

From novice to expert: Implications of language skills and writing-relevant knowledge for memory during the development of writing skill

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Abstract: This article outlines a theory of the development of writing expertise illustrated by a review of relevant research. An argument is made for two necessary (although not sufficient) components in the development of writing expertise: fluent language generation processes and extensive knowledge relevant to writing. Fluent language processes enable the developing writer (especially the young developing writer) to begin to manage the constraints imposed by working memory, whereas extensive knowledge allows the writer to move beyond the constraints of short-term working memory and take advantage of long-term memory resources by relying instead on long-term working memory.

Keywords: writing, composition, working memory, development



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Even a brief examination of the development of writing skill prompts a basic question: Given the complexity of the writing process, how do novices manage it? The transition from novice to expert writer has been the focus of much research by multiple research groups, some of which will be reviewed here.

Studies of skilled writers illustrate well the complexity of the writing process. The seminal work of Hayes and Flower (1980) provided a cognitive account of the writing process, and elaborations of that model over the years (Hayes, 1996; 2006) have incorporated additional social and affective components. Hayes (1996) reorganized the processes originally described (in Hayes & Flower, 1980) as planning, translating, and reviewing. Planning was subsumed under the broader label *reflection*, which encompasses problem solving (including planning), decision making, and inferencing. Translating was retitled *text production* and has been elaborated considerably by Chenoweth and Hayes (2001; see also Berninger & Swanson, 1994). The original reviewing process was expanded to include *text interpretation* as well as embedded *reflection* and *text production* (see also Hayes, 2004). New in the 1996 model was the explicit inclusion of working memory, as well as specifications of affective goals, predispositions, beliefs, and the social environment.

Within such a framework, the present review focuses on linguistic processes that support text production, especially as they interact with other aspects of knowledge relevant to writing, all within the constraints of working memory. It is this focus on linguistic processes – and on related memory and processing implications for young writers in particular – that distinguishes the present theoretical frame from other discussions of writing expertise (e.g., Berninger et al., 2002; Kellogg, 2008). Figure 1 presents the frame for the argument that follows: Initially, operations of linguistic processes and other processes involving writing-relevant knowledge (e.g., knowledge of genre) are constrained by traditional working memory (or “short-term working memory,” STWM), but as linguistic skill and writing-relevant knowledge increase, eventually the constraints of STWM give way to more expansive long-term working memory resources.

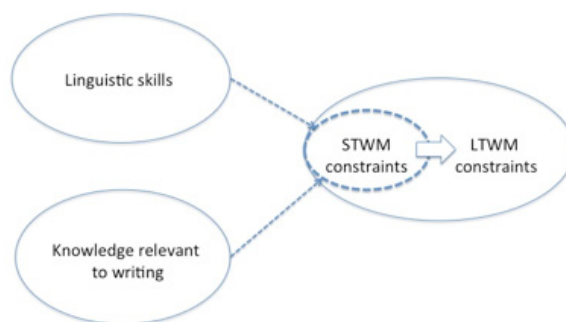


Figure 1: Interdependence of language, knowledge and memory processes during writing.

The review that follows will survey empirical studies of working memory constraints involving the language processes entailed in text production. The review then turns to relevant studies of topic knowledge and genre knowledge, and it concludes with a discussion of how long-term working memory might be enacted during an episode drawn from the protocol of a skilled writer.

When we think of novice writers, especially children, it is clear that they are still learning to control the linguistic (as well as motor) processes involved in text production. In contrast, skilled writers have fluent text production processes, as well as other writing knowledge; therefore, we might expect writing to be easier for skilled writers than for novices. When we look at writers in action, however, these expectations are not always met. Consider an excerpt from a protocol from a wine columnist of a metropolitan newspaper, a protocol representative of many produced by skilled writers (see Table 1).

Table 1. Excerpt from a professional writer's protocol

Writer's Protocol	Text Produced
<p>... See, what we have to do is tell them why it is that cabernet sauvignon gives it the longevity. Why does it? Because it is a hard grape; it takes a long time to come around. OK (reviews) "This is the grape <u>that</u> -- " You can't get too technical or everybody won't understand it, but (rereads) "This is the grape that" ah, (types) "provides backbone --" not just this but all wines</p> <p>(from McCutchen, 1984, p. 229)</p>	<p>... This is the grape used in the hardest</p> <p>(edits) This is the grape that provides backbone to the wines of Bordeaux.</p>

At this point the writer is well into his weekly column describing a tasting of Bordeaux wines, and he is discussing the longevity of the wines from that region. (In Table 1, time progresses from the top of the table to the bottom. The writer's speech is on the left; the text produced is on the right.) A comparison of the ratio of speech to text reveals that the ratio is rather high. The writer shows considerable thought behind the words that ultimately appear on the page.

In contrast, consider the protocol of a seven-year old student writing an essay about swimming, an excerpt of which is presented in Table 2.

For this young writer, the ratio of words in the protocol to text is much lower; in fact, the written text mirrors the protocol almost exactly. Given the fact that this young writer was still far from fluent in handwriting and spelling, the question becomes: How do young writers manage the complexity of the writing task and make their writing process appear even smoother than that of the expert (see also Torrance, 1996)?

Table 2. Excerpt from a young novice writer's protocol

Writer's Protocol	Text Produced
(silence until prompted)	I like to swim under water.
My dad can swim better than us all.	My Dad is the swimmer.
Sometimes my brother tries to dunk me.	Sometimes my brother dunk's me.
My mom makes me swim back and forth ten times.	My mom make's me swim back and forth over and over.

(from McCutchen, 1988, p. 314)

Answering that question was exactly the task that Bereiter and Scardamalia (1987) set for themselves. Bereiter and Scardamalia explored the writing strategies used by children and offered an alternative to Hayes and Flower's model of expert writing, which they termed "knowledge telling" (Bereiter & Scardamalia, 1987). During knowledge telling, the writer probes memory with a cue derived either from the writing assignment's topic or genre and thereby retrieves relevant information for potential inclusion in the text. The seven-year-old writer was quite articulate about her strategy to probe memory. After writing the last sentence depicted in Table 1, she noted "All my sentences start with *my*, so I should just put it there," and she wrote *My, My, My* on three consecutive lines. Thus, according to Bereiter and Scardamalia (1987), the way novices manage the complexity of writing is by adopting a strategy that simplifies the task, a strategy that is fundamentally different from those employed by expert writers.

Multiple researchers have argued that a central feature of the development of writing skill is the increasing fluency of linguistic processes involved in text production (Alamargot & Fayol, 2009; Berninger et al., 2002; McCutchen, 1996, 2000) and the lack of fluent text production has far-reaching implications arising from the limited capacity of working memory, as discussed by Baddeley (1986). Knowledge telling might, in fact, be considered an adaptive strategy because it eases the load on working memory that results from lack of fluent text production.

There is abundant evidence that novice writers, especially young novices, are severely constrained by their lack of fluent text production (see Graham, Berninger, Abbott, Abbott, Whitaker, 1997; Graham & Harris, 2000; McCutchen, 1996). Berninger and Swanson (1994) distinguished two kinds of text production skills, *transcription* and *text generation* (see also Chenoweth & Hayes, 2001). Text generation is assumed to share many components with oral language production, such as content selection, lexical retrieval, and syntactic processes. In contrast, transcription entails the cognitive and physical acts of forming *written* (as opposed to *spoken*) representations of text and so includes spelling and motor skills involved in handwriting and typing.

1. Development of Transcription Fluency

Transcription processes (notably spelling and handwriting) seem most limiting in the earliest stages of writing acquisition. For example, King and Rental (1981) found clear quality and quantity differences favoring dictation over writing (that is, text generation with and without added transcription demands) in a study of first- and second-grade children. However, differences favoring dictation are more qualified for older writers. Children's written texts typically tend to be shorter than their dictated texts (Bereiter & Scardamalia, 1987; McCutchen, 1987), whereas length differences favoring dictation are not as consistent for adults (Gould, 1980; Grabowski, Vorweg, & Rummer, 1994; Reece & Cumming, 1996), suggesting that transcription is more fluent for adults than for children.

Differences in quality are less consistent in dictation studies, even for children. In their seminal study comparing dictation and handwriting, Bereiter and Scardamalia (1987) asked children to produce texts in three conditions: (1) writing, (2) regular dictation, and (3) slow dictation (i.e., a dictation rate indexed to the child's writing rate). Although dictation yielded longer texts, quality ratings showed little difference across conditions. However, following simple prompts to produce more, children's written texts were rated higher in quality than those produced in either of the dictation conditions. Bereiter and Scardamalia concluded that the brevity of children's written texts (due more perhaps to executive control over self-prompting) is the primary factor contributing to the perception that children often speak better than they write, not the working memory demands of transcription. Bereiter and Scardamalia argued that by middle childhood, the processing cost associated with transcription is largely offset by other affordances of writing, if children simply persevere in generating longer texts. (For children with disabilities, however, transcription demands can be a persistent problem; see Alamargot, Lambert, Thebault, & Dansac, 2007; Graham, 1990.)

Bourdin and Fayol (1994; 2000) directly examined the working memory demands of transcription in a series of experiments by varying response modality (spoken versus written) in a recall task. Bourdin and Fayol (1994) found that serial recall was significantly poorer in the written condition for children but not for adults and, as a result, reasoned that transcription processes of children are still relatively inefficient and draw on working memory resources that could otherwise be devoted to the recall task (see also Grabowski, 2010). Bourdin and Fayol (2000) argued that written production is essentially oral production with the additional task demands of handwriting and spelling, and they experimentally demonstrated that working memory demands during a writing condition were similar to those during an oral condition that included a demanding secondary task. In similar experiments, the task was changed from serial recall to text recall (Bourdin, Fayol, & Darciaux, 1996) and text generation (Olive & Kellogg, 2002), with the consistent finding that transcription imposed higher working memory costs for children than for adults. However, when adults' over-learned, highly fluent transcription processes are disrupted by requiring them to write in cursive upper-case letters, adults then show poorer recall when writing compared with speaking

(Bourdin & Fayol, 1994; Grabowski, 2010) and their texts contain shorter sentences and receive lower quality ratings (Olive, Alves, & Castro, 2009).

The fluency of transcription processes generally increases with age (Berninger & Graham, 1998; Berninger & Swanson, 1994), theoretically decreasing demands on working memory and enabling resource allocation to other aspects of writing (Olive, Favart, Beauvais, & Beauvais, 2008). Although estimates of working memory capacity also tend to increase with age (Conrad, 1971), such increases are often explained by knowledge (Chi & Koeske, 1983) or processing differences (Conrad, 1971) rather than by absolute structural differences in capacity; and the experimentally induced increase in working-memory demands due to unfamiliar transcription modes (Bourdin & Fayol, 1994; Grabowski, 2010) suggests similar process-based explanations are relevant in writing.

Examining a wide range of component processes, Berninger and Swanson (1994) found that transcription measures accounted for more unique variance in composition quality among primary grade children than among older children (see also Berninger et al. 2006; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997). Furthermore, improving handwriting fluency among children has led to general improvements in the fluency of their text generation (Berninger et al., 1997; Graham, Harris, & Fink, 2000). Hoskyn and Swanson (2003) found that transcription factors continued to contribute to age-related differences in text structure from adolescence to elder adulthood, and an independent measure of working memory accounted for additional unique variance in their text measures. Levy and Ransdell (1995) also documented that writers of higher quality texts transcribed text more fluently than writers of lower quality texts. Similar emphasis on the importance of fluency can be seen in studies examining typing as the transcription mode (Cochran-Smith, 1991; Dunn & Reay, 1989), as opposed to handwriting.

2. Development of Text Generation Fluency

Text generation, text production's second major component, also plays a role in the development of writing skill. Text generation, according to Berninger and Swanson (1994; see also Chenoweth and Hayes, 2001) is the mental production of a linguistic message, distinct from transcription of that message into written text. Models of speech production (e.g., Levelt, Roelofs, & Meyer, 1999) suggest a multi-phase route from semantic intent to selection and articulation of a given word, and like speech, text generation during writing involves turning ideas into words, sentences, and larger units of discourse within working memory. During writing, however, the extended production window may allow the route from semantic intent to word and phrase production to be more bidirectional than is typical in speech; for example, Galbraith (1996) argued that for some writers the writing process itself contributes to the generation of new semantic intent or ideas. Still, as in speech, pauses in the stream of language generated during writing are often influenced by syntactic junctures such as

clause, sentence, and paragraph boundaries (Chanquoy et al., 1996; Spelman Miller, 2006); the larger the syntactic boundary (paragraph, sentence, or clause), the longer the average pause, presumably due to the larger demand on working memory.

Text generation has been linked to working memory in a number of studies. McCutchen, Covill, Hoyne, and Mildes (1994) found that skilled elementary and middle school writers had larger working memory spans than less skilled writers, and higher skilled writers generated sentences more fluently during the span task and accessed words in memory more quickly (see also Ransdell & Levy, 1996). In a study with writers ranging in age from adolescents to elderly adults, Hoskyn and Swanson (2003) found that working memory span predicted the structural complexity of texts even after reading skill, spelling, and handwriting speed were taken into account. Jeffrey and Underwood (1996) found a significant correlation between young writers' memory spans and their ability to coordinate ideas within a sentence and a similar (although nonsignificant) correlation between memory span and text quality. Tetroe (1984; reported in Bereiter & Scardamalia, 1987) also linked working memory and text generation at the discourse level. Tetroe asked children to write stories that were to end with specific sentences, varying the number of constraints imposed by the ending sentences. She found a marked decrease in children's ability to honor the ending-sentence constraints when the number of constraints exceeded children's working memory spans. Bereiter and Scardamalia (1987) also found that the number of ideas children could coordinate within a single sentence was related to how well they defended a thesis in an expository writing task, and Bereiter and Scardamalia attributed the relationship to the working memory resources that each child had available. Dellerman, Coirer, and Marchand (1996) found that a similar coordination task predicted writing skill even for high school students.

The working memory constraints that are caused by lack of fluent text production may also make it difficult for writers to avoid or correct certain syntactic errors. For example, subject-verb agreement and other complex syntactic structures become more difficult to coordinate as working memory load increases (Chanquoy & Negro, 1996), and Daiute (1984) found negative correlations between short-term memory capacity and the frequency of errors in students' texts. In addition, Fayol, Largy, and Lemaire (1994) experimentally induced agreement errors by increasing writers' memory load.

Thus, when text production processes (transcription and text generation) are not fluent, the demands on working memory are sizable for novice writers. Although these demands decrease as writers gain fluency (Alamargot, Plane, Lambert, & Chenet, 2010), text production seems to require some working memory resources even for skilled writers (Kellogg, 1987, 1988, 1994; Ransdell & Levy, 1996).

3. Development of Other Writing-Related Knowledge

Of course, linguistic aspects of text production are not the only aspects of writing that develop with expertise. Skilled writers also hold considerable knowledge of discourse forms (i.e., genre) and frequently have extensive topic knowledge.

Familiarity with a genre can theoretically influence writing by providing access to an organized schema in long-term memory, which can facilitate planning, direct revision and even affect working memory demands during translating (Olive, Favart et al. 2009). Early in his protocol the previously referenced wine columnist clearly revealed his genre knowledge as part of his detailed vision for the structure of his column:

... The general structure has got to be, we've got to give them some information about Chateau Latour, make it kind of real to them, give them something to chew on, and then we've got to go through the tasting notes because we had a tasting of Chateau Latour from 1924 to 1967, which means that you have to save enough space to write about, you know, the wines themselves. But [first] we've got to say something about Chateau Latour ...

(from McCutchen, 1984, p. 228)

Issues of genre also relate to writers' broader knowledge of the disciplinary community for whom (or perhaps more appropriately *with* whom) they write. For example, writers generally learn the discourse forms and honor the rhetorical values of their respective academic disciplines (Gee, 2007, MacDonald, 1992; Myers, 1985, Stockton, 1995). Skilled writers seem to have ready access to, if not explicit awareness of, such rhetorical knowledge (Langer, 1992; Stockton, 1995). This ready access is evidenced by the fact that genre and stylistic knowledge seem to influence many other processes, including even lexical and syntactic choices (Barton, 1995; Bazerman, 1984; MacDonald, 1992; Vande Kopple, 1998).

Existing research provides considerable evidence for developmental differences in genre knowledge and for links between genre knowledge and writing skills. Due largely to children's broad early experience with narratives at home and at school (Durkin, 1978-1979; Sulzby & Teale, 1987), very young children show signs of emergent narrative schemas (Brown, 1975; Stein & Glenn, 1979; Sulzby, 1985). Fitzgerald and Teasley (1986) provided evidence for a causal link between genre knowledge and writing skill, demonstrating that the quality of children's written stories improved after instruction in narrative structure. Children's knowledge of expository genres generally develops later (Englert, Stewart & Hiebert, 1988; Langer, 1986), and comparisons reveal that children's written narratives are generally superior to their expositions (e.g., Cox, Shanahan, & Tinzmann., 1991; Hidi & Hildyard, 1983; but see Langer, 1986, as well as McCutchen, 1987, for qualifications). Moreover, the cognitive demands of writing expository texts (specifically argumentative texts) are higher for younger writers, compared to writing narratives (Olive, Favart, et al., 2009). The difference in genre

familiarity is apparent to children themselves, and they claim to be better at writing narratives than essays (Bereiter & Scardamalia, 1987).

McCutchen, Francis, and Kerr (1997) documented marked differences in access to genre knowledge by students with different levels of writing skill. They recorded protocols as middle-school students collaboratively revised texts in which they had both planted spelling errors and rearranged sentences to disrupt the chronology of events, thereby affecting discourse-level meaning. Skilled writers quickly developed a macrostructure of the text (Kintsch, 1998; Kintsch & van Dijk, 1978), reflecting their knowledge of the genre. Even during their initial reading, skilled writers recognized concluding statements that appeared in the introductions, noting these problems with comments such as "That shouldn't be there either 'cause it's too fast." In contrast, less skilled writers paid little attention to discourse-level features. Less-skilled writers examined sentences individually and rarely considered the global structure of the text. Such a strategy made it particularly difficult for them to detect problems involving discourse-level meaning (as opposed to spelling errors). The following excerpt is illustrative of the sentence-by-sentence strategy. (Italics are added to highlight the student's evaluative statements.)

(reading) 'Christopher Columbus was determined to find an all water route to the East Indies . . . East Indies.' *That's good.* (reading) 'Discovering this could bring him fame and fortune. However, however, Columbus also believed that the world was round.' *OK.* (reading) 'Many people' -- *geez!* (corrects spelling, then reads) 'laughed at this idea. They thought the world was flat.' *Next, that's good.* (reading) 'But still the sailors threatened to take over and turn, take over and turn back.' *That's good.*

(from McCutchen et al., 1997, p. 673)

With his sentence-by-sentence strategy, this reader completely overlooked the fact that the text described the sailors threatening to turn back even before they had set sail. In contrast, more skilled writers seemed to construct a macrostructure for the text on which they were working, and such macrostructures seemed to be derived from their general knowledge of text structures, or genres.

Considerable research also documents a substantial role for topic knowledge in writing. Teachers of writing have long argued that topic knowledge should improve writing (Calkins, 1986), and empirical research supports that claim. Bereiter and Scardamalia (1987) observed that children generated more content during planning about familiar topics, compared with unfamiliar topics. In a study of students from fourth, sixth, and eighth grades, McCutchen (1986) found that writers who were more knowledgeable about their topic wrote more coherent texts than did writers who were less knowledgeable (see also Langer, 1984). DeGroff (1987) linked topic knowledge to the quality of children's first drafts, as well as to their revision. In addition, Butterfield,

Hacker, and Plumb (1994) extended such findings to adult writers, documenting a positive relationship between adults' topic knowledge and their revising effectiveness.

McCutchen et al. (1997) also examined the effects of topic knowledge in the revision study discussed previously. Participants revised two texts, one about Christopher Columbus (a familiar topic) and another about Margaret Mead (an unfamiliar topic). Both adults and middle-school students were more likely to detect and correct discourse-level, meaning-related problems in the Columbus text than in the Mead text. Not surprisingly, topic knowledge did not influence the correction of spelling errors.

4. Instruction to Develop Linguistic Skills

The causal relationship between linguistic skills and writing outcomes has been explored in several instructional studies, albeit indirectly. In a series of studies McCutchen and colleagues worked to deepen teachers' linguistic knowledge and then examined effects on the writing of their students (McCutchen, Abbott, et al., 2002; McCutchen & Berninger, 1999; McCutchen, Green, Abbott, & Sanders, 2009; McCutchen, Harry, et al., 2002). Although the importance of phonological awareness, morphological awareness and other metalinguistic skills has been discussed widely in the research literature (often more in relation to reading than writing), the concepts are not well understood by many classroom teachers, nor are their applications apparent in some classroom instruction. For example, teachers frequently teach the mnemonic "long vowels say their names" in English. McCutchen and Berninger (1999) observed a teacher telling students that *cute*, *prune*, and *tube* all contain "long u," an assertion that is not linguistically accurate according to the "says its name" rule. The internal sounds in *cute* and *tube* are indeed close, but not identical; in both *prune* and *tube* (at least in most American dialects), the letter *u* does not in fact "say its name." (Readers who are not convinced are asked to compare the initial phonemes they hear in *use* and *ooze*.)

To help teachers avoid such confusion, the research team worked over the course of several years with multiple cohorts of elementary school teachers, helping them develop knowledge of structural aspects of spoken and written English. The teachers' professional development emphasized the importance of developing students' knowledge of letters (i.e., orthographic awareness), including their ability to transcribe letters fluently as well as spell words accurately. Interventions with teachers also stressed the importance of children's knowledge of discourse genres in their writing development, as well as in their reading.

Work with kindergarten and first-grade teachers (McCutchen, Abbott, et al., 2002) documented that kindergarten students in classrooms of intervention teachers showed increased transcription fluency at the end of the year (measured as fluency in writing letters legibly), compared to their peers in control classrooms. A more detailed examination of teachers' classroom practices revealed that students of kindergarten teachers who spent more time on explicit phonological and orthographic activities

showed increased transcription fluency, as well as increased phonological awareness and word reading skill (McCutchen, Abbott et al., 2002). In addition, first-grade students in intervention classrooms also showed increased spelling skill and composition fluency (measured as longer written narratives), as well as increased reading gains (McCutchen, Abbott et al., 2002).

A second study (McCutchen et al., 2009) involved teachers of grades three, four, and five. Compared with their peers in control classrooms, lower performing students in intervention classrooms showed significantly higher levels of performance at year end on all the writing measures, including spelling, writing fluency, and composition quality, as well as higher performance in word reading, comprehension, and vocabulary. In addition, the measure of teacher's linguistic knowledge was positively related to improved student achievement in spelling and composition quality. Additional analyses indicated that the literacy gains in intervention classrooms generalized to all students, not just the lower-performing students, although with smaller effect sizes.

Thus, interventions with teachers across the elementary school year have documented that students' writing skills improved when their teachers had more literacy-relevant linguistic knowledge to inform their practice (McCutchen, Abbott et al., 2002; McCutchen et al., 2009). Such informed practice presumably deepened students' own linguistic knowledge (however implicit) and benefited their related writing skills.

5. Transition from Novice to Expert

A theory of writing development should entail a principled account of how the novice writer gains expertise and should include an explanation of how multiple sources of knowledge, stored in long-term memory, are coordinated and used in various writing processes, all within the limits of a constrained working memory. The current argument, based on the evidence surveyed in the prior pages, is that writing expertise depends on the development of two necessary (but not sufficient) components: fluent language generation processes (see also Alamargot & Fayol, 2009) and extensive knowledge relevant to writing (e.g., topic knowledge, genre knowledge). (See Figure 1.) Fluent language generation processes enable the developing writer to begin to manage the constraints imposed by working memory. The addition of extensive writing-relevant knowledge allows the writer to move beyond the constraints of working memory (as traditionally defined) and take advantage of long-term memory resources by relying instead on *long-term working memory* (Ericsson & Kintsch, 1995; see also Kellogg, 2001 for a discussion of LTWM in writing).

The construct of long-term working memory (LTWM) was articulated by Ericsson and Kintsch (1995) to account for the kinds of extensive reasoning and knowledge application that characterize expertise in real-world cognitive tasks such as chess, medical diagnosis and comprehension (Kintsch, 1998). Theoretically LTWM contains

not only the limited number of elements activated in working memory as traditionally defined (what Ericsson and Kintsch called *short-term working memory*, or STWM), but also retrieval structures that link items activated in STWM to related elements in long-term memory. The items already activated within the capacity-limited STWM then function as retrieval cues for those parts of long-term memory to which they relate. Thus, the information available in LTWM is of two types: those items activated in STWM and those items in long-term memory that can be reached via the retrieval structures. Such long-term memory elements are not actually stored within working memory, but they can be quickly retrieved when needed (in about 400 ms, as estimated by Ericsson & Kintsch, 1995).

Unlike STWM, which has strict capacity limitations (Baddeley, 1986), the capacity of LTWM is limited only by the nature of the processes that build retrieval structures and by the extent of knowledge in long-term memory to which those structures connect. Kintsch (1998) argued that, in the case of comprehension, effective retrieval structures result from knowledge that is “strong, stable, well practiced, and automated, so that it can be employed for encoding without additional resource demands” (Kintsch, 1998, p. 242) and from encoding processes that are rapid and reliable. Such encoding processes are specific to particular knowledge domains. In the case of comprehension, Kintsch’s (1998) primary focus, these encoding processes are the normal processes of skilled comprehension (e.g., word recognition, syntactic parsing). According to Kintsch’s account of LTWM in skilled comprehension, a coherent text representation develops within LTWM, entailing information stored in episodic memory of the text being read as well as relevant information retrieved from long-term memory. Retrieval structures (capitalizing on knowledge of topic and text structures in long-term memory) provide ready access to previous text representations, as well as knowledge stored in long-term memory, and link them to text elements currently being processed (see also, Kintsch, Patel, & Ericsson, 1999).

In the case of writing, LTWM resources allow the skilled writer to compose new text in the context of easy access to: a) sections of previously written text in episodic text memory, and b) relevant information from long-term memory, such as extensive vocabulary and nuanced knowledge of genre, audience, etc. To illustrate, Figure 2 depicts a portion of the wine columnist’s protocol (presented previously in Table 1) mapped on to a schematic of the network of knowledge momentarily activated in LTWM. The nodes in Figure 2 depicted as squares represent information active in episodic text memory; nodes depicted as circles represent information in long-term memory. The color saturation reflects the level of activation: Black nodes are those that would be active within working memory (as discussed by Baddeley, 1986); grey nodes are those retrieved and activated within LTWM; white nodes are inactive.

As illustrated in Figure 2, active within traditional working memory (STWM) are the gist of the sentence just written (80% of Latour vineyards contain cabernet sauvignon grapes) and potential phrasings for the current sentence, drawn from the protocol (“This is the grape used in the hardest” which is edited and replaced by “This is the grape that

provides backbone"). Access to the resources of LTWM enables the writer to expand "activated knowledge" to include more of the previous text from episodic memory (represented in shaded ellipses) as the lexicon in long-term memory is probed for more appropriate lexical items (represented in non-shaded ellipses). It is the interplay between the lexicon and an expanded view of the prior text, including repeated references to the longevity of Latour wines, that eventually enables the writer to invoke the concept of "hard" and ultimately reject it in favor of a more metaphorical reference to "backbone."

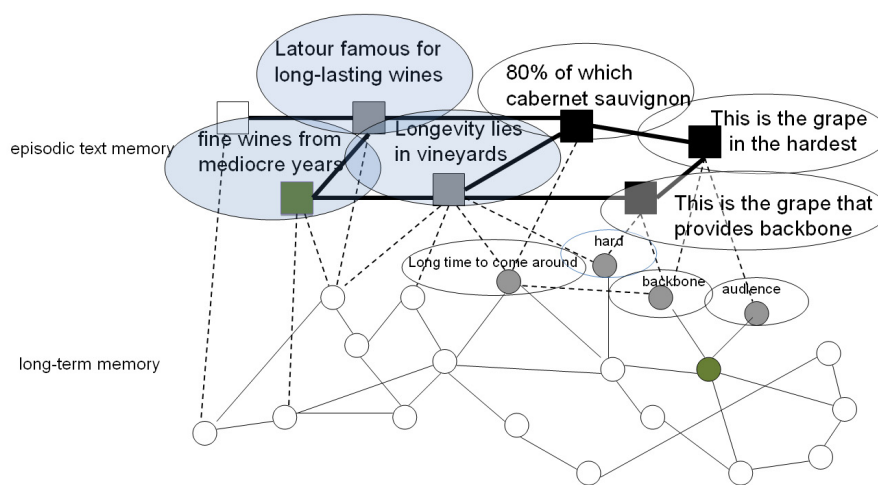


Figure 2: LTWM during skilled writing (adapted from Kintch, Patel, & Ericsson, 1999).

In the account of writing development sketched here, emerging fluency in language generation processes enables developing writers to begin to manage constraints imposed by working memory, as traditionally defined (Baddeley, 1986). However, without considerable fluency in text production *and* without extensive writing-relevant knowledge, novice writers remain limited by working memory capacity. Within such constraints, writing strategies such as knowledge telling may well serve an adaptive function. Because knowledge telling merges content retrieval with text generation, it gets the job done for developing writers in many writing situations.

However, once language production processes become sufficiently fluent and knowledge bases sufficiently rich, writers can transcend the limits of working memory and capitalize on LTWM. Like beginning writers, skilled writers use working memory resources to construct the sentences that make up their texts. However, fluent sentence generation processes, combined with rich writing-relevant knowledge bases, enable skilled writers to link developing sentences to extensive knowledge stored in long-term

memory. Sentence constructions (including interactions among semantic intent, word choice, and syntax) can therefore be influenced by earlier text choices (stored in a text representation in long-term memory), by structural constraints for the chosen genre, by knowledge about a specific audience, by knowledge about the topic, etc. However, access to and coordination of these multiple sources of knowledge become possible only when processing shifts from STWM to LTWM.

The present portrait of how LTWM might contribute to writing expertise has been painted in only the broadest of strokes. Empirical research continues to provide relevant empirical evidence that will ultimately support or refute the theoretical claims sketched here. However, the considerable evidence reviewed here is, at minimum, consistent with such a theoretical account.

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