuss questionnaire responses here.

Feasibility. A high level of consistency in responses suggests positive experience with the intervention, supporting its feasibility. Participants attended to prompts when presented and found their presentation acceptable. No participants reported confusion about how to respond to the prompts. None reported disliking the prompts, or the interruptions they experienced with each on-screen prompt delivery. Of relevance, the assessor of feasibility for this study also served as the interventionist. Accordingly, participants may have experienced positive perceptions of the intervention if they also perceived the interventionist positively. However, review of post-intervention questionnaire ratings revealed they were not uniformly high or low across participants, suggesting that participants applied ratings with some objectivity. Based on that observation, responses were judged as representative.

Social validity. Responses with high consistency indicated that no participants had difficulty understanding the prompts. Positively, participants reported that the prompts reminded them of items they might change to improve their writing. Responses with moderately high consistency indicated that writers found the intervention helpful and useful. Participants reported that the prompts reminded them of items they sometimes forget when writing. They also reported experiencing that the prompts helped them to better organize their essays and to write better in general. Although writers' responses to the post-intervention questionnaire suggest that writers generally found the intervention beneficial, further studies could investigate the degree to which certain types of prompts may be useful to individual writers. The accessibility and acceptability of this computer-based prompting intervention is a valuable finding, as it suggests the intervention holds merit for the intended users and thus would be likely to be adopted. This study opens the

way for development of more computer-based prompting interventions designed with the needs of writers with acquired cognitive impairments in mind. To that end, this work constitutes an important proof of concept.

Although several computer-based tools are available to assist school-aged and college writers who have difficulty with the writing process, these tools address concept mapping, outlining, planning, brainstorming ideas, word prediction, text-to-speech, spelling and grammar checking functions (Bouck, Meyer, Satsangi, Savage & Hunley, 2015). Such tools differ notably in purpose from the intervention tested in this study. Intelligent tutoring systems (ITS) for writing also exist. One such non-commercially available ITS offering computer-based scaffolding and assistance with strategies for the writing process is WritingPal (Roscoe & McNamara, 2013). The purposes of WritingPal are similar to those of the intervention the present study tested, insofar as the aim of each tool is to improve both writing product and process. The intervention evaluated in this study is distinct from WritingPal (Roscoe & McNamara, 2013) in at least two unique ways: (1) it delivers sequenced, targeted prompts at scheduled intervals during the writing process, and (2) the writer does not have to decide to access information in modules; rather, the prompts appear on-screen at pre-set intervals to remind the writer of items to consider while writing. These distinctions are important for writers with ABI and others with attention, working memory or executive function impairments, as computer-based revision prompting intervention may help writers compensate for difficulty accessing task schema knowledge. Writers from these populations are likely to benefit from interventions that alleviate demands on working memory, thus freeing capacity (Olive, 2012) for managing complex writing tasks.

Study Limitations

Design compromises are a primary limitation of this study. Recruitment challenges necessitated a non-concurrent design. Non-concurrent designs do not require that subsequent participants be held in baseline before implementing intervention with the previous participant. The lack of concurrent baseline data for participants P3 and P4 in this study may compromise to some degree the internal validity of the study. Another design compromise noted initially when describing the methods is the decision to deviate from the single-case design standard of including a minimum of five data points per phase (Horner et al., 2005) in order to protect against practice effects with repeated essay writing. Given design challenges, treatment effects as determined through visual inspection and statistical analysis may in reality be somewhat smaller or larger than reported.

In addition to design limitations, further piloting of procedures for measuring revision behavior may have allowed for capturing revision changes in TPSF (Hayes, 2012b). The revision taxonomy (Faigley & Witte, 1981) used for coding revision changes has not been used in prior studies of writers with brain injury. The taxonomy may be inadequate for coding revision for this population. Also, because the taxonomy had not been used for coding TPSF snapshots in prior studies, more extensive piloting may have been needed for the current study. Finally, the 7-minute delivery interval for the prompts limited capacity to identify revision changes..

Another conceivable limitation is the possibility of a moderating effect of essay topic. Controlling for topic effect consisted of combined use of random topic selection and a topic rating procedure. The intent of the random topic selection and rating

procedure was to ensure topic equivalency across trials by establishing a similar degree of familiarity and interest for a given participant's writing topics. Despite this effort, topics varied considerably (see list of topics in the Appendix). Some topics may have been easier or more challenging for some writers, a reality that may have introduced variability into the quality scores, and in turn may have influenced the study outcome.

Finally, the small sample size limits generalizability of findings. Despite limitations, this study's findings invite further research questions. For example, what types of writers with brain injury would most benefit from this intervention? What are the profiles of those most likely to benefit from it?

Conclusions

This study provides some of the first data on writing intervention for writers with ABI. Results suggest that computer-based prompting during the writing process can be effective in increasing self-monitoring, leading to improved essay quality. Further, results suggest that undergraduate writers with ABI perceive computer-based prompts as both acceptable and useful. An important clinical implication of this study is that undergraduate writers with ABI who present with expository writing difficulties may respond positively to computer-based prompting to self-monitor during the writing process.

Importantly, this study encourages further investigation of writing after ABI, as there are clearly writers in this heterogeneous and complex population in need of supports. Descriptive studies of writing after ABI would be useful in identifying and describing profiles of writers with brain injury. Apparently only the second study of writing after ABI, this study's findings add to the findings of Wheeler and colleagues

(2014), and along with their study, help begin to build an evidence base. Wheeler and colleagues (2014) found difficulty with sentence fluency and conventions (grammar and spelling) among characteristics of writing difficulty for adult writers with brain injury. Interestingly, results of the current study pointed to organization, ideas and content as most responsive, making the difference between non-passing and passing quality scores for participants. What might account for this difference in findings? In their study, Wheeler and colleagues (2014) analyzed 10-minute paragraph writing samples, whereas this study analyzed essay quality across multiple essays for each participant. The difference in findings could be accounted for by writing sample length and heterogeneous profiles among individuals with ABI. Further research is warranted to continue to build the evidence base on writing after brain injury.

Future research directions. This intervention study responded to MacArthur's (2012) suggestion that there is a need for brief, theoretically driven interventions for writing. To continue the current work, research into design and development of computer-based prompting interventions for writers with ABI might follow a two-part agenda. Studying writing process behaviors separately from intervention prior to conducting further investigations of response to prompting would add to the evidence base describing writing after ABI. Mixed methods studies of writing process for writers with ABI should be conducted with a large enough sample size and matched controls to gather quantitative data on product and process along with qualitative data on writers' perceptions of their process, strategic decisions while writing, and tapping of writing knowledge during the process. Such studies might employ screen-capture technology and

online video-recording tools combined with keystroke logging to gather large amounts of data on writers with ABI to inform the design of future intervention studies.

Secondly, results of the current study suggest that prompting to self-monitor and self-evaluate writing improved quality of writing for these participants, but this finding requires more robust examination in further experimental studies. Studies examining types of prompts delivered and their impact on writing process for this population would be useful in refining prompting procedures. For example, a first step may be to compare task-specific to task-general writing prompts with better control over prompt delivery intervals with analysis of keystrokes to capture revisions in real time incorporated into methods. Another research need for intervention design and development in this area is to test the integration of customized strategies into computer-based prompting intervention for writing. Also, determining the feasibility of self-deliverability for this type of intervention would be useful in addressing the needs of undergraduate writers with busy schedules who are seeking support for their writing process.

Ultimately, there may be broader applicability of computer-based prompting interventions like this one to other populations of undergraduates with writing challenges. Refinements to the intervention in its current form with subsequent testing of design features and functions may best be tested initially using single-case design methods.

APPENDIX A

EXPOSITORY ESSAY TOPICS

1. Parenthood is not easy. Explain some of your thoughts on what makes an effective parent and why.

2. Think of a successful person. Explain what makes a successful person by using specific examples of the qualities, characteristics, behaviors, etc., that contribute to that person's success.

3. Imagine for a moment that there are no budget problems that affect schools. Explain your idea of the best possible education that a school could offer and explain how this education would benefit students.

4. What mistakes did you make in high school? Explain to a 9th grader some lessons you learned to help them avoid making similar mistakes.

5. You are serving on a committee that will design a new high school for your community. Choose one feature for the new high school that you will suggest to the design committee. Write a report to the committee, explaining what this feature is and why it is beneficial.

6. People have many admirable character traits, like courage, enthusiasm, compassion, integrity, friendliness, strength, etc. Choose a character trait, explain what makes it important, and tell about how you see examples of that character trait in yourself or others.

7. Visitors from another country want to learn about your community, region, or country. What can you explain to them that will help them to understand more about where you live?

8. Think of something that you learned outside of school. Explain clearly what you learned and why it was important so that your reader will gain some new information.

9. Young people sometimes question how things they learn will help them in their later lives. Think of a positive learning experience that you have had and explain how what you learned will be useful to you in the future.

10. Bullying is a problem in many schools. Write a paper to explain what students, teachers, and parents can do about bullying and how their actions would help eliminate this problem.

11. Looking back over your years in school so far, explain what you would want to tell your teachers and how your advice might help teachers teach other students more

effectively.

12. Think of a place or object that you have seen or read about. Explain what this place or object is and why it is interesting or important.

13. What do you think is the best thing to do when someone says, "Who wants to go first?" or "Does anyone want to volunteer?" Write a paper to explain what you think is the best approach when you hear those words and why.

14. Research shows that people communicate messages about who they are by the clothing they wear. Explain how and in what ways you think clothing sends messages to other people.

15. Think of an important decision you had to make once. Write an essay explaining why the decision you made was the right decision.

16. Explain something important about life that you learned outside of school, and why it matters to you.

17. Someone once said, "When the character of a person is not clear to you, look at his or her friends." Explain how and why this quote relates to you or someone you know.

18. You graduated from high school not too long ago. What advice would you give a 9th grade student at your old high school to help them be successful in school? Write an essay detailing the experiences and advice you believe would help someone starting out in high school.

19. Common fads or trends in music, clothing, and recreation come and go. Choose one fad or trend that is popular now and explain why it is popular and if you think its popularity will last.

20. Think of three inventions you could not live without. Explain what those three inventions are and why they are so important to you.

21. Choose an invention from the past 100 years or so (telephone, car, computer, TV, etc.) and write an essay on how that invention has changed people's lives. Has the invention made things better or worse? Why?

22. Think of one object that is important or valuable to you. For example, it could be a book, a piece of clothing, a game, or any object you care about. Describe the object and explain why it is valuable or important to you.

23. Choose a problem in your community that concerns you. Write an essay in which you describe the problem and offer possible solutions.

24. Name one goal you would like to accomplish and give specific reasons why. Give enough details so that your reader will understand your ideas.

25. Choose an object that you could imagine being and describe why you would choose to be that object. It could be anything: a tornado, a computer, a clock, a volcano, a river, an airplane—anything!

26. Write an essay explaining how to study effectively for a test. Include strategies that you think would help study effectively, and explain how you believe those strategies would help you prepare for taking the test.

27. Think about something you really want: a situation, a job, an object, or a characteristic. Write an essay about what you really want and explain why you really want it.

28. If you could change places with another person for a whole day, who would you change places with and why would you choose that person?

29. Write an essay to explain what you can do to keep occupied in a week of no TV, computer, or video games. Explain why you chose the activities you describe.

30. Think about your closest friends. Write an essay to explain what makes someone a good friend and why.

31. Write an essay explaining what success means to you. What goals do you need to meet to be able to consider yourself successful? What are the ingredients required for leading a successful life?

32. Imagine yourself four years ago. Compare and contrast yourself four years ago with your current self. Explain how you've changed and how you've stayed the same.

33. What are the qualities that help someone earn the respect of their peers? Write an essay in which you describe what characteristics help someone earn the respect of others.

34. Sometimes students lose interest in school. What can be done to keep students motivated and focused on their studies? Write an essay to describe how to make class and learning interesting in order to keep students motivated.

35. In order to survive, people have been known to do things they would not ordinarily do. Write an essay that explains what people will do in order to survive. Use examples from real life, books, movies, or television shows to support your essay.

36. Write an essay explaining the importance of being able to see a situation from another person's point of view.

37. Think of a time you experienced foregiveness from someone, or a time when you realized you needed to foregive someone. Write an essay explaining the importance of forgiveness.

38. Write an essay explaining the role music plays in your culture or in your own life. How is music important to you or those close to you?

39. Write an essay explaining what makes a great leader. What characteristics and actions make a person successful leader?

40. Identify an improvement you think schools could make to better prepare students for life after high school. Write a letter to the school board in which you describe this improvement and explain why it is needed.

APPENDIX B

FAMILIARITY AND INTEREST RATING SCALES

least familiar 1 2 3 4 5 6 most familiar

least interesting 1 2 3 4 5 6 most interesting

APPENDIX C

REVISION DEMONSTRATION SCRIPT

While you are writing your essay, you will see a prompt appear on the screen about here [point to screen] each 7 minutes.

The prompts will ask you to think about things you might want to revise in your writing.

I'd like to show you an example prompt and how I might respond to it. Here is a prompt that might appear:

Check to make sure you've included supporting sentences in your paragraphs to back up each main idea. Revise if needed.

Imagine I've already written this paragraph when I see the prompt above:

Using Google calendar helps me stay organized. I use it nearly every day to keep track of appointments. I also like to include lunch dates with friends because I don't like to double book by accident.

When I see the prompt, it asks me to be sure I've included supporting sentences to back up my main idea. My main idea here is that Google calendar helps me stay organized. But I only really have two sentences to support that idea. Hmm. I could add a sentence about another way Google calendars helps me stay organized. I know—I could add this sentence:

Google calendar also allows me to set reminders so I don't miss any of my appointments.

By adding this sentence, I've strengthened the support for my main idea that Google calendar helps me stay organized.

This is just one type of prompt you might see asking you to revise. Do you have any questions, or are you ready to get started?

APPENDIX D

POST-INTERVENTION QUESTIONNAIRE

Date:
Age:

1 = Not at all
2 = A little bit
3 = Some
4 = A lot
5 = Almost always

Please rate each of the following statements using the scale above. When you respond, think about whether the statement is true of your experience with the computer-based revision intervention.

____I noticed the reminders when they changed at the top of the screen.

____I feel like the revision reminders helped me write better essays.

____The reminders at the top of the screen distracted me.

____The reminders made me think of things I could change to make my writing better.

____I disliked this experience because I kept getting interrupted.

____It was hard to focus on my writing.

____The reminders reminded me to do things I already know but sometimes forget to do.

____I was confused about what to do.

____I had trouble deciding what to revise.

____I like the presentation of the reminders at the top of the screen.

____I feel like I learned something that helped me write better.

____I thought revision was something I should do after I finish writing.

____I wasn't sure what some of the reminders meant.

____Some of the writing topics were easier than others.

____The reminders helped me organize my essay.

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