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Reading Fluency and Adolescent Students'
Reading Processes During Writing

Scott F. Beers

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requirements for the degree of

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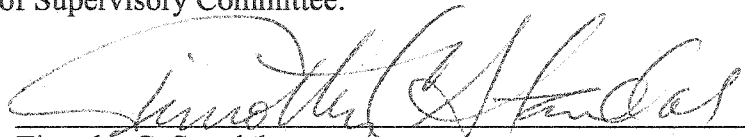
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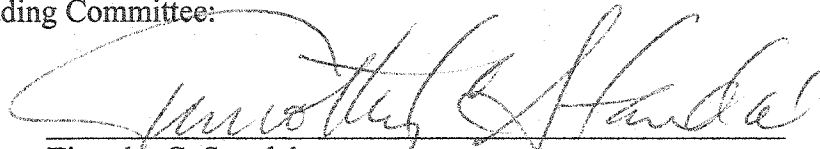
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Abstract

Reading Fluency and Adolescent Students'
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Reading is an important part of the writing process, and mature writers frequently reread their developing texts as they compose. From basic proofreading to planning and idea generation, reading-during-writing processes can facilitate text production in many ways. If word-recognition processes are inefficient, however, reading-during-writing processes may be constrained. The primary aim of this study was to determine the effects of reading fluency skills on the reading-during-writing processes of adolescent students. One group of fluent (N=18) and one group of less fluent (N=18) 7th and 8th grade readers composed narrative and expository texts, while an eye-tracking device recorded students' eye movements during composing sessions to measure reading patterns. Eye movement patterns were coded as *monitoring* (eye fixations on the most recently composed words), *reading* (eye

fixations on previously written text), *prompt* (eye fixations on the writing prompt), or *off-text*. Repeated-measures ANOVAs showed that although fluent readers composed higher quality texts, the reading-during-writing behaviors did not differ significantly across groups. In both groups, adolescent students exhibited high levels of *monitoring* and relatively little *reading* processes.

In a secondary analysis designed to examine the effects of writing skill upon reading-during-writing processes, students were grouped according to gender. Repeated measures ANOVAs revealed robust differences in reading-during-writing processes. When writing essays, girls employed more *reading* behaviors, exhibited less *monitoring*, and wrote higher quality texts than boys. These findings parallel national reports of persistent gender gaps in writing performance, and begin to explain how different writing processes (including reading-during-writing) contribute to this gap. Increased reading-during-writing processes may indicate “border crossings” into *knowledge transforming* approaches to writing (Bereiter & Scardamalia, 1987), which rely upon frequent interactions with the developing text. Effective approaches to writing instruction and intervention may need to pay increasing attention to the development of reading-during-writing processes.

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DEDICATION

To my wife Kristen and my sons Cameron and Connor.

Chapter 1: Statement of Problem

Adolescents entering the adult world in the 21st century will read and write more than at any other time in human history.

(Moore, Bean, Birdyshaw, & Rycik, 1999, p. 3)

Despite the increasing need for well-developed literacy skills, many adolescents in the US are struggling to achieve basic competency in reading and writing. According to the most recent national assessment of eighth-grade reading, 26% scored below the *Basic* level and only 32% demonstrated *Proficiency* or more advanced reading skills (NAEP, 2003). Students who cannot read at the *Basic* level struggle to demonstrate a literal understanding of what they read and may not be able to make simple inferences or interpretations. In Washington State the profile of reading achievement is similar (OSPI, 2001), with 33% of the state's eighth-grade students at *Below Basic* levels. On Washington's Assessment of Student Learning (WASL), 58% of the state's seventh grade students failed to meet the benchmark standards for reading (OSPI, 2001). Although benchmark scores and proficiency levels are arbitrarily determined and should be interpreted cautiously, these assessments strongly suggest that substantial numbers of students are struggling with reading.

Many of these students have inefficient word decoding processes that can impair comprehension. According to Perfetti's (1985; 1992) depiction of reading ability, efficient word identification processes underlie text comprehension. When reading is efficient, word-level identification requires few attentional resources, which can instead

be marshaled for evaluating the text and constructing meaning (Just & Carpenter, 1992; National Reading Panel, 2000). When reading is less efficient, decoding is often a painstaking, effortful process that hinders comprehension (Fuchs, Fuchs, Hosp, & Jenkins, 2001; Pinnell, Pikulski, Wixson, Campbell, Gough, & Beatty, 1995). Less efficient decoding requires substantial cognitive resources that could otherwise be allocated to comprehension (Pinnell et al., 1995). In other words, less fluent reading requires more working memory resources than fluent reading, constraining comprehension processes (Just & Carpenter, 1992). According to the national assessment of oral reading fluency (Pinnell et al., 1995), 44% of fourth graders were considered disfluent when reading grade-level stories. Although reading fluency is rarely measured at the middle school level, a study of a Seattle-area school (Standal, Beers, Coskie, & Jones, 1999) found that 12-15% of eighth-grade students struggled with basic decoding processes and demonstrated fluency problems.

Inefficient reading processes may also affect writing performance. As with reading, the majority of middle school students consistently perform below expected proficiency levels. Nationally, 69% of eighth-grade students demonstrated *Basic* or *Below Basic* levels of writing achievement in 2002 (NAEP, 2002). Student performance in Washington State mirrors the national picture, with 66% of eighth-grade students at *Basic* or *Below Basic*. On the WASL, 51% of students in seventh grade failed to meet the standard for grade-level writing achievement (OSPI, 2001). Part of the performance deficit in writing may be explained by poor reading skills. Research into the reading-

writing relationship (i.e. Fitzgerald & Shanahan, 2000) has consistently shown that reading processes contribute to writing processes.

Inefficient reading processes may constrain specific components of the writing process. As writers compose, they frequently reread their developing texts (Beers & Quinlan, 2000; Breetvelt, van den Bergh, & Rijlaarsdam, 1996; Kaufer, Hayes, & Flower, 1986; Faigley, Cherry, Jolliffe, & Skinner, 1985; Perl, 1979; Pianko, 1979; Stallard, 1974). In their influential model of writing, Hayes and Flower (1980) asserted that the “text produced so far [is] a very important part of the task environment because the writer refers to it repeatedly during the process of composition” (p. 12). In Hayes’ and Flower’s original model rereading serves reviewing functions such as editing and/or proofreading as well as evaluative functions, as writers compare their texts against their goals recursively. Recent models of writing (Hayes, 1996; Kellogg, 1996) depict a more expanded role of reading processes that occur during writing tasks. For example, Kellogg’s model (1996) portrays reading-during-writing as a process that contributes to planning and text generation processes (transforming ideas into language representations in working memory, see Berninger & Swanson, 1994). Hayes’ model (1996) suggests that reading-during-writing involves complex processes of text interpretation and reflection, which lead to additional text production.

Inefficient reading processes may hinder reviewing/proofreading processes as well as more evaluative processes. At minimum, proofreading involves text comprehension processes plus error detection processes, making the reading task potentially more difficult than comprehension alone. If word level identification

processes are difficult, the ability to detect errors in spelling, grammar, or syntax may be compromised. Similarly, reading to assess whether the text accurately represents the intended meaning involves complex text interpretation processes (Hayes, 1996). When reading processes are inefficient, reading-during-writing that serves evaluative functions and contributes to planning and text generation processes may be constrained or prevented.

These more sophisticated reading processes may be essential components of a *knowledge transforming* approach to writing (Bereiter & Scardamalia, 1987). According to Bereiter and Scardamalia (1987), *expert* or more accomplished writers engage in a recursive and increasingly complex problem-solving approach to writing. This dynamic problem-solving process, involving frequent assessments of rhetorical effect upon an intended audience, depends upon reading. As Bereiter and Scardamalia (1987) assert, “the distinctive capabilities of the knowledge-transforming model lie in formulating and solving problems and doing so in ways that allow a two-way interaction between continuously developing knowledge and continuously developing text” (p. 12). Fluent reading processes likely facilitate this “two-way” interaction between writers and their texts, whereas less fluent reading may serve as a bottleneck that constrains this interaction. Inefficient reading processes may simply restrict the amount of reading-during-writing that can occur, limiting the potential problem-solving activities that may arise from rereading. Additionally, inefficient word recognition processes may require substantial cognitive resources for basic comprehension,

potentially leaving fewer resources for the problem solving processes necessary for knowledge transforming approaches.

When cognitive resources are limited, writers are more likely to employ a *knowledge telling* approach to composition (Bereiter & Scardamalia, 1987). Knowledge telling, used by both expert and novice writers, does not employ recursive problem solving—it is a unidirectional approach functioning to bring a writer's content (background) knowledge held in long-term memory to written production. As a result, knowledge telling does not require the same type of dynamic interaction with the developing text. Knowledge telling approaches do not preclude going back and revisiting previously written text; activities such as proofreading for errors can be used in this composing process. But knowledge telling does not *require* reading, especially the type of reading required for planning and text generation processes. Less accomplished writers may use knowledge telling approaches to reduce the cognitive demands of writing, and since reading-during-writing is not essential to generate text, rereading processes are likely to be limited. When reading itself is cognitively costly, as in the case of less fluent readers, reading-during-writing may be avoided altogether in an effort to streamline efforts to “get ideas down on paper.”

Despite the important roles reading-during-writing processes may serve in writing, few empirical studies of reading processes during writing exist. Fewer still explore the role reading-during-writing may play for adolescent writers. As a result, knowledge concerning reading-during-writing remains largely theoretical and untested, primarily housed in evolving models of writing (cf. Kellogg, 1996; Hayes, 1996). Many

important questions remain unexplored. Do young writers employ rereading processes during writing? Is this rereading restricted to basic error detection, and if so, when do young writers begin to utilize other reading-during-writing processes? Previous studies strongly suggest that accomplished writers read some portion of their developing texts as they write, but what exactly are they reading? Do the ways in which writers reread their developing texts change across different writing tasks or genres? Additionally, these studies are limited by the methodologies employed to determine rereading processes. Many are observational studies that depend upon a researcher to infer that reading is occurring, when in fact a writer may be simply staring at a blank space on a page or screen. Others rely upon think-aloud methods, which are at least minimally intrusive and require that writers have sufficient metacognitive awareness to articulate what they are doing in the midst of a complex activity. For younger writers still learning to juggle the multiple processes involved in composing text, think-aloud methods may add an additional and burdensome cognitive load. Finally, existing studies overlook the ways less fluent reading processes may constrain the type of reading-during-writing that occurs and the subsequent contributions it may make to text quality.

Purpose of Study

The main purpose of this study is to examine empirically the effects of reading fluency upon the reading-during-writing processes of adolescent writers. Two groups of seventh and eighth grade students composed two texts (narrative and persuasive essay) in the study: one group of students consisted of fluent readers, and the other group

consisted of less fluent readers. Since previous studies of reading-during-writing have largely neglected adolescent writers, this study also begins to establish baseline levels of reading behaviors exhibited by seventh and eighth grade students during specific writing tasks.

Additionally, this study will pioneer the use of eye-tracking technology to analyze reading processes, in real time, within a writing context. Reading researchers have used eye-tracking methodologies for decades (Rayner, 1997) to examine an array of reading processes. The precision afforded by tracking eye movements, however, has been lacking in studies of reading-during-writing, which have largely relied upon observational measures (i.e. Stallard, 1974; Pianko, 1979; Perl, 1979) or think-aloud techniques (i.e. Breetvelt et al., 1996). Eye-tracking technology provides a minimally intrusive way to measure the frequency, duration, and location (on the text) of specific reading processes that occur during writing.

Hypotheses

Specifically, this study will test four hypotheses concerning the reading-during-writing processes of fluent and less fluent adolescent readers:

- 1) Fluent seventh and eighth grade readers will read their developing texts proportionally more than less fluent seventh and eighth grade readers. Fluent word identification processes may facilitate reading-during-writing, whereas inefficient word identification processes may constrain reading-during-writing. Because total

writing times vary in this study, proportions of time reading the developing text will be calculated.

- 2) Less fluent seventh and eighth grade readers will exhibit a greater proportion of reading fixations upon the most recently composed text (*text monitoring*) than fluent seventh and eighth grade readers. Reading that is restricted to the recently composed text may be indicative of more basic error detection processes.
- 3) Less fluent seventh and eighth grade readers will write texts of lower quality than fluent seventh and eighth grade readers. Reading-during-writing can contribute to writing quality (Breetvelt, van den Bergh, & Rijlaarsdam, 1996). If the first two hypotheses are supported, less fluent readers will exhibit less developed reading-during-writing processes, resulting in lower quality texts.
- 4) Fluent seventh and eighth grade readers will employ more *global* reading patterns during an essay writing task when compared to a narrative task, while less fluent seventh and eighth grade readers will exhibit similar reading patterns across writing genres. Children tend to find narratives easier to write than other genres (Hidi & Hildyard, 1983; McCutchen, 1987), suggesting that more basic writing approaches (indicative of knowledge telling) may suffice during composition. Persuasive essays, on the other hand, may trigger more complex reading-during-writing processes.

Chapter 2: Conceptual Framework and Literature Review

According to several influential models of writing, reading processes play a potentially important role in composing. In Hayes' and Flower's (1980) original model, writing consists of three major processes: planning, translating, and reviewing (see Figure 1). Reviewing in this model serves to "improve the quality of the written text" (p.16), and it involves two modes of interaction with the "text produced so far." One mode, which they term "reviewing" in their description, typically occurs at the end of a translation process. In this mode, writers cease text production to reread, evaluate, and improve the text. If significant changes are deemed necessary, the other writing processes (planning and translating) are employed. Editing processes, on the other hand, can occur at any time during text production and they primarily serve to detect and correct violations of writing conventions. Like reviewing, the editing process can also trigger other writing processes. In describing editing, Hayes and Flower (1980) suggest that it can serve a more complex evaluation process beyond proofreading, where a writer reads to compare the written text with his or her goals. In some cases, they add, "the action (of editing) may invoke the whole writing processes recursively" (p.17).

In the Hayes and Flower model (1980), reading occurs frequently. As they asserted, "this text (produced so far) is a very important part of the task environment because the writer refers to it repeatedly during the process of composition" (p. 12). As their description of the model indicates, reading the text produced so far can serve multiple purposes, from basic error detection to a more complex evaluative function

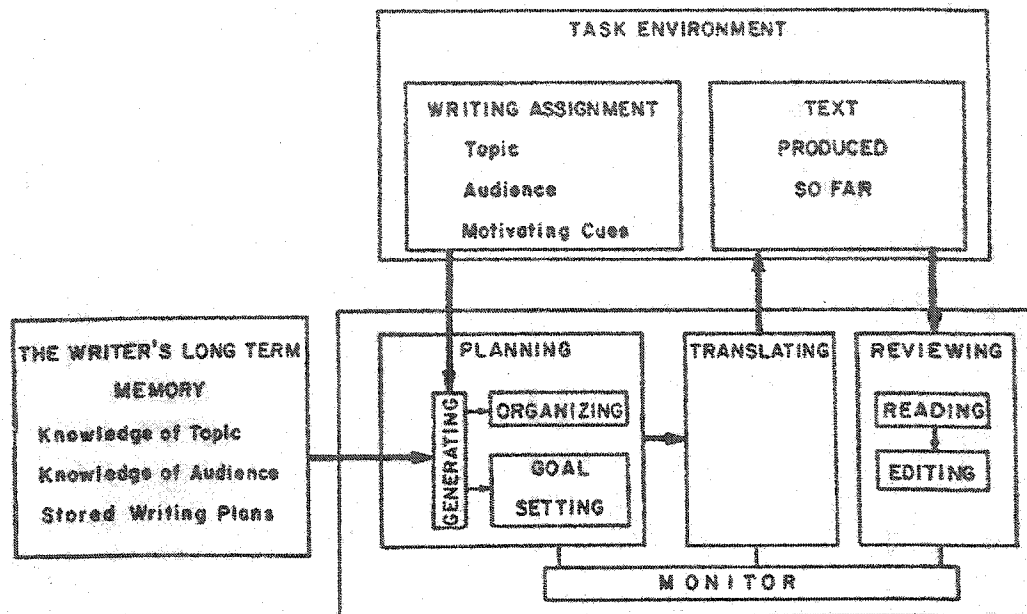


Figure 1. Hayes' & Flower's (1980) Model of Writing.

that compares the written text against the writer's goals for the composition. Reading for at least some of these different purposes may require proficient reading skills. For students struggling with word-level identification, it seems unlikely that processes beyond basic proofreading would be used. For efficient readers, reviewing and editing may contribute to the writing process by triggering planning and translating processes in a recursive manner exemplified by accomplished writers.

The Hayes and Flower model (1980) suggests that reading-during-writing is different than reading for text comprehension. Of course, word decoding is critical to both, and in both cases the reader is constructing meaning. But reading-during-writing, even if only proofreading, adds error detection processes to these decoding processes,

making the reading task potentially more complex. Adding an evaluation component to reading processes makes it potentially even more complex, as writers consider their own texts against their goals for the composition. An expansion of Hayes and Flower's model (1980) of reviewing demonstrates the multiple ways reading-during-writing can involve additional cognitive processes (Hayes, Flower, Schriver, Stratman, & Carey, 1987; see Figure 2).

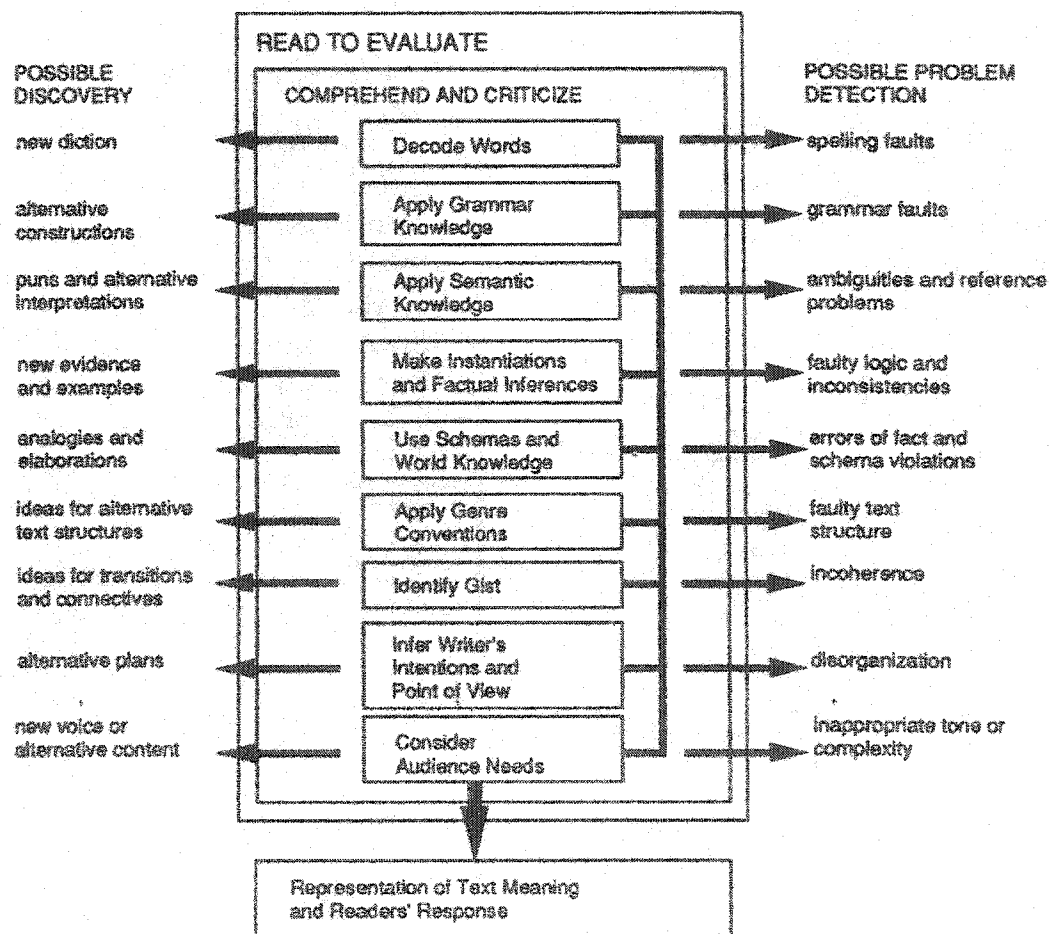


Figure 2. Hayes et al. (1987) Model of Reading-During-Writing.

As the model indicates, “reading to evaluate” the developing text involves up to nine distinct subprocesses, eight of which depend upon effective decoding skills. Along the right column of this model, Hayes et al. (1987) described nine “problem detection” subtypes, which can be roughly grouped into errors of syntax (spelling, grammar, incoherence, text structure) and semantic errors (ambiguities/reference problems, faulty logic, errors of fact, schema violations, disorganization, and problems of tone). Among accomplished writers, all of these problem detection processes may be used depending upon the writing task. For younger writers, who generally do little revision without prompting (Fitzgerald & Markham, 1987; Hayes, Flower, Carey, Schriver, & Stratman, 1987), problem detection may be limited to errors of syntax. If a reader struggles with word-level identification, even these syntactic problem detection processes may be constrained or prevented altogether.

For proficient readers and writers, reading to evaluate the developing text during writing can lead to new knowledge. Along the left column of the model (see Figure 2), Hayes et al. (1987) listed nine types of possible discovery that can follow from the nine subprocesses of reading to evaluate. These areas of discovery range from adding new diction to generating new evidence, creating new examples, developing alternative plans, and shifting the tone of the composition. In other words, reading to evaluate can spur a dynamic process of discovery as writers interact with their texts and consider whether they are accomplishing their goals.

Reflecting this potentially dynamic role reading-during-writing can play, Hayes modified the Hayes and Flower model (1980) and emphasized reading as one of three

main cognitive process (Hayes, 1996; see Figure 3). Instead of focusing upon planning, translating, and reviewing processes, Hayes collapsed planning and translating processes (text production) while amplifying the role of reading-centered processes (text interpretation and reflection). Unlike the previous Hayes and Flower (1980) model, the contributions reading processes can make to text production clearly extend beyond editing/reviewing functions. In this model, reading plays a primary role. Text interpretation and reflection require substantial interaction with the *text so far*, writers must be interpreting and reflecting upon something.

Although these models remain to be validated empirically, the theoretical roles reading may play in the writing process have been given increasing prominence. Given the range of purposes reading-during-writing can serve (see Figure 2), being saddled with inefficient reading skills could theoretically constrain writing performance in a variety of ways. Most likely, the kinds of evaluative reading processes that lead to *possible discovery* would not be possible for a writer lacking fluent reading skills. Surface-level proofreading for spelling errors might be all a struggling reader can manage during writing. The potential benefits of generating new knowledge during writing may remain out of reach.

Working Memory and Writing

Hayes' revised model of writing (1996) includes the construct of working memory as a component of writing. Working memory, in theory, has processing and

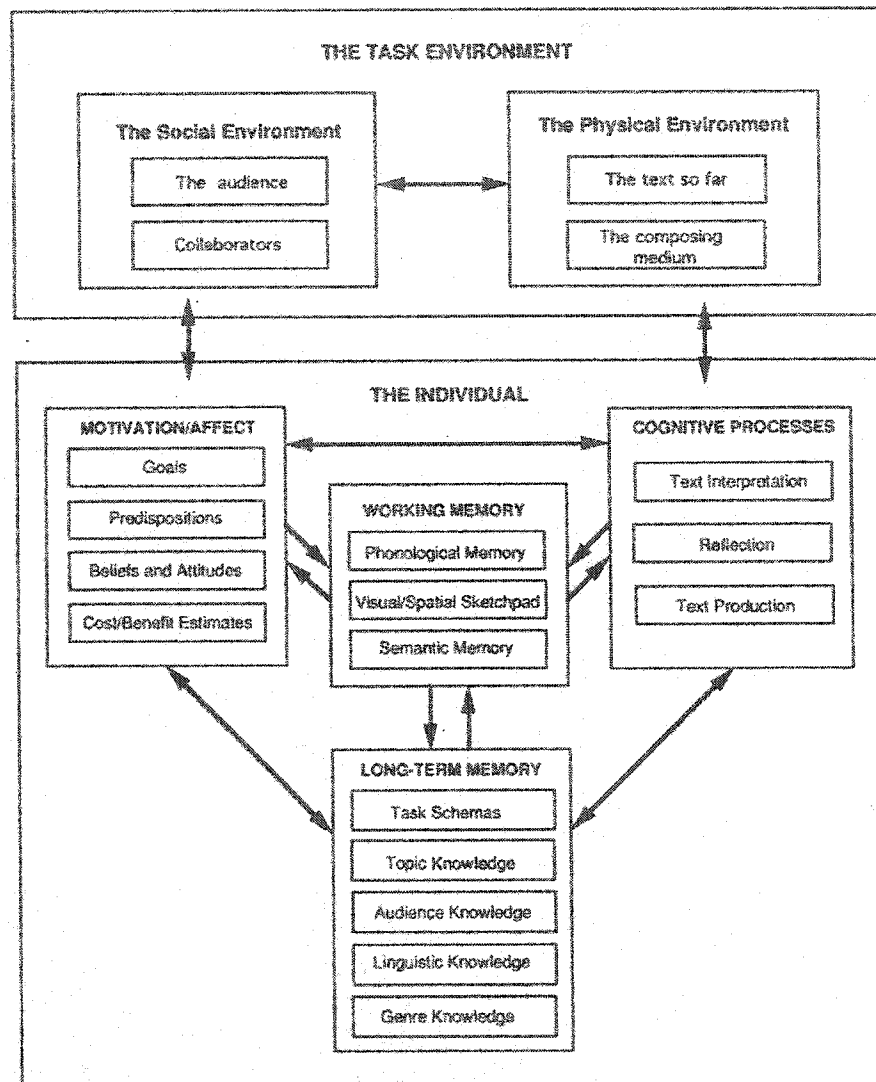


Figure 3. Hayes' (1996) Revision of the Writing Model.

storage functions that occur within a limited capacity system. In most formulations of working memory and writing, two factors determine a writer's working memory capacity: 1) the size of the permanent working memory "span" or genetically determined overall pool of resources; 2) the efficiency with which writers can

accomplish the different processes of writing, often in parallel (Just & Carpenter, 1992). Although each writer may have a different overall “span” or pool of working memory resources available, it is how these resources are organized and shared among the different processes of writing that may encourage or constrain the development of more accomplished writing. As the demands of certain writing subprocesses decrease they require fewer cognitive resources, which may in turn free up resources for other processes (Kellogg, 2001).

Limited working memory capacity has been shown to constrain comprehension processes (Daneman & Green, 1986) as well as the ability to maintain multiple representations of a sentence while decoding and comprehending its meaning (Miyake, Just, & Carpenter, 1994). If decoding is inefficient, significant working memory resources are likely required for basic word recognition, leaving relatively fewer resources for interpretation and retention of meaning. As a result, reading comprehension suffers (Calfee & Piatkowski, 1981; Herman, 1985; Stanovich, 1986). If basic comprehension processes are hindered due to insufficient working memory resources, how might inefficient reading processes influence reading-during-writing?

McCutchen (1996, 2000) proposed that working memory capacity plays a central role in the development of writing expertise. Specifically, McCutchen (2000) asserted that fluent language generation processes allow writers to transcend the constraints of *short term* working memory to take advantage of rich knowledge bases in *long term* working memory. Writers struggling with language generation processes are limited by the constraints of short term working memory, confining them to more basic

writing approaches. In one experiment, McCutchen, Covill, Hoyne, and Mildes (1994) found that elementary and middle school students with fluent text-generation processes and word retrieval skills were better able to manage working memory constraints when writing. Young writers lacking fluent encoding processes (such as transcription and text generation) suffer working memory constraints, which result in poorer texts (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; Graham & Harris, 2000). Reading fluency may interact with working memory constraints in two ways. Overall, less efficient reading processes may serve as a general constraint upon limited working memory resources. If reading requires substantial working memory resources, fewer resources will be available for higher-level planning and evaluation modes. In this way, less fluent reading may act as a bottleneck hampering writing even if the writer is skilled in other language processes.

The second way reading fluency may interact with working memory constraints involves reading processes themselves. Simply put, writers may choose not to read at all during writing if reading is deemed too effortful. Given the substantial cognitive demands of planning and translating processes in writing, less fluent readers may have few resources available for reading of any type (cf. Kellogg, 2001). For fluent readers, stopping text generation processes to read the developing text poses few problems. But for less fluent readers, adding the cognitive demands of reading-during-writing to the other processes involved in text production may overwhelm their functional working memory resources. Hayes' et al. (1987) model of reading-during-writing suggests that reading may make different demands upon limited working memory resources than text

comprehension processes. The interpretive and reflective processes in Hayes' revised model of writing (1996) can involve comparing the *actual* or written text against a writer's *intended* or internal representation of the text—requiring the writer to maintain at least two representations of the text in working memory (Hayes & Flower, 1983; McCutchen, Francis, & Kerr, 1997). Reading that leads to *discovery* and new text production likely requires parallel processing and considerable cognitive resources. For writers already taxed by the concurrent demands of planning and text generation, adding a laborious reading process seems unlikely.

Knowledge Telling and Knowledge Transforming

The expanded model of reading-during-writing proposed by Hayes et al. (1987, Figure 2) outlines nine potential ways *reading to evaluate* can lead to *possible discovery*. Writers may generate new knowledge as they evaluate their developing texts and check for errors or problems. This idea that *discovery* can accompany writing processes has been articulated by various writing theorists (e.g. Britton, 1980), many of whom extol the potential virtues of freedom or creativity in writing. For Bereiter and Scardamalia (1987), however, *discovery* is not a pleasant byproduct enjoyed by writers in an inspired moment. Instead, expert or accomplished writers employ an approach to writing designed to generate new knowledge, which Bereiter and Scardamalia term *knowledge transforming*. Novice writers, on the other hand, generally employ a *knowledge telling* approach to writing, which is a more streamlined approach suited for text production that is appropriate to the task.

Novice writers, in Bereiter and Scardamalia's model (1987), use the knowledge telling approach (see Figure 4) to take advantage of existing cognitive structures developed for oral language production.

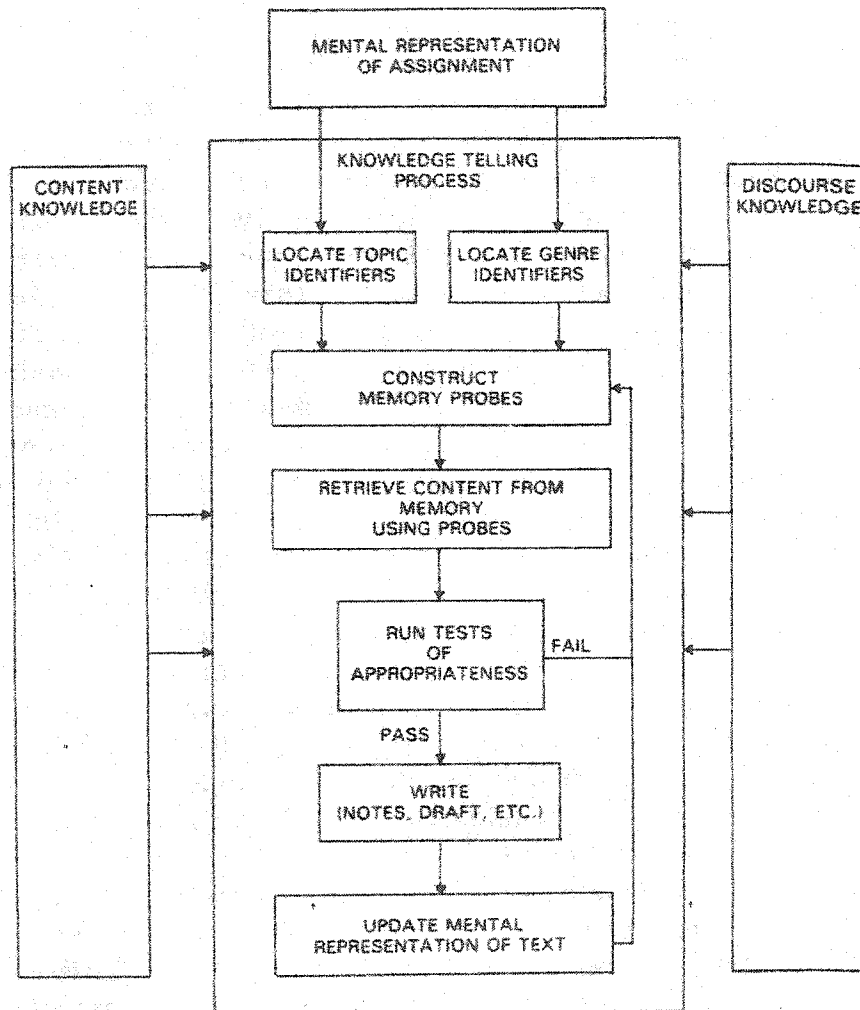


Figure 4. The Knowledge Telling Model, Bereiter & Scardamalia (1987).

What is missing when writing, however, is a conversational partner to provide cues or prompts for additional thoughts. To compensate for the lack of a conversational partner,

young writers seek cues from the topic, from their knowledge of discourse schema, and from the text they are writing. These cues assist novice writers in content retrieval, helping them generate texts in an efficient manner that minimizes the problems caused by the lack of conversational support. In this way, novice writers can get down on paper the ideas they have in their heads in a form that is appropriate to the assignment. As Bereiter and Scardamalia mentioned, "it preserves the straight-ahead form of oral language production and requires no significantly greater amount of planning or goal setting than does ordinary conversation" (pp. 9-10).

The knowledge transforming approach, on the other hand, is a complex problem-solving process that leads to changes in the text as well as changes in what the writer wishes to convey. As writers evaluate their developing texts, they are not merely detecting problems and attempting to fix them. Instead, these writers assess the text for its rhetorical effects and consider new ways of expressing their evolving ideas. Although it is less efficient than knowledge telling, knowledge transforming is an iterative process that involves "a two way interaction between continuously developing knowledge and continuously developing text" (p. 12). Through this interaction, the writer's knowledge and text are changed (see Figure 5).

In knowledge telling and knowledge transforming approaches, reading processes play different roles. When using the knowledge telling approach, writers may read portions of their developing texts as a way to promote additional content retrieval. For

example, writers may scan their texts to remind themselves of the content they've already covered, prompting them to assess whether they have anything more to add. Additionally, these writers likely initiate some type of proofreading processes to repair

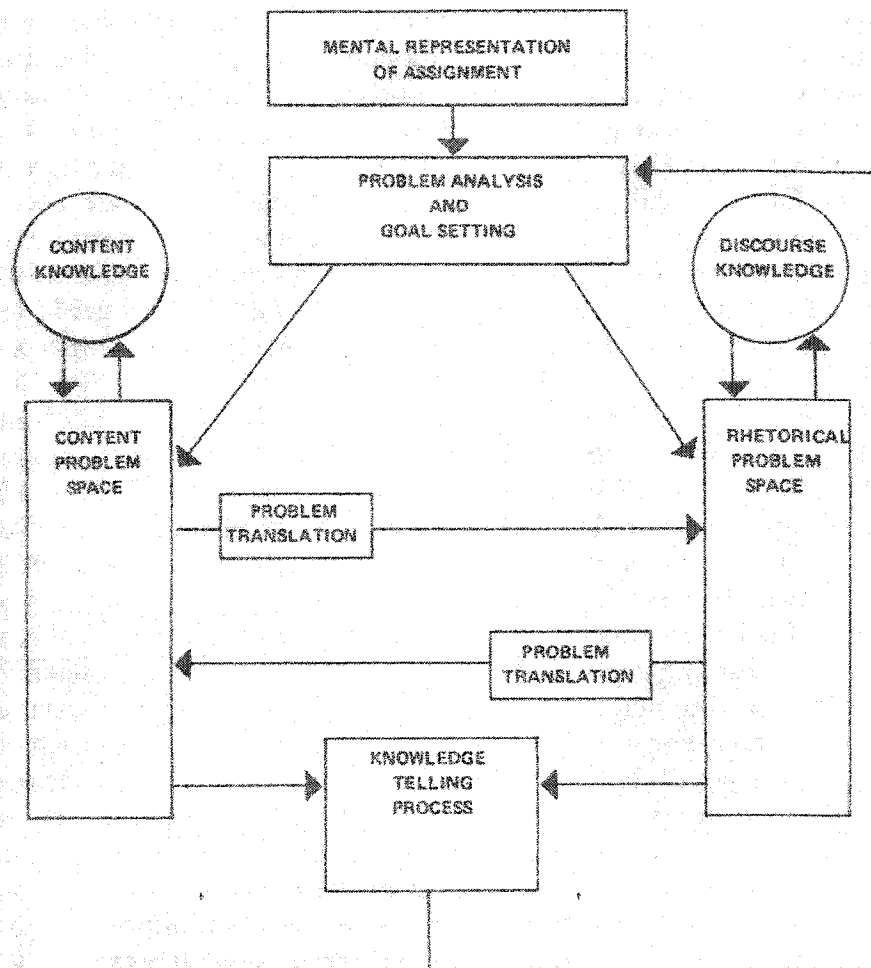


Figure 5. The Knowledge Transforming Model, Bereiter and Scardamalia (1987).

problems in the text. At the same time, the knowledge telling approach does not *require* substantial reading processes during writing. If a writer has well-developed content on a familiar subject, for example, he or she may not need additional cues for content

retrieval. If the writer's goal is to produce a text efficiently, surface-level proofreading may be all that's needed. Although it may be hampered in some respects, knowledge telling can proceed quite well without reading.

As a result, inefficient reading processes may not impair knowledge telling modes of writing. In fact, inefficient reading processes may restrict writers exclusively to knowledge telling approaches. As previously discussed, inefficient reading processes require working memory resources that might otherwise be allocated for planning and evaluation processes. In their description of knowledge transforming, Bereiter and Scardamalia (1987) made it clear that this problem-solving approach to writing requires great effort that would likely require significant working memory resources. Not only is this an effortful approach, it is also dependent upon substantial reading. Continuously revisiting their texts, writers in the knowledge transforming mode rely upon advanced interpretive processes to achieve their goals for content and rhetorical effect. Without the fluent reading skills necessary for these interpretive processes, struggling readers may not be able to navigate the distance between knowledge telling and knowledge transforming. At the same time, fluent reading processes likely facilitate the leap from knowledge telling to knowledge transforming approaches.

Research on Reading-During-Writing

Although current models of writing indicate that reading processes during writing play important roles, relatively little research has directly investigated reading-during-writing. Additionally, existing research efforts have failed to consider how

inefficient reading processes may impair adolescents' writing performance and how these processes interact with working memory limitations. Research on reading-writing relationships has generally focused upon the cognitive processes and *meta*-knowledge sources that are shared by reading and writing (cf. Fitzgerald & Shanahan, 2000). The guiding assumptions behind this work are that reading and writing "depend upon identical or similar knowledge representations, cognitive processes, and contexts and contextual constraints (Fitzgerald & Shanahan, 2000, p. 40). The knowledge a student may have about phonemic, orthographic, and syntactic processes in reading theoretically transfers to writing, such that improvements in one skill (reading) would lead to improvements in another (writing). Based upon these assumptions, many researchers have conducted correlational analyses of measures of reading (i.e. decoding) and writing (i.e. spelling) (Tierney & Shanahan, 1991; Shanahan, 1984; Shanahan & Lomax, 1986, 1988).

In the most complex series of reading-writing studies, Shanahan (1984) and Shanahan and Lomax (1986, 1988) used LISREL analyses to compare alternative models of reading-writing relations. Using an extensive collection of reading and writing measures, they found that neither reading nor writing could account for more than 43% of the variance in the opposite set. In their "interactive" model, reading and writing influenced each other, with knowledge from either reading or writing contributing to the other process. They also found that the relationships changed across grade levels, with word recognition-spelling connections being relatively more important with younger students and more structural aspects of text knowledge

becoming more important with older students. As Shanahan and Lomax (1986) concluded, "reading influences writing, and writing influences reading; theories of literacy development need to emphasize both of these characteristics similarly" (p. 208).

The conclusion that "reading influences writing" (p. 208) provides, at best, indirect evidence that inefficient reading processes may impair writing processes. Unfortunately, these correlational approaches do not examine whether young writers read their texts as they write, nor do they provide evidence that reading processes contribute to writing performance. It's possible that simply acquiring certain reading skills (such as knowledge about text structures) could lead to better writing performance without requiring the use of any reading-during-writing processes. Additional evidence concerning the use of reading processes during writing comes from two bodies of research: studies of dictation, where writers compose orally and do not have a text to review (i.e. Gould, 1980; Hidi & Hildyard, 1983; McCutchen, 1987); and studies using empty pen or carbon paper methods where writers cannot see the texts they write by hand (i.e. Britton, Burgess, Martin, McLeod, & Rosen, 1975; Gould, 1980; Hull & Smith, 1983; Olive & Piolat, 2002). In these studies, subjects generally compose under two conditions, one in which they compose normally (with the developing text available for review) and the other in which this text is invisible or nonexistent. By analyzing the writing processes and text products that result when reading-during-writing is prevented, this research sheds additional light upon how reading processes may contribute to writing.

The evidence from the dictation studies can be distilled into a few general patterns. Writers produce text more quickly when dictating (Gould, 1980), and they tend to produce longer texts (Scardamalia et al., 1982; Hidi & Hildyard, 1983; McCutchen, 1987) than those that are handwritten. One interpretation of these findings is that reading-during-writing processes slow text production, ultimately leading to shorter texts. Additionally, there is some evidence that reading-during-writing contributes to text quality. Several experiments found that handwritten texts were superior in quality to the dictated texts (Newcomer, Barenbaum, & Nodine, 1988) and/or coherence (Hidi & Hildyard, 1983; McCutchen, 1987), while others found few differences. The lack of quality differences between texts composed with or without the developing text may be explained by the types of tasks given to the writers in these experiments. With familiar or low-demand writing tasks, writers may employ a knowledge telling approach to writing that requires little reading. In support of this explanation, McCutchen (1987) found that narratives produced using either method were similar, but essays produced by dictation were less coherent.

The empty pen studies, where writers cannot see the texts they are writing (Britton, Burgess, Martin, McLeod, & Rosen, 1975; Gould, 1980; Hull & Smith, 1983), provide additional evidence that reading processes may facilitate writing, especially with more demanding writing tasks. When reading was impossible (when writing with invisible ink or with a stylus upon carbon paper), the quality of most of the texts suffered due to hypothesized constraints upon editing and planning processes. For example, Britton et al. (1975) concluded that "because scanning back was impossible . .

the carbon copies showed many inconsistencies and logical and syntactical discontinuities” (p. 35). Further, Hull and Smith (1983) found that when writers composed essays using invisible ink, they wrote lower quality texts. To explain their results, Hull and Smith (1983) suggested that the writing quality suffered without the ability to read because “rescanning allows a writer to compose recursively” (p. 977). Without the ability to interact with their developing texts, these writers were unable to “compose recursively” in a manner required for knowledge-transforming approaches, nor could they engage in local editing or planning. Gould’s (1980) experiment had adult executives compose business letters using an invisible pen stylus. Like Britton et al. (1975), these adult writers were able to write relatively simple business letters and memos equally well with or without the ability to read, and more difficult tasks that may lead to knowledge transforming approaches were not included. An exception to these findings is Olive and Piolat’s (2002) study, which found no differences in the texts produced by undergraduate writers when visual feedback was suppressed, despite their use of argumentative essays.

More direct approaches to examining reading-during-writing, such as observational and think-aloud studies, provide stronger evidence that reading processes play important roles beyond basic proofreading functions. Several studies have found that writers may read portions of their texts to prompt them to write more. In a think-aloud study, Kaufer, Hayes, and Flower (1986) found that writers often reread a sentence as part of finishing it, suggesting that rereading facilitates a type of local or sentence-level planning. Additionally, Pianko (1979) found that undergraduate writers

used “most of their rescannings . . . to reorient themselves to what they had just written for the purpose of deciding what to write next . . . a sentence or two or perhaps a paragraph would be reread” (p.10). In this way, the developing text can serve as a type of local writing prompt, as writers reread portions of their recently composed text to help them generate additional phrases or sentences.

In addition to reading for sentence-level planning, several studies suggest that writers may read for more global planning and evaluation purposes reflecting a knowledge transforming approach. In Perl’s (1979) think-aloud study of college-level writers, planning activities were coded as either instances of *local* planning (sentence level) or *global* planning (thinking about the text as a whole). In discussing the role that rereading plays in *global* planning, Perl argued that “seeing ideas on paper enables students to reflect upon, change, and develop those ideas further” (p. 330). Breetvelt, van den Bergh, and Rijlaarsdam’s (1996) study of rereading, text generation, and text quality provides additional empirical evidence that reading can facilitate planning processes and contribute to text quality. In this think-aloud study exploring the temporal aspects of writing, Breetvelt et al. (1996) found that the rereading processes of undergraduate writers contributed to text quality throughout the writing process. As these writers composed, the relationships between rereading and text quality strengthened, reaching apogee at 30 minutes. Importantly, rereading the developing text was also strongly correlated with text generation processes. As Breetvelt et al. assert, this evidence demonstrates that “rereading one’s own text does not serve reviewing only but also serves the process of generating ideas” (19).

Struggling readers may be less able to use their developing texts for planning and text generation during writing. In a study with adolescent writers, a colleague and I (Beers & Quinlan, 2000) explored whether students identified with reading and writing disabilities (LD) would choose to access their developing texts during writing as frequently as their normally-achieving (NA) peers. In this study, there were two writing conditions: dictating to a scribe with the developing text available, and dictating to a tape recorder without an accessible text to read. When dictating to the scribe, however, the developing text was not automatically visible. Instead, we configured a computer monitor to display each writer's developing text (for intervals of 30 seconds) only when the writers pushed a button. Thus we obtained a measure of how frequently these writers chose to access their developing texts. Under these conditions, we found that students with LD chose to access their developing texts as frequently as their NA counterparts (as measured by button activations). When we compared their written products across the two writing conditions (dictation vs. scribe), however, strong differences emerged. As hypothesized (and congruent with other studies, see Britton, Burgess, Martin, McLeod, & Rosen, 1975; Hull & Smith, 1983), the NA students wrote higher quality texts when they could reread their developing texts. The students with LD, however, did not compose texts of higher quality when they could reread their developing texts: the texts dictated to the scribe were similar to those dictated to the tape recorder. Although these students *appeared* to be reading their developing texts during writing with approximately the same frequency as the normal writers, this rereading process did not contribute to text quality.

Why did this apparent reading-during-writing fail to contribute to text quality for the students with LD? One explanation is that they simply chose not to reread their texts, despite activating the screen so that their texts would be visible. When we compared text length across the writing conditions, however, we found that the students with LD wrote shorter texts when they activated their screens to view their compositions. Shorter texts, in themselves, do not prove that reading occurred, but they do suggest that the presence of the developing text changed the composing process. Another explanation is that these writers did reread portions of their developing texts, but that this rereading contributed less to planning and text generation processes. Although these students appeared to be rereading their developing texts as frequently as their NA counterparts, perhaps they were interacting with their texts in a qualitatively different way. They may have simply reread their texts less frequently. Or perhaps they restricted this rereading to short, recently composed segments of their texts. When word-level identification processes are cognitively demanding, students may not have the necessary working memory capacity required for the type of reading processes that lead to planning. Differences in the frequency of rereading have been shown to help explain differences between accomplished or expert writers and novice or struggling writers. Stallard's (1974) observational comparison of good and average high school writers revealed significant differences in the number of rereading episodes each group initiated. In this study, the "good" 12th-grade writers "stopped writing more frequently to read what they had written" than the average writers (p. 215).

Pianko's (1979) study of college-level remedial and typical writers is consistent with Stallard's (1974) results, with the typical writers pausing and *rescanning* their texts more often than the remedial writers. In this study, 17 freshman students were videotaped (10 remedial, 7 traditional) writing essays and narratives and interviewed following the taped sessions. Based on the interview data, Pianko asserted that the frequency of rereading activities only partly explains differences in reading-during-writing processes: the *type* of rereading that occurs and the extent to which it contributes to other processes like monitoring, editing, text generation, or planning may also be critical. Highlighting the importance of the differences in rereading processes between the two groups in her study, Pianko concluded "what basically separates them (the typical and remedial writers) is *the ability to reflect on what is being written*" (p. 20, emphasis hers). In other words, the remedial writers in this study were indeed reviewing their texts, but this rereading served more limited purposes. The typical writers not only rescanned more often, but they seemed to be rereading to achieve different, more sophisticated goals than did the remedial writers.

Of the studies that have been reviewed here, several tentative conclusions can be drawn. First, writers appear to engage reading processes during writing tasks, including adolescent students with reading disabilities (Beers & Quinlan, 2000; Breetvelt, van den Bergh, & Rijlaarsdam, 1996; Kaufer, Hayes, & Flower, 1986; Faigley, Cherry, Jolliffe, & Skinner, 1985; Perl, 1979; Pianko, 1979; Stallard, 1974). Second, more accomplished writers appear to reread more frequently than less accomplished writers (Perl, 1979; Pianko, 1979; Stallard, 1974). Third, more accomplished writers appear to read in a

qualitatively different manner than less accomplished writers, characteristic of a more recursive, reflective, knowledge-transforming approach to writing (Bereiter & Scardamalia, 1987; Pianko, 1979). Fourth, reading-during-writing may contribute to planning and text generation processes in a manner that influences overall text quality (Breetvelt, van den Bergh, and Rijlaarsdam, 1996; Britton, Burgess, Martin, McLeod, & Rosen, 1975; Hull & Smith, 1983).

As McCutchen argued (2000, 1996), writers vary in their working memory capacities. Functional working memory capacity results from the combination of three factors: 1) overall available resources, which may be genetically determined; 2) the efficiency of the cognitive processes utilized; and 3) the efficiency by which these cognitive processes are managed. Within a writing context, if any of these factors results in fewer available working memory resources, writers will likely attempt to streamline their writing processes by employing a knowledge telling approach. For less fluent seventh and eighth grade readers, the inability to read efficiently may impede writing development such that it prevents progress towards a knowledge transforming approach to writing. In other words, until reading processes become more fluent, reading-during-writing may only serve relatively basic proofreading/editing purposes. Conversely, fluent seventh and eighth grade readers may have ample working memory resources available for more complex reading-during-writing processes, facilitating the development of writing skills and making possible the knowledge transforming approach.

Chapter 3: Methodology

Participants

The sample consisted of 43 students in the seventh or eighth grade (chronological age $M = 13.25$ years) drawn from 5 urban schools in the North Seattle area. Fifteen students (35%) were in eighth grade, and twenty-eight (65%) were seventh graders. There were slightly more boys (23, 53%) than girls (20, 47%). Because this study compared fluent and less fluent readers, two recruiting strategies were used. To recruit students for the fluent group, middle schools were contacted and flyers were distributed widely to the student population. To recruit students who are less fluent readers, school counselors and reading specialists were asked to distribute flyers to students with inefficient reading processes. Students interested in participating were instructed to have their parents or guardians contact the researcher, and meeting times were arranged for the study. All study procedures took place in the LUTE Usability Lab (College of Engineering, Dept. of Technical Communication) on the University of Washington campus. Students were paid \$15 for their participation, which took approximately one and a half hours.

Once consent was given and a study time was arranged, students took a norm-referenced reading fluency measure (Woodcock-Johnson III, 2001) to determine grouping status (fluent or less fluent). This measure requires reading discrete sentences and answering yes/no questions about them (for example, "The moon is in the sky"). Students read and responded to as many sentences as they could in three minutes. Scoring consisted of adding the correct responses and incorrect responses. Once raw

scores were obtained, Woodcock-Johnson (2001) scoring software converted these scores to percentile rank scores based upon chronological age. Because there is no consensus as to what constitutes reading fluency at the middle school level, students were grouped according to their percentile rank scores. Students scoring above the 55th percentile were included in the Fluent group, and students scoring below the 40th percentile were included in the Less Fluent group.

Based upon the reading fluency scores, data from five students were not included in the analysis because they scored between the 40th and 55th percentile. Due to equipment failure or excessive head movement, data were insufficient to analyze for two additional students (one boy and one girl). Additionally, children were excluded from the study if: (a) English was not their primary language; (b) they had been diagnosed or treated for an attention-deficit disorder; or (c) they had been identified as having a speech disorder. In all, data from 36 students were used (18 in each group based upon their fluency scores). The Fluent group consisted of 9 boys and 9 girls; the Less Fluent group consisted of 13 boys and 5 girls.

Language and Memory Measures

To control for other factors that may influence reading-during-writing processes, students were assessed for writing fluency and working memory. To tap written language, the norm-referenced Writing Fluency test of the Woodcock-Johnson Psychoeducational Tests of Achievement--Revised III (2001) was administered. On this measure, students were asked to write (by hand) grammatically correct sentences that

had to include, without any changes or inflections, three given words (for example, “frog, jumping, rock” could be written as “The frog is jumping over the rock”).

Students wrote as many sentences as they could in seven minutes.

To assess working memory, Daneman and Carpenter’s (1980) sentence span task was used. This task required the presentation (by the experimenter) of sets of unrelated sentences to be read aloud, and students were asked to remember and later recall the final word in each of the sentences read. The sentences, each between 13 and 17 words in length, were selected from a group of 7th grade-level reading passages and typed upon note cards (see Appendix A). Students were given three practice sets of two-sentence-length groups, after which they saw a blank card and were asked to recall, in order, the final words from the sentences. Students began reading sets of two sentences each, and as the assessment continued, the number of sentences in each set gradually increased (up to sets of five sentences each, which required recalling five words at the end of the set). Reading span is defined as the maximum number of sentences the participant could read aloud at their own pace while maintaining perfect recall of final words on two out of three sets.

Procedures

After contacting the researcher and arranging a time, students came to the University of Washington’s Usability lab for the study. Once parental consent and student assent were obtained, students began by completing the reading fluency and writing fluency assessments. For the next 30 minutes, students became familiarized

with the equipment and writing tasks. To become comfortable with oral composition using the typist (*Listening Word Processor*, see below), students practiced writing in this mode until they indicated that they felt comfortable. To prepare for the writing tasks, students were seated in a high-backed chair with a flexible headrest and positioned for accurate eye tracking. Once the students successfully completed the short (20-30 second) calibration process, the first writing task (counterbalanced by genre) began. Students were instructed to do their best and told that they had up to 10 minutes to complete their texts, although they could finish in less time if they wanted. Including all assessments, calibration procedures, and writing tasks, data collection for each student took approximately 1.5 hours.

Writing Tasks

Children composed two texts in genres familiar to them as school tasks (see Appendix B for writing prompts). A narrative writing task was chosen in the interests of facilitating fluency, since, relative to other genres, children tend to be better at composing stories (Hidi & Hildyard, 1983; McCutchen, 1987). A persuasive essay task was selected to increase the level of difficulty and to encourage more sophisticated reading-during-writing processes. The narrative task required students to complete a story that had been partially written, using the characters and situations provided in the story prompt. The persuasive essay task required a response as to whether students should attend school year-round to improve academic performance among adolescents. Before each writing session, students listened to the examiner read aloud a short sample

essay or a sample story to remind them of basic text elements in each genre. Students were then given up to 10 minutes for each composition.

To control for individual differences in keyboarding ability, students composed orally while a typist (same for all tasks) transcribed their texts. Transcription occurred in real time, and the students' texts were visible on their own computer monitor (the typist worked at a second monitor behind and to the right of the student). This mode of composition, called the *Listening Word Processor* (LWP) in other experiments (i.e. Reece & Cumming, 1996), has been shown to enable young writers to compose texts of equal or better quality when compared with handwriting. Although changing the mode of composition alters the writing environment, using the LWP offered three advantages that outweighed risks to ecological validity. First, it controlled for differences in keyboarding speed. Students lacking keyboarding proficiency may transcribe so slowly (while looking exclusively at their hands) that they produce little text in 10 minutes, making reading-during-writing irrelevant. Second, it controlled for differences in spelling skills, thereby ensuring a highly readable text. Poor spelling skills could lead to an illegible, incomprehensible text that might deter a student from reading. Third, using the LWP relieved students of any cognitive load associated with graphomotor transcription processes, which can constrain younger writers (Berninger & Swanson, 1994) and could impede reading. Since this study examines the effects of reading fluency (and not transcription processes) upon reading-during-writing processes, removing these constraints and providing highly readable texts allowed us to isolate the effects of reading fluency more effectively.

Each student practiced composing via the LWP until they were comfortable with it. In practice sessions, students were encouraged to practice revising behaviors by giving oral commands (“go back and change that word to . . .”; “delete _____ and use _____ instead”). Additionally, students were instructed to provide punctuation orally, with the minimal requirement of saying “period” at the end of each sentence. After some practice, all students reported that they were comfortable with this procedure, and all included punctuation in their texts.

Writing Measures

Texts were analyzed for length and quality. Length was determined by total word count, calculated automatically by a word processing program. Additionally, rates of text production as a measure of compositional fluency were calculated by dividing the total number of words by the total composing time. All narratives were formatted identically, in terms of margins, spacing, and font, and then assigned a unique identification code to ensure participant anonymity. To assess text quality, two independent raters blind to the conditions of the study were hired and trained. Raters were recruited based upon their experience teaching middle-school Language Arts.

To assess text quality for the narratives and essays, the writing scoring guide developed for the Grade 7 Washington Assessment of Student Learning (WASL, 2003) was used. This is an holistic scoring rubric, and each text received an overall score ranging from 0-4. Scores were given based upon how well the writer met four basic criteria: a) maintaining focus on the topic; b) using supporting details/elaborations

effectively; c) using effective language and word choice; c) using effective tone or voice (See Appendix C). In the assessment process, raters studied and discussed the scoring criteria with the researcher, then scored sample papers, assigning each sample a score from "0" (low) to "4" (high). Raters then shared their scores, discussing discrepancies when they occurred. Using the scoring guide as a baseline, the raters and the researcher agreed upon specific ways to operationalize the quality criteria. After scoring 40 sample papers, raters reached an acceptable level of interrater reliability ($r = .80$ or greater), at which point they began judging the 72 experimental narratives. To assess reliability, 52% of the students' texts were judged by both raters and compared using Pearson correlations. The interrater reliability for judging the quality of the experimental narratives and essays was high ($r = .88$).

Equipment

All students' texts were composed on the same Pentium/Windows-based computer. To enable the use of a typist, a second computer monitor was connected which mirrored the display of the experimental computer. This second monitor, along with the keyboard for the typist, were placed on an adjoining table to the right (and slightly behind) the experimental computer, so that the typist would close enough to hear the students compose orally without being in a direct line of sight.

The eye-tracking system (Eye Response Technologies, ERICA system) was installed on the experimental computer, which consisted of a camera housed in a small box directly underneath the front of the monitor. With the ERICA system, the camera

focuses upon and tracks the incremental movements of a glint of reflected infrared light directed a person's pupil. Once initial focus upon this glint was achieved, a short calibration process was necessary to align the students' eye movements with X/Y coordinates upon the computer screen. Calibration was a simple process requiring each participant to fixate briefly upon a series of flashing lights upon the screen for a total of 20-30 seconds. Once calibration was achieved, eye fixations were sampled at a rate of 60 frames/second. To ensure accurate eyetracking head movements must also be minimized, so participants were seated in a comfortable chair with an attached headrest. To monitor head movements, the experimenter reviewed a small LCD screen showing the position of the participants' eyes throughout each writing task. If students moved more than a few inches in any direction, they were reminded to resume their original head position.

Measuring Eye Movements

Eye movement methodologies have been used for decades to study language processes (Rayner, 1997), including examinations of reading patterns to determine specific words that are fixated upon (Rayner & Duffy, 1986; Rayner & Fischer, 1996). Although eye movement approaches have not been used in writing research, they are well suited to studying reading processes during writing. Unlike think-aloud protocols, which may interrupt composing processes and can only provide intermittent estimates of how often (and what) writers are reading, eye movement data can provide precise information about all reading-during-writing behaviors. In optimal conditions, the

ERICA system can measure eye positions, including fixation durations, upon individual words using 12-point font. Although the ERICA system is very accurate, small head movements can affect the precision of the sampled eye positions. To account for minor drift due to head movements, texts were double-spaced to maintain clarity in determining which line of text students were fixating upon.

One advantage of the ERICA system is that it records keystrokes in real time as it records eye positions upon the computer monitor. This simultaneous recording, along with the software's playback function, enables the analysis of reading behaviors in real time concurrent with text production. In the playback mode, the writer's eye movements are represented by a dynamic red "X," which is superimposed upon the text as it develops (see Figure 6). Unfortunately, the ERICA software used did not enable the conversion of these playback files into exportable video files suitable for coding software tools. To circumvent this problem, analog playback files were laboriously converted to digital video files (using Adobe Premiere Pro 7) and stored upon DVD disks. All student writing sessions were assigned randomized numerical codes so that coders would be blind to writers' identities and reading level.

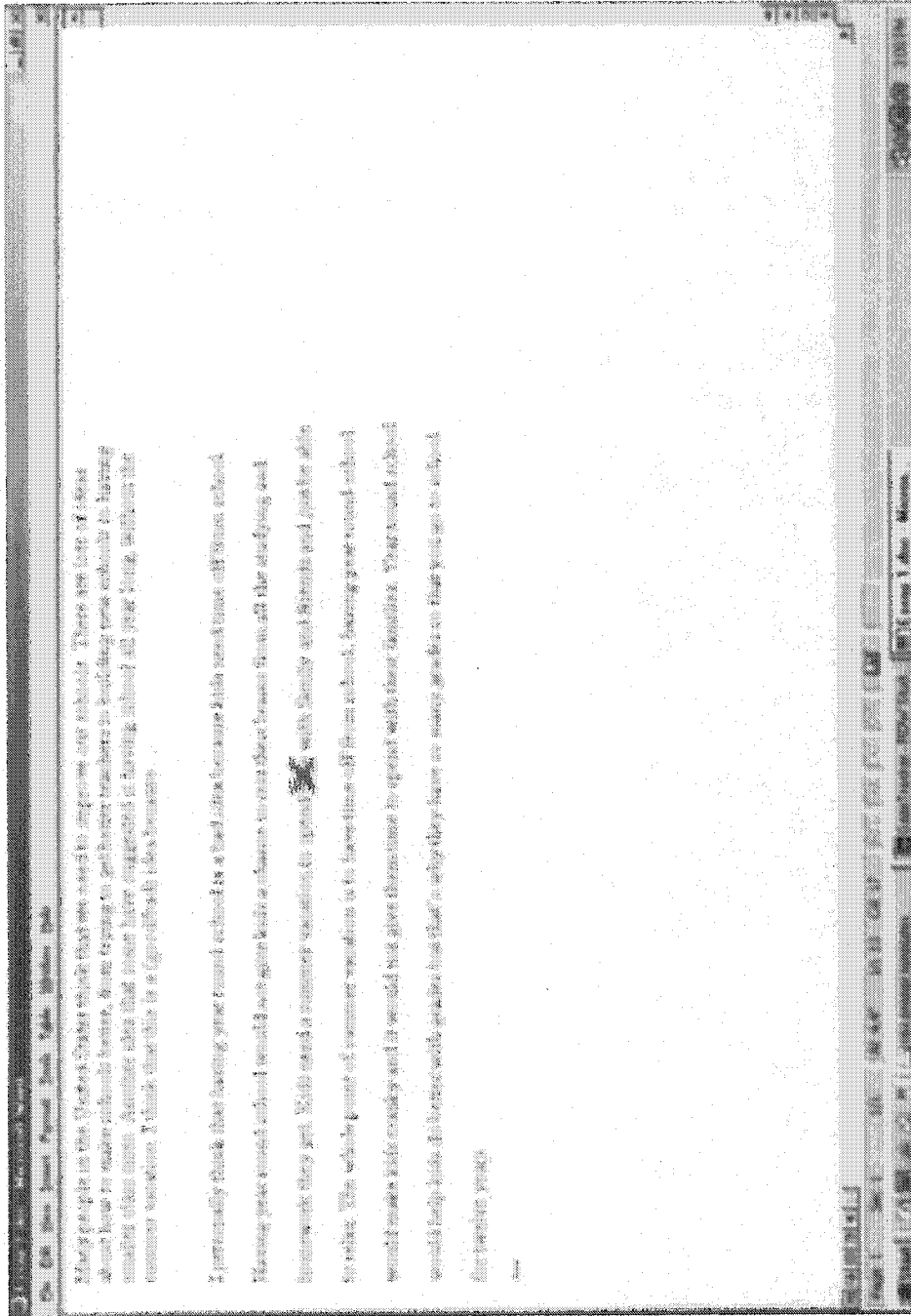


Figure 6—Frame showing eye position on text.

Coding Reading Patterns

As Bereiter and Scardamalia (1987) asserted, knowledge transforming involves “a two-way interaction between continuously developing knowledge and continuously developing text” (p. 12). This “two-way” interaction is part of a recursive process that likely includes reading previously written portions of the text as well as reviewing the most recently composed words. With knowledge telling, this interaction with the developing text may be restricted to basic proofreading processes focusing on the most recently composed words. To capture the different types of reading (or nonreading) eye movements during writing, four codes were developed: *monitoring*, *reading*, *prompt*, and *off-text*. When writers viewed the most recently composed two words or watched as new text appeared on the screen, this was coded as *monitoring*. When writers viewed previously written text that was at least three or more words away from the cursor (indicating the end of the text so far), it was coded as *reading*. All eye positions upon the narrative or essay prompt were coded as *prompt*, and *off-text* events included all eye positions in “blank space” on screen or when their eyes were off the screen entirely. An additional code, *freeze*, was used when the ERICA system failed to collect eye movement data, which was indicated when the dynamic red “X” stopped all movement for more than two seconds. These codes accounted for all reading and non-reading behaviors that occurred in each writing session.

All coding was conducted using the Observational Coding System Tools (OCS, Triangle Research Collaborative, Inc., 2003), which enables an experimenter to code specific events by assigning a keyboard key for each code of interest. For example,

“monitoring” would be coded by pushing the “M” key as soon as the writer’s eye position was within the most recently composed two words. As soon as the monitoring event shifted to another reading event (reading previously written text), the coder would press the “R” button. In this fashion, all of the eye positions indicating reading (and not reading) behaviors were coded, summing to the total writing duration. Because eye movements can be very rapid, all texts were coded at one-half speed (15 frames/second), and coders could go back and recode any portion of the video file to maintain accuracy. OCS software calculates time durations for each coded event, and sums the durations for each code (see Appendix D).

Two coders (the experimenter and a colleague) trained to use OCS software coded the playback files. To test for reliability, 20% of the students writing sessions were coded by both investigators. Interrater reliability was calculated using Pearson correlations for the durations of eye positions coded as *reading* ($r = .96$) and *monitoring* ($r = .99$).

Chapter 4: Analysis and Results

Grouping measures:

To determine whether the groups consisted of fluent and less fluent readers, an analysis of variance (ANOVA) was used. On the reading fluency test, the Fluent group scored significantly higher than the Less Fluent group, $F(1, 35) = 73.41, p < .01$. The writing fluency scores were similar to the reading fluency scores, with the fluent readers scoring higher on the writing fluency measure than the less fluent readers, $F(1, 35) = 17.80, p < .01$. Not surprisingly, the reading fluency and writing fluency scores were highly correlated, $r = .746, p < .01$, with the Fluent group comprised of more fluent readers and writers. The groups did not differ significantly on the working memory measure. See Table 1 for means, standard deviations, and effect sizes.

Table 1. One-Way Analysis of Variance of Fluent and Less Fluent Readers on Reading Fluency, Writing Fluency, and Working Memory

Measure	Fluent <i>n</i> = 18		Less fluent <i>n</i> = 18		<i>F</i> (1, 35)	Effect size η_p^2
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Reading fluency raw score	70.00	9.94	45.28	7.14	73.41**	.68
Writing fluency raw score	23.94	3.54	18.67	3.96	17.80**	.34
Working memory	2.33	.91	1.94	.66	2.12	.06

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

Text Measures

To test the effects of reading fluency upon the written products across genre, text length, text quality, composing time, and compositional fluency, the groups were analyzed using a 2 (Group) x 2 (Genre) repeated measures analysis of variance

(ANOVA). See Table 2 for estimated means, standard deviations, standard errors, and effect sizes.

Quality. There was a significant main effect for Group, $F(1, 34) = 13.13, p = .001$. As hypothesized, fluent readers composed higher quality texts than less fluent readers. No effect for Genre was found and there was no significant Group x Genre interaction, indicating that students in the Fluent group wrote higher quality texts in both genres. In partial support of this finding, reading fluency was correlated with essay quality, ($r = .572, p < .01$), but not with story quality ($r = .291$).

Length. Although students in the Fluent group tended to write longer texts in both genres, no significant main effect for Group was found. There was, however, a main effect for Genre, $F(1, 34) = 21.78, p < .001$. Both Fluent and Less Fluent readers wrote longer texts when composing narratives ($M = 194.7$ words) vs. essays ($M = 143.4$ words).

Composing time. Students in the Fluent group tended to have longer composing sessions, although the 2 (Group) x 2 (Genre) repeated measures ANOVA revealed only a trend toward significance for group differences, $F(1, 34) = 3.93, p = .056$. There was also a trend toward significance for Genre, $F(1, 34) = 4.04, p = .052$, indicating that students wrote for longer intervals during narrative tasks than during essay tasks (see Table 2).

Compositional fluency. Complementing the findings concerning text length, a main effect for Genre was found for compositional fluency, $F(1, 34) = 9.61, p = .004$. Not only did adolescent writers compose longer texts when writing narratives, they also (on average) composed more rapidly on the narrative task ($M = .42$ words per second / 25.2 words per minute) than the essay task ($M = .35$ words per second / 21 words per minute). As with text length, no main effect for Group was found, indicating that fluent adolescent readers do not compose at a different rate than less fluent readers (see Table 2).

Table 2. Estimated Means, Standard Deviations, Standard Errors, and Effect Sizes for Text Quality, Text Length, Composing Time, and Compositional Fluency

Group		Quality (0-4)		Length (words)		Composing Time (seconds)		Compositional Fluency (words/second)	
		Narrative	Essay	Narrative	Essay	Narrative	Essay	Narrative	Essay
Less-fluent	<i>M</i>	2.17	1.97	171.11	132.33	426.66	401.4	.42	.34
	<i>SD</i>	.45	.65	77.66	50.70	145.67	125.16	.15	.11
	<i>SE</i>	.15	.17	20.38	12.66	30.17	29.23	.04	.03
Fluent	<i>M</i>	2.58	2.78	218.28	154.56	514.29	461.45	.43	.36
	<i>SD</i>	.79	.81	94.47	56.60	107.44	122.87	.20	.16
	<i>SE</i>	.15	.17	20.38	12.66	30.17	29.23	.04	.03
Effect Size	η_p^2	.28		.07		.10		<.01	

Reading Measures

To analyze the reading measures, several calculations were required. Most important, the analysis needed to account for different composing durations. Some

students used the entire 10 minutes allowed, while others composed for less than 5 minutes. Since the units of analysis are cumulative time durations of specific reading behaviors (i.e. how much time spent *reading* vs. *monitoring*), a student composing for a shorter time period will almost certainly have shorter durations of each coded behavior. To control for time differences, quotients were calculated for each coded reading behavior. By dividing the total duration of a given reading activity by the total composing time, ratios representing percentages of the total time were developed for each reading behavior and used for statistical analysis.

An additional calculation was necessary to account for intermittent gaps in the eye movement data. During some composing sessions, the ERICA system failed to capture eye position data at different points. These data gaps occurred as a result of an overburdened computer or excessive head movement, and did not reflect any systematic pattern that skewed the data collected. When the "X" representing the eye position stopped moving for more than two seconds, the *freeze* code was used. For most of the 72 texts analyzed, the total durations coded as *freeze* were less than 20 seconds, and for only five of the texts was the duration longer than one minute. To account for the missing data in the calculation of the reading behavior ratios, the *freeze* durations were subtracted from the total composing time durations.

Monitoring (reading the most recently composed words). To evaluate whether reading fluency influenced the amount of monitoring, a 2 (Group) x 2 (Genre) repeated measures ANOVA was used. No significant differences were found between groups.

Students in both groups monitored their texts for the majority of the composing time, and there was a trend indicating that students monitored their texts more when writing narratives than essays, $F(1, 34) = 3.40, p = .054$. Monitoring the text occurred during pauses in text production as well as during text production itself. See Table 3 for estimated means, standard deviations, standard errors, and effect sizes.

Reading (reading previously written text). As with monitoring, a 2 (Group) x 2 (Genre) repeated measures ANOVA was used to examine the effects of reading fluency on the amount of reading previously written text. It was hypothesized that inefficient reading processes would impair this type of reading-during-writing, which only occurred during pauses in text production. Although the means for reading were higher for the Fluent group (see Table 3), no significant differences were found in reading behaviors across groups, failing to support this hypothesis. Additionally, it was hypothesized that reading would increase when writing essays as compared to narratives for the fluent the group. This hypothesis was not supported. Both groups of students spent from 9-13% of the total composing time reading previously written text in both genres.

Prompt. The text prompt can be used to help generate new content and to help evaluate whether the developing text is appropriate to the task. To examine whether reading fluency affected reading processes involving the prompt, a 2 (Group) x 2 (Genre) repeated measures ANOVA was used. No significant differences were found

for group or genre (see Table 3). Student writers reviewed the prompt from 6-9% of the total composing time.

Off-Text (eye positions in white space on screen or off screen). One hypothesis of the study was that students in the Less Fluent group would spend less time interacting with their texts during writing than the Fluent group. It was therefore anticipated that less fluent readers would take their eyes off the text more often. A 2 (Group) x 2 (Genre) repeated measures ANOVA revealed no significant differences in off-text behaviors, failing to support this hypothesis (see Table 3).

Table 3. Estimated Means, Standard Deviations, Standard Errors, and Effect Sizes for Monitoring, Reading, Prompt, and Off-Text Eye Movements.

		Monitoring		Reading		Prompt		Off-Text	
		Narrative	Essay	Narrative	Essay	Narrative	Essay	Narrative	Essay
Less-fluent	<i>M</i>	.71	.64	.09	.11	.07	.09	.13	.16
	<i>SD</i>	.10	.15	.06	.08	.05	.06	.07	.11
	<i>SE</i>	.04	.04	.02	.02	.02	.02	.02	.03
Fluent	<i>M</i>	.68	.64	.12	.13	.07	.06	.13	.17
	<i>SD</i>	.21	.20	.09	.11	.11	.06	.12	.14
	<i>SE</i>	.04	.04	.02	.02	.02	.02	.02	.03
Effect Size	η_p^2	<.01		.03		.02		<.01	

Correlational analyses

Correlational analyses between the coded reading behaviors and text measures also failed to support the main hypotheses of this study. Although reading fluency was

moderately correlated with essay quality ($r = .572, p < .01$), reading fluency was not significantly correlated with story quality. Further, reading-during-writing (coded as *reading*) was not significantly correlated with text quality in both genres.

Secondary Analysis

Overall, the main hypotheses of the study were not supported. Although trends favoring the Fluent reading group emerged in the analysis, high variability within groups in the coded reading behaviors and small effect sizes made between-groups comparisons unlikely to reach significance. At the same time, the data indicated that some students spent a great deal of time reading their texts during writing sessions while others hardly read their texts at all. Some students wrote texts judged to be of high quality, while others wrote relatively poor texts. Reading fluency couldn't account for these differences, perhaps because writing skill involves a more complex interplay of reading and writing subskills and metacognitive factors. Reflecting this complexity, the students were regrouped according to gender as a proxy for writing skill. Gender was selected as the secondary grouping variable primarily because girls have for decades consistently outperformed boys on standardized writing assessments at every grade tested (NAEP, 2003). At the middle school level, girls are generally more skilled writers than boys. Also, the participants in the study for whom we had sufficient data were almost equally distributed across genders (22 boys, 19 girls). In this secondary analysis, the same measures were examined as in the primary analysis.

Language and Memory Measures:

To evaluate potential differences between the groups on the language (reading fluency / writing fluency) and working memory measures, an ANOVA was used. Using the raw scores from the reading fluency and writing fluency measures, a significant difference was found for writing fluency, $F(1, 40) = 4.50, p = .040$. Girls scored higher on the writing fluency measure than the boys. No significant differences were found for reading fluency or working memory. See Table 4 for a summary of the ANOVA and the means, standard deviations, and effect sizes.

Table 4. One-Way Analysis of Variance of Boys and Girls on Reading Fluency, Writing Fluency, and Working Memory.

Measure	Girls <i>n</i> = 19		Boys <i>n</i> = 22		<i>F</i> (1, 40)	Effect size η_p^2
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Reading fluency raw score	60.89	16.20	54.41	11.86	2.18	.05
Writing fluency raw score	23.00	4.32	20.23	4.05	4.50*	.10
Working memory	2.00	.69	2.22	.87	.81	.02

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

Text measures

To evaluate differences between gender groups on the written products, text length, text quality, composing time, and compositional fluency were analyzed using a 2 (Sex) x 2 (Genre) repeated measures analysis of variance (ANOVA). See Table 7 for estimated means, standard deviations, standard errors, and effect sizes.

Quality. A significant main effect for Sex was found, $F(1, 39) = 6.63, p = .01$. No effect for Genre was found, and no Sex x Genre interaction was found, indicating that girls wrote higher quality texts in both genres.

Length. Although text length is often correlated with quality, no main effect for Sex was found despite the higher quality of the girls' texts. Surprisingly, visual inspection of the means indicates that the boys wrote slightly longer texts, although these differences were not significant. There was a main effect for Genre, $F(1, 39) = 26.78, p < .001$, with boys and girls writing longer narratives than essays.

Composing time. A significant main effect for Sex was found, $F(1, 39) = 6.56, p = .014$, with girls taking longer to write in both genres. Additionally, a main effect for Genre was found, $F(1, 39) = 4.66, p = .037$. Both boys and girls wrote for longer periods of time when composing narratives than when composing essays. No significant Sex x Genre interaction was found.

Compositional fluency. Significant main effects were found for Sex, $F(1, 39) = 5.95, p = .019$, and Genre, $F(1, 39) = 13.82, p = .001$. On average, both boys and girls composed more words per minute in the narrative condition. The main effect for Sex, however, indicated that the boys composed more words per minute (on average) than the girls in both genres.

Table 5. Estimated Means, Standard Deviations, Standard Errors, and Effect Sizes for Text Quality, Text Length, Composing Time, and Compositional Fluency.

Group		Quality (0-4)		Length (words)		Composing Time (seconds)		Compositional Fluency (words/second)	
		Narrative	Essay	Narrative	Essay	Narrative	Essay	Narrative	Essay
Boys	M	2.27	2.14	198.55	156.32	432.53	394.55	.45	.40
	SD	.75	.64	98.56	55.04	136.89	105.08	.16	.12
	SE	.15	.16	18.39	11.21	26.51	24.76	.04	.03
Girls	M	2.58	2.71	184.42	124.42	518.13	478.44	.38	.28
	SD	.58	.87	69.25	49.53	107.86	127.80	.18	.12
	SE	.16	.17	19.79	12.06	28.53	26.64	.04	.03
Effect Size	η_p^2	.15		.03		.14		.13	

Reading Measures

Monitoring (reading the most recently composed words). To evaluate the amount of monitoring across gender groups, a 2 (Sex) x 2 (Genre) repeated measures ANOVA was used. A significant main effect for Sex was found, $F(1, 39) = 7.20, p = .011$, along with a main effect for Genre, $F(1, 39) = 8.87, p = .005$. However, the ANOVA also indicated a Sex x Genre interaction, $F(1, 39) = 6.96, p = .012$. Girls did less monitoring when writing essays than when writing stories, whereas the boys maintained similar amounts of monitoring in both genres. Post-hoc analysis using the Bonferroni t test to control for family wise Type I error rate indicated that girls monitored their texts significantly less ($M = .55$) than boys ($M = .72$) when writing essays, $t(1, 39) = 3.75, p < .001$, but not when writing narratives. When writing essays, only the girls decreased their overall proportion of monitoring processes significantly,

$t(1, 39) = 2.52, p = .016$. See Table 6 for estimated means, standard deviations, standard errors and effect sizes.

Reading (reading previously written text). As with monitoring, a 2 (Sex) x 2 (Genre) repeated measures ANOVA was used to examine differences across genders on the amount of reading previously written text. A main effect for Sex was found, $F(1, 39) = 47.95, p < .001$. In both genres, girls devoted more time to reading than boys. See Table 6 for estimated means, standard deviations, standard errors and effect sizes.

Prompt. The 2 (Sex) by 2 (Genre) repeated measures ANOVA for reading the prompt did not indicate any significant main effects for Sex or Genre. The analysis did indicate a significant Sex x Genre interaction, $F(1, 39) = 4.62, p = .038$, although post-hoc t -tests failed to find further significant differences across groups or genres. See Table 6 for estimated means, standard deviations, standard errors and effect sizes.

Off-Text (eye positions in white space on screen or off screen). The 2 (Sex) x 2 (Genre) repeated measures analysis of variance revealed a main effect for condition, $F(1, 39) = 7.79, p = .008$. Both boys and girls had higher proportions of non-reading, off-text eye positions in the essay genre versus the narrative genre. See Table 6 for estimated means, standard deviations, standard errors and effect sizes. No other significant effects were found.

Table 6. Estimated Means, Standard Deviations, Standard Errors, and Effect Sizes for Monitoring, Reading, Prompt, and Off-Text Eye Movements.

		Monitoring		Reading		Prompt		Off-Text	
		Narrative	Essay	Narrative	Essay	Narrative	Essay	Narrative	Essay
Boys	M	.73	.72	.06	.06	.08	.06	.13	.16
	SD	.15	.14	.04	.04	.10	.06	.09	.12
	SE	.03	.03	.01	.01	.02	.01	.02	.03
Girls	M	.67	.55	.15	.18	.05	.09	.12	.18
	SD	.16	.15	.08	.09	.03	.06	.10	.13
	SE	.04	.03	.01	.02	.02	.01	.02	.03
Effect Size	η_p^2	.16		.55		<.01		<.01	

Chapter 5: Discussion

The primary aim of the study was to compare the effects of reading fluency upon the reading-during-writing processes of adolescent students. As depicted in influential models of writing, reading processes can play a central role in writing (Hayes & Flower, 1980, Hayes, 1996, Kellogg, 1996). These reading processes appear to take on a greater role as writing develops, with accomplished writers reading their own texts more often than novice writers (Stallard, 1974). Because the reading-during-writing behaviors of adolescent students had not been examined previously, this study posed specific developmental questions. Do younger students read their own texts as they write? Do fluent readers employ reading processes more often, or in more sophisticated ways, than less fluent readers? Reading-during-writing can contribute to writing processes in several ways, ranging from more basic error detection to sophisticated processes of text interpretation, reflection, and planning (Hayes, Flower, Schriver, Stratman, & Carey, 1987). If a writer has inefficient reading processes, these more sophisticated elements of reading-during-writing may be constrained or prevented. Furthermore, inefficient reading processes may impede the development of a *knowledge transforming* approach to writing (Bereiter & Scardamalia, 1987).

Although the Fluent reading group wrote higher quality texts, few differences were found in the specific reading-during-writing behaviors measured. In general, students in both groups monitored their recently composed texts the majority of the time. This type of reading process, which often occurred during text production, may be indicative of a *knowledge telling* approach to writing. Viewing the most recently

composed words as they appear on a computer screen is an efficient way to conduct error detection (is it the right word? Is it spelled correctly?) and sentence-level planning (what did I just say?), both of which fit nicely in the knowledge telling model. For the problem-solving processes characteristic of knowledge transforming, different reading processes, including frequent rereading of previously written text, are necessary. There were trends indicating that fluent readers were indeed reading their previously written texts more, but these differences failed to reach significance. In this study, students in the Fluent reading group did not read their texts significantly more often during writing than students in the Less Fluent group. On the writing measures, students wrote longer texts and composed more quickly when writing narratives, supporting previous research studies showing that students find essays more difficult than narratives (Hidi & Hildyard, 1983; McCutchen, 1987). Yet even in the more difficult genre (essays), no significant differences emerged among the reading patterns examined. What might account for these null findings? Why were the main hypotheses in this study unsupported?

There are five main explanations, each of which may (individually or in some combination) account for the lack of differences across reading fluency groups.

Five Explanations of the Results

1. The nature of the writing tasks. a) *Short composing times:* Providing the students with only 10 minutes of composing time may have influenced the approach they used to write. Knowledge telling, according to Bereiter and Scardamalia (1987), is

an efficient mode of writing that facilitates content retrieval and text production. With only 10 minutes of composing time, students may have felt it necessary to compose in the most efficient manner possible, even if they were capable of more complex writing approaches. In this study, students began writing shortly after reading the prompt, suggesting very short pre-planning activities. As Bereiter and Scardamalia (1987) note, short start-up times are indicative of knowledge telling (pp. 13-14). If the condensed composing times encouraged knowledge telling approaches, reading processes focused on error detection and monitoring could be expected for fluent and less fluent readers.

b) *Low-stakes writing tasks*: Knowledge transforming is a cognitively demanding approach that does not guarantee a higher quality product. Knowledge telling, on the other hand, is well suited to producing a text that is appropriate to the task. The experimental tasks were of little importance to the students. Although the students were paid, there were no consequences for poor writing performance. Students in either group may not have been sufficiently motivated to take the more effortful approach to writing. As a result, the types of reading that can lead to new knowledge or new planning may not have been used.

2. Small sample size. As the analysis indicated, there was a trend favoring the Fluent group on the *reading* measure. With more participants, this trend may have reached significance. Having only 18 students in each group resulted in a study with relatively low statistical power.

3. Reading-during-writing develops later. The seventh and eighth grade students in this study may have simply been too young to employ the types of sophisticated reading processes hypothesized. Stallard's (1974) observational study of reading-during-writing examined high school students, and he found that only the good writers showed frequent reading processes. Bereiter and Scardamalia (1987) found that fifth-grade students almost exclusively showed knowledge telling approaches, and that 10th-grade students rarely showed evidence of knowledge transforming. Although Bereiter and Scardamalia did not offer a developmental age at which students become able to use a knowledge transforming approach, middle school may be too early, regardless of reading ability.

4. Measures of reading-during-writing based upon time durations miss *amounts* of reading. In this study, proportions of time spent engaging in different types of reading behaviors during writing were analyzed. These proportions are potentially confounded with reading fluency; a slow reader may spend *more* time reading *less* text than a fluent reader. In other words a highly fluent reader might actually read more words, and engage with his or her text more frequently, but have devoted a lower proportion of time in doing so than a less fluent reader. Although sufficient reliability was not achieved to analyze the frequencies of specific reading-during-writing behaviors, this type of analysis may be possible in the future. Additionally, a microanalysis of actual words read during writing may reveal more accurate data concerning reading behaviors.

5. Reading fluency is necessary, but not sufficient for knowledge transforming.

One hypothesis of this study was that inefficient reading processes might impair reading-during-writing processes. This hypothesis may be accurate without necessarily leading to the conclusion that reading fluency, alone, facilitates reading-during-writing. In other words, reading fluency may be necessary but not sufficient for more sophisticated reading-during-writing processes. Other language processes may need to be efficient, such as writing fluency. Furthermore, other elements of overall writing skill need to be considered. Knowledge transforming, and the sophisticated interaction with the developing text it requires, does not necessarily follow from achieving a collection of efficient writing subprocesses. Knowledge about rhetoric and considerations of audience, for example, need to be developed to make the leap to knowledge transforming approaches. Writing skill may be more than the sum of the parts.

Gender and writing skill.

Writing skill may also be more advanced in adolescent girls than in adolescent boys. National assessments show a persistent performance gap between girls and boys in writing achievement. According to the NAEP (2002) results, 21% of boys at the 8th grade level are *below basic* writers. Only 9% of girls fall into the *below basic* category. At the same time, 42% of girls score *at or above proficient* in writing, whereas only 21% of boys are *at or above proficient* (NAEP, 2002). A discrepancy in writing skill

between boys and girls has also been reported in other English-speaking countries (i.e. Gambell & Hunter, 2000).

Along with scoring higher in writing achievement, girls also appear to have better writing practices and more positive attitudes about writing. Within the Canadian national achievement assessment, the School Achievement Indicators Programme (SAIP) examined the literacy of a random cross-Canada sample of approximately 36,000 children, ages 13 and 16. Half of this sample completed a questionnaire of writing practices and attitudes (Gambell & Hunter, 2000). The results revealed that girls and boys differed significantly in their responses to 9 of the 56 writing-related questions. For example, girls more frequently reported writing in excess of six to ten pages per month (outside of school) and reading in excess of 15 minutes per day. A multiple regression analysis revealed the following elements to be the best predictors of writing performance:

- Studying a second language
- Student's grade
- Revises and edits writing
- Uses a grammar handbook when writing
- Degree of confidence as a writer

Revising and editing typically lead to better quality texts, and they are considered processes associated with mature writing. *Confidence as a writer* suggests self-efficacy, a belief in his or her own ability to complete a given writing task. Thus, the writing behavior and attitudes of girls appears to be more mature than that of boys.

In order to reduce within-group variability and to see if reading processes varied across skill levels, the participants in this study were regrouped according to gender for a secondary analysis. In the secondary analysis, a different picture concerning reading-during-writing emerged. As expected, the girls wrote higher quality texts in both genres. But the ways they approached the writing tasks differed from the boys in important ways. Based upon their eye movement data and text measures in this study, two profiles of adolescent writers can be developed.

Adolescent Boys' Writing

Boys appeared to approach the narrative and essay tasks in roughly the same way. On both tasks, the boys as a group monitored their texts for an average of over 70% of the time, focusing upon the most recently composed words as they wrote. They took their eyes off their texts about 15% of the time on average, and revisited the prompt about 7% of the time. Going back to read previously written text was rare, occurring only about 6% of the time when writing essays or narratives. In general, the boys spent very little time interacting with their developing texts in a recursive manner. Monitoring can (and usually does) occur in a linear fashion, rarely amounting to more than a single pass over the text as it appears on the computer screen.

There were a few differences across genres. Boys generally wrote longer texts and wrote more words per minute of composing time when writing narratives, which is consistent with evidence suggesting that essays are more difficult for young writers than

narratives (McCutchen, 1987, Hidi & Hildyard, 1983). Despite these differences, the boys seemed to employ a similar approach to writing regardless of genre (see Figure 7).

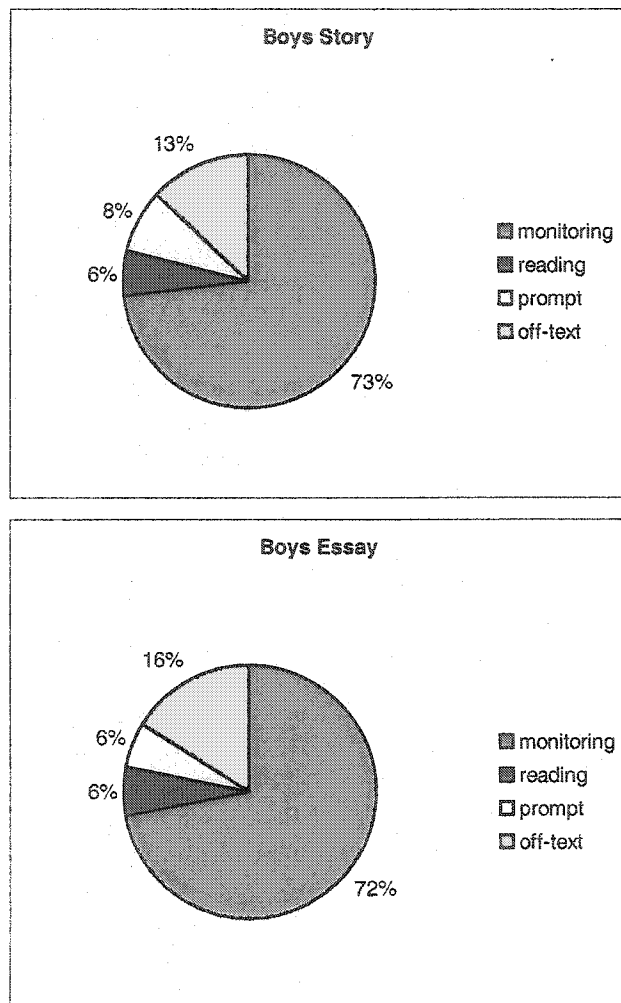


Figure 7. Pie Charts of Reading-During-Writing—Boys.

Adolescent Girls' Writing

Unlike the boys, the girls appeared to employ more flexible, recursive approaches to writing. Regardless of the genre, the girls spent more time, on average, reading their previously written texts than the boys. They also (on average) composed fewer words per minute when writing essays than the boys, despite significantly higher writing fluency scores on our assessment. Although the girls as a group demonstrated more fluent text production abilities than the boys, they appeared to employ less efficient writing processes on the essay task.

On the stories, the girls as a group monitored their texts on average for about 68% of the time, which is similar to the boys. Reading, however, accounted for an average of about 15% of the composing time, which is substantially higher than the average of the boys (6%). The differences were greater in the essay condition, with reading accounting for an average of about 18% of the composing time for girls (vs. 6% for the boys). At the same time, monitoring dropped to an average of about 55% of the total composing time (see Figure 8). As the writing task became more difficult, the girls responded with different reading-during-writing processes to handle them. Although narratives may not require more than local planning and proofreading to generate reasonable quality, writing an effective essay may require more global reading and planning. The drop in monitoring, the decrease in word production per minute, and the concurrent increase in reading previously written text all suggest that girls used a more flexible and advanced approach to writing in this study, which resulted in higher quality texts.

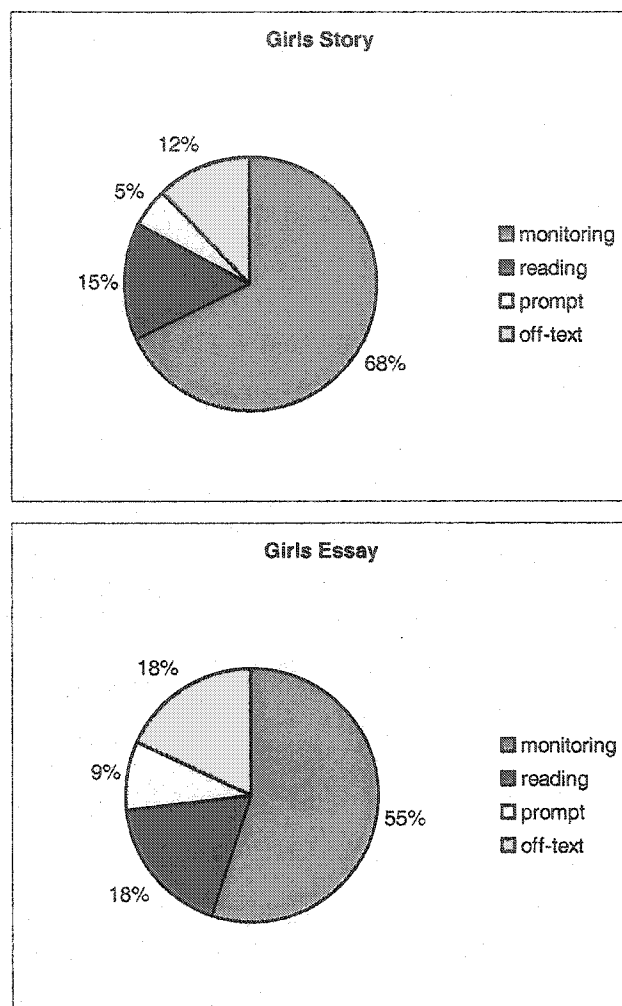


Figure 8. Pie Charts of Reading-During-Writing—Girls.

Although they may not yet be in full *knowledge transforming* mode, the girls in this study were clearly approaching the writing tasks differently than the boys. Given that each writing task was only 10 minutes long, it is remarkable that the girls appeared to alter their approach to text production in the essay condition. They could have simply employed a more efficient approach to these writing tasks—*knowledge telling*—and utilized their superior text production skills to complete the tasks with as little effort as

possible. Instead, the girls chose a less efficient approach to text production in the essay condition, which involved more reading-during-writing and less text monitoring. These reading behaviors during writing may be indications of border crossings into more advanced approaches to writing such as *knowledge transforming*.

The performance gap in writing skill across genders has been noted for decades, but few studies have made progress in discovering the sources of these differences. Fewer still have examined reading and writing processes in real time. Using eye-tracking technology, this study has shown that reading processes during writing vary across skill levels. More specifically, this study suggests that more skilled writers not only read more, but they interact with their developing texts in more flexible, sophisticated ways than less skilled writers.

Furthermore, this study has shown the potential for utilizing eye-tracking methods to study reading-during-writing processes. Experiments with writers at different age and ability levels may, for example, help to describe the development of writing skill as writers employ more sophisticated reading processes. This methodology also makes possible micro-analyses of specific words read during writing, leading to explorations of how specific reading events may contribute to specific text generation and production events. Although the primary hypotheses regarding reading fluency and the reading processes of adolescent writers were not supported, research into the reading processes writers employ remains a promising field of inquiry.

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Appendix A: Reading Span Test Sentences (Working Memory).

Sentences for 2-Sentence Sets (6 total):

- 1) One factor that contributes to a strong economy is the effectiveness of marketing plans and strategies.
- 2) Felicia and Gregory collected food and money for their high school's annual holiday food drive.

- 1) Suppose that some of your peers in school suddenly began wearing purple high-top tennis shoes.
- 2) Jim went to a local supermarket, and with permission, he set up a card table.

- 1) Sometimes that research is based upon careful analysis of current trends and fashions.
- 2) It's good to smile at the seasonal shoppers when they have angry looks on their faces.

Sentences for 3-Sentence Sets (9 total):

- 1) When people rely on their senses to explain the world around them, they make assumptions.

2) Although many think that Abner Doubleday invented baseball in New York, it is not true.

3) In the southwest corner of the state of Colorado, there is a group of cliff dwellings.

1) The sign said “please contribute food or cash to Cascade High School’s Food Drive.”

2) It’s not difficult to find many examples of incorrect ideas people once believed.

3) Professionals in market research wonder how trends originate and evolve for young people.

1) There is an English game called rounders, and rounders most likely evolved from cricket.

2) Initially, the two friends were nervous and somewhat reticent because they had never been there before.

3) A few centuries ago people believed that the sun revolves around the Earth.

Sentences for 4-Sentence Sets (12 total):

1) The scientific method, with its tests and experiments, is not just for scientists in laboratories.

2) The ancient villages in this region, now called Mesa Verde, once had about seven thousand people.

- 3) They were exceedingly polite when people complimented them, thanking them and responding kindly.
 - 4) Imagine that an increasing number of kids starting working for the local aluminum plant.
-
- 1) At its highest level of play, we now find players from every continent except Antarctica.
 - 2) A good automobile mechanic works hard to discover why a car is not running properly.
 - 3) The cliff dwellings housed a complex culture that included religion, a calendar, and ceremonial places.
 - 4) To scientists, systematic observation means designing and carrying out experiments under controlled conditions.
-
- 1) A long period of very dry weather resulted in a drought, making it harder to survive.
 - 2) As an increasing number of truck drivers voluntarily gave free rides, Joe remembered his old job.
 - 3) Whatever it was, the Anasazi people left us with intriguing buildings, pottery, and an enduring mystery.
 - 4) It would be economically valuable to know who starts fads, and valuable to set up interviews.

Sentences for 5-Sentence Sets (15 total):

- 1) Tom and Melinda starting sorting the groceries before the shift bell started ringing loudly.
 - 2) Many individuals are not concerned about being unique, and they will wear unfashionable clothing.
 - 3) The groundskeeper was pleasantly surprised at how quickly and enjoyably the time had passed.
 - 4) The concept of control in science means trying to eliminate as many alternative explanations as possible.
 - 5) Several talented players are from Japan and Cuba, and they have fabulous skills and reverent attitudes.
-
- 1) A good shoe store has an adequate inventory of shoes available in various colors and sizes.
 - 2) They continued to farm the mesa, and they made beautiful and intricately decorated pottery.
 - 3) The young children outside the bank had braided hair, gleaming white smiles, and shirts crisply starched.
 - 4) Consider the commonsense, but incorrect conclusion that heavy objects fall to Earth faster than lighter objects.
 - 5) When people plan to return, they tend to leave clothing and even food stored in containers.

- 1) Scientists develop theories to explain natural events in the real world and then form specific hypotheses.
- 2) The need for a mythic and purely American origin for our national pastime reveals our insecurity.
- 3) Rigorous marketing research and careful analysis provide the information essential for economic planning.
- 4) Mike felt wonderful for helping his less fortunate neighbors as they cleaned up after the hurricane.
- 5) Some people are different from the norm, and they are usually quite happy about resisting trends.

Appendix B: Writing Prompts.

Narrative

Jane, Paul, and Judy got together one day after school and were looking for something to do. They weren't talking much, because Paul and Judy were mad at each other. Jane tried to get her friends to get along, but it wasn't working today. As they were walking down the street, they suddenly heard a strange sound from above. Paul looked up first, and his eyes grew wide. Jane and Judy, seeing the expression on Paul's face, were afraid to look up. Then, . . .

Persuasive Essay

Many people in the United States think that we need to improve our schools. There are lots of ideas about how to make schools better, from trying to get better teachers to building new schools to having smaller class sizes. Another idea that some have suggested is having school all year long, without the summer vacation. I think that this is a (good/bad) idea because . . .

Appendix C: Scoring Guide for Written Texts (WASL, 2003).

Points	Description
4	<ul style="list-style-type: none"> • maintains consistent focus on the topic and has ample supporting details has a logical organizational pattern and conveys a sense of wholeness and completeness • provides transitions which clearly serve to connect ideas • uses language effectively by exhibiting word choices that are engaging and appropriate for intended audience and purpose • allows the reader to sense the person behind the words
3	<ul style="list-style-type: none"> • maintains adequate focus on the topic and has adequate supporting details has a logical organizational pattern and conveys a sense of wholeness and completeness, although some lapses occur • provides adequate transitions in an attempt to connect ideas • uses effective language and appropriate word choices for intended audience and purpose • provides the reader with some sense of the person behind the words
2	<ul style="list-style-type: none"> • demonstrates an inconsistent focus and includes some supporting details, but may include extraneous or loosely related material • shows an attempt at an organizational pattern, but exhibits little sense of wholeness and completeness • provides transitions which are weak or inconsistent • has a limited and predictable vocabulary which may not be appropriate for the intended audience and purpose • attempts somewhat to give the reader a sense of the person behind the words
1	<ul style="list-style-type: none"> • demonstrates little or no focus and few supporting details which may be inconsistent or interfere with the meaning of the text • has little evidence of an organizational pattern or any sense of wholeness and completeness • provides transitions which are poorly utilized, or fails to provide transitions • has a limited or inappropriate vocabulary for the intended audience and purpose • provides the reader with little or no sense of the person behind the words
0	<ul style="list-style-type: none"> • response is "I don't know"; response is a question mark (?); response is one word; response is only the title of the prompt; or the prompt is simply recopied

Appendix D: OCS Data Table with Durations for Reading Events.

SUMMARY STATISTICS REPORT

EVENT	FREQ	TOTAL
1 freeze	1	00:00:01.05
2 duration	1	00:10:05.17
3 monitoring	89	00:06:55.64
4 rereading	38	00:00:52.90
5 off-text	58	00:01:33.83
6 prompt	16	00:00:41.48

VITA

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