Chapter 20
Comprehension Ability in Mature Readers

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1. INTRODUCTION

Readers construct detailed mental representations of texts with relative ease; this tends to obscure the fact that reading is a complex, intellectual skill, requiring the coordination of multiple component processes. At the word level, processes are necessary to encode the printed word, access its sound-based representation, and retrieve its meaning from memory. At the sentence level, processes are devoted to the formation of structures that specify the syntactic and conceptual relations within and across phrases; these processes are involved in understanding "who did what to whom" in a sentence. This results in a representation that some theories call propositional–abstract units of meaning that encode the explicit ideas in a sentence. At the discourse level, the explicit ideas in a text are integrated across sentences and with contextually relevant semantic and pragmatic knowledge. This results in a mental representation that researchers call a discourse or situation model. It reflects features of the real or imaginary world that the text describes. In order to construct a discourse model, readers must engage in active inferential processing to interpret and restructure text information in light of their prior understanding of the relevant knowledge domain.

The ability to learn and execute the component processes of reading varies widely. The challenges faced by beginning readers are detailed elsewhere in this volume (see Torgesen & Wagner, this volume); therefore, we focus here on the comprehension performance of adult readers. These readers differ on a broad range of component reading abilities. At the word and sentence levels, poor comprehenders, relative to good ones, have slower and less efficient word-identification skills and greater difficulty processing low-frequency syntactic structures (Bell & Perfetti, 1994; Curtis, 1980; Frederiksen, 1981; Jackson & McClelland, 1979; Just & Carpenter, 1992; King & Just, 1991; MacDonald, Just, & Carpenter, 1992; Palmer, MacLeod, Hunt, & Davidson, 1985; Pearlmutter & MacDonald, 1995). The greatest variation, however, is seen in readers' ability to execute high-level interpretive processes involved in constructing a coherent discourse model. Poor reading comprehension is frequently associated with a systematic

Handbook of Psycholinguistics: 2nd Edition
ISBN: 0-12-369374-8

failure to make appropriate inferences during reading. Poor comprehenders have difficulty making inferences to integrate ideas in a text, to answer questions, and to identify main ideas and themes (Garnham, Oakhill, & Johnson-Laird, 1982; Long & Golding, 1993; Long, Oppy, & Seely, 1994, 1997).

Reading comprehension involves language specific processes as well as domain-general cognitive abilities–sensation, perception, attention, memory, and reasoning. Variation in any of these abilities potentially underlies individual differences in comprehension performance. Thus, one important question concerns the extent to which variation in some ability is central to individual differences in comprehension performance and the extent to which variation in the ability is derivative. For example, researchers have found that poor comprehenders have more difficulty parsing complex syntactic structures than do good comprehenders. Does variation in parsing ability explain individual differences in comprehension, or is this variation secondary to some other ability, such as fast and accurate word recognition?

In the following sections, we review five reader characteristics that are associated with comprehension ability in mature readers. We used two criteria in selecting these particular characteristics from all of those that are potentially involved in comprehension. First, we selected characteristics that have the strongest correlations with comprehension performance. Second, we chose characteristics that play a central role in different theories of comprehension skill. The characteristics that we selected are: word-level ability, working memory (WM) capacity, suppression ability, print exposure, and background knowledge.

We review each characteristic in a separate section; however, it is important to note that they are not independent. They are correlated with each other as strongly as they are correlated with measures of comprehension performance. The theories of comprehension skill that we review explain these correlations by means of different causal mechanisms. We include figures in each section to illustrate how these theories partition variance among the five reader characteristics in different ways. These figures do not represent all conceivable relations among the characteristics; they represent only those that are emphasized according to different explanations of individual differences in comprehension ability.

2. INDIVIDUAL DIFFERENCES IN WORD-LEVEL ABILITIES

The most straightforward explanation of poor comprehenders' failure to construct coherent discourse models is that they result from deficits in basic linguistic abilities–in particular, word-identification skill (Perfetti & Lesgold, 1977; Perfetti, 1985, 1989, 1994; Vogel, 1975). Individual differences in the component processes of word-recognition are well documented (Bell & Perfetti, 1994; Curtis, 1980; Frederiksen, 1981; Jackson & McClelland, 1979; Palmer et al., 1985).

In beginning readers, word-identification skill is strongly related to measures of phonological awareness–explicit knowledge about the phonological structure of the language (Perfetti, 1991; Perfetti, Beck, Bell, & Hughes, 1987). Mature readers, however, show little variability on phonological awareness tasks. Nonetheless, they vary widely in the speed and accuracy with which they can map a letter string onto a sound-based representation (Bell & Perfetti, 1994; Olson, Kliegl, Davidson, & Foltz, 1985; Perfetti, 1989). The three tasks that are most commonly used to assess adult readers' word-level abilities are naming (i.e., rapid pronunciation of words and pseudowords), phonological decision (i.e., a decision about which of two pseudowords–e.g., brane and blane–would be a real word if pronounced aloud), and orthographic decision (i.e., a decision about which of two letter strings–e.g., brane and brain–is correctly spelled).

The view that comprehension problems at the discourse level have a lexical basis is the primary assumption of Perfetti's (1985) *verbal efficiency theory*. Perfetti argues that comprehension depends on the rapid retrieval of high-quality lexical codes during word recognition. A lexical code is high quality to the extent that it is specific–it has a fully specified orthographic representation–and redundant–it has a representation that can be retrieved from both spoken language and from orthographic-to-phonological mapping.

Verbal efficiency theory suggests two ways that deficits in word-identification skill can influence comprehension performance. First, comprehension processes that depend on high quality, lexical representations, such as syntactic analysis, will be negatively affected if readers retrieve low quality lexical codes. Second, slow retrieval of lexical codes can compromise higher-level interpretive processes by consuming WM resources that would otherwise be devoted to these processes.

Figure 1 depicts the five reader characteristics that are discussed in this chapter. *Verbal efficiency theory* emphasizes three of these: word-level ability, WM capacity, and print exposure. Figure 1 shows a direct effect of word-level ability on word-level processes and on print exposure. Readers with fast and efficient word-identification skills learn more about words than do readers with poorer skills and this is related to their enthusiasm for reading. Individuals who read often will improve their word-level ability, further increasing their desire to read. Figure 1 also depicts indirect effects of word-level ability on sentence-level and discourse-level processes via a direct effect on WM capacity. Slow and inefficient word-level processes will consume WM resources that would otherwise be devoted to high-level interpretive processes.

2.1. Are Comprehension Problems Secondary to Poor Quality Representations?

According to *verbal efficiency theory*, if readers retrieve low-quality lexical representations, then "down-stream" processes that depend on high-quality codes will be affected. Do adult readers fail to execute high-level interpretive processes because they fail to construct adequate representations at lower-levels of processing? Answering this question is difficult because researchers have yet to identify the minimum level of word-identification

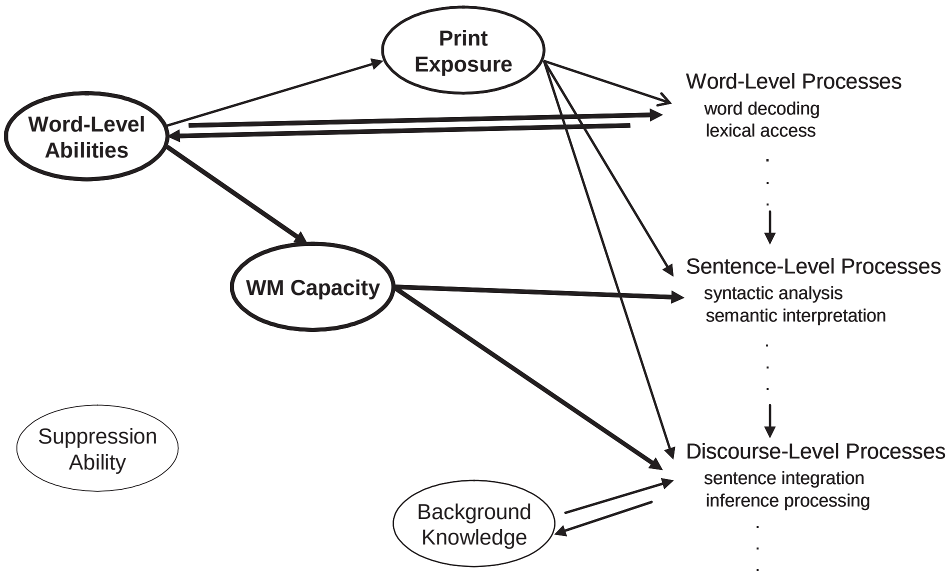

Figure 1. Hypothesized relations among the five reader characteristics according to verbal efficiency theory. The figure is gray-scaled to indicate strength of relations. Dark print corresponds to stronger relations than does light print.

skill that is necessary for constructing an accurate sentence-level representation. The assessment of word-level ability is always a relative one; if poor comprehenders perform worse than good ones on some measure of word-level processing (e.g., word-naming speed), then researchers often assume that these readers lack the ability to construct accurate sentence-level representations. This assumption, however, may not be warranted. Poor comprehenders may have less accurate word-identification processes than good comprehenders, but these processes may be adequate to the task of constructing an accurate sentence-level representation.

Long and her colleagues have conducted a series of studies in which they examined the accuracy of poor comprehenders' sentence-level representations as well as their ability to execute processes at the discourse level (Long et al., 1994, 1997). In one study (Long et al., 1994), they contrasted good and poor comprehenders' ability to execute a process necessary to represent the meaning of a sentence (i.e., to select the context-appropriate sense of an ambiguous word) with their ability to make an inference related to the sentence topic.

Long et al. (1994) argued that sense selection depends on reasonably accurate representations of sentence contexts. If poor comprehenders can quickly and accurately select context-appropriate senses of ambiguous words, their failure to make topic-related inferences should be attributed factors other than poor quality sentence representations. Long et al. (1994) had participants read short-passages containing a sentence that ended with a homograph prime (e.g., The townspeople were amazed to find that all the buildings had collapsed except the *mint*. Obviously it had been built to withstand natural disasters) and respond to lexical-decision targets. The targets were (a) context-appropriate associates of the homographs (e.g., money), (b) context-inappropriate associates of the homographs (e.g., candy), (c) words related to the topics of the sentences (e.g., earthquake), (d) words unrelated to the topics of the sentences (e.g., breath), and (e) nonwords. The time course of sense selection and inference processing was examined by presenting the targets at different stimulus onset asynchronies (SOAs).

Long et al. (1994) found that both good and poor comprehenders responded faster to appropriate than to inappropriate associates of the homographs within 300ms of processing. In contrast, they found that only good comprehenders responded faster to appropriate than to inappropriate topic words. They also found that poor comprehenders' failure to make topic-related inferences was not due to lack of knowledge about the sentence topics; when the two groups were asked to provide single-word descriptions of the topics of the sentences, they showed no differences.

In a second set of studies, Long et al. (1997) provided additional information about poor comprehenders' ability to construct accurate sentence-level and discourse-level representations. They used an item-priming-in-recognition procedure to examine the structure readers' memory representations. The logic of the paradigm is that activation of a concept in memory facilitates recognition of other concepts to which it is linked (Ratcliff & McKoon, 1978).

Long et al. (1997) used this procedure to investigate readers' structural (propositional) representations of sentences, their representation of context-appropriate senses of ambiguous words, and their representation of topic-related information. Participants received a series of study-test trials. Each trial consisted of a set of passages similar to those used by Long et al. (1994) (e.g., The townspeople were amazed to find that all the buildings had collapsed expect the *mint*. Obviously, the architect had foreseen the danger because the structure withstood the natural disaster). The passages were followed by a list of single-word recognition items. Embedded in each test list were three types of priming pairs: (a) <u>propositional-priming pairs</u> consisted of a target that was preceded by a prime from the same proposition or by a prime from a different proposition in the same sentence (e.g., *disaster-structure* versus *danger-structure*), (b) <u>associate-priming pairs</u> consisted of a target that was either the appropriate or the inappropriate associate of a homograph in the sentence and was preceded by a prime from the sentence containing the homograph (e.g., *buildings-money* versus *buildings-candy*), and (c) <u>topic-priming pairs</u> consisted of a target that was either the topic of a passage or was an unrelated word and was preceded by a prime from the final sentence of the passage (e.g., *architect-earthquake* versus *breath-earthquake*). (Note: targets in the associate-priming and topic-priming pairs did not appear in the passages; thus, the correct answer to these items was "no.")

Long et al. (1997) found a strong propositional-priming effect. Both good and poor comprehenders recognized targets faster when they were preceded by primes from the same than different propositions. Both groups also showed reliable priming for targets in associate-priming pairs. They had difficulty rejecting appropriate associates of ambiguous words because these items resonated with information in their memory representations. Only good comprehenders, however, showed topic-priming effects–difficulty rejecting topic words that were related to the passages.

Using a similar method, Long et al. (1997) examined the extent to which good and poor comprehenders integrated ideas from different parts of a text. They contrasted the groups' ability to make connections among idea units that were relatively distant in the surface structure of a story and between stories that shared the same theme. Participants received study-test trials in which they read pairs of stories that were either thematically related or were unrelated. They then made recognition judgments to a list of sentences. Target items in the test list were sentences from one of the stories that described the outcome of a character's attempt to achieve a goal. The targets were paired with different types of primes: (1) in story-priming pairs, the outcome was preceded by the character's goal from the same story or a character's goal from the other story in the pair; (2) in thematic-priming pairs, the outcome was preceded by the outcome of a story that shared the same theme or the outcome of a story that had an unrelated theme.

Good and poor comprehenders showed differences in their ability to integrate information from different parts of the story and their ability to elaborate their representations with topic-related information. Good, but not poor, comprehenders made connections between a character's goal and a later description of the goal outcome. In addition, good comprehenders, but not poor ones, represented connections in memory between stories that shared the same theme.

One explanation for why poor comprehenders fail to integrate information from different parts of a text is that they fail to activate prior text ideas when they read new incoming information. Long and Chong (2001) tested this idea using an inconsistency paradigm. First, they demonstrated that poor comprehenders could detect an inconsistency when relevant information was adjacent in the text, but not when it was separated by intervening sentences. Good and poor comprehenders received a set of passages in which a target action (e.g., Ken enrolled in boxing classes) was either consistent or inconsistent with a description of the character presented earlier in the passage (e.g., Ken loved/hated contact sports). In one condition, the target and character description were separated by a single statement (the local condition). In another condition, the target action and character description were separated by several sentences (the global condition). Both good and poor comprehenders showed an inconsistency effect in the local condition; they were slow to read the target when it was inconsistent with the character description presented earlier in the text. Only good comprehenders, however, showed the inconsistency effect in the global condition, when the target action and character description were separated by several intervening sentences.

In their second experiment, Long and Chong (2001) used a probe-verification paradigm to determine whether poor comprehenders failed to detect the inconsistency in the global condition because they failed to reactive the character description when they read the inconsistent action. Probe sentences asking about the character description were presented (a) immediately after the character description, (b) after several intervening filler sentences, but before the target, and (c) after the target. They found that both groups exhibited the same pattern of results. They responded faster to probes presented after the character description and after the target than to probes presented after the filler sentences. This suggests that the character description was replaced in WM by information from the filler section and then reactivated when readers comprehended the target. Thus, poor comprehenders had a representation of the character description that was reactivated when they read the target action; however, activation of this information had no effect on their comprehension of the target.

In summary, the studies described above suggest that poor comprehenders have word-level and sentence-level processes that are accurate enough to encode structural relations among concepts in a sentence (i.e., propositional relations), to use content in selecting the appropriate sense of an ambiguous word, and to support the reactivation of prior text information. Thus, poor comprehenders appear to construct quality sentence representations; why, then, do they fail to execute high-level interpretive processes to construct a coherent discourse model? We address this question in the next section.

2.2. Are Comprehension Problems Due to Slow Word-Level Processing?

A central claim of *verbal efficiency theory* is that slow word-level processes can consume resources that would otherwise be devoted to higher-level interpretive ones. Only a few studies have been conducted to examine the unique influence of rapid word-identification on mature readers' comprehension ability separate from other skills that affect comprehension. In one of these, Bell and Perfetti (1994) investigated the relative contributions of general language ability and word-decoding skill. Participants read a set of texts about different topics: science, history, and fiction. They then received a multiple-choice comprehension test for each passage. Bell and Perfetti conducted a series of regression analyses; the critical predictors were listening comprehension, vocabulary, reading speed, and pseudoword decoding. General language ability–listening comprehension, vocabulary, and reading speed–were significant predictors of comprehension for all text types. Pseudoword decoding emerged as a significant predictor for the difficult science texts. Their results suggest that word decoding made a contribution to comprehension that was independent of general language ability, but only when readers comprehended the more difficult science texts.

Long, Prat, Blozis, Widaman, and Traxler (2006) provided somewhat stronger evidence that word-decoding ability plays a unique role in adult comprehension ability using a technique called multilevel modeling. They assessed participants' performance on several information processing and language tasks. These tasks included (a) phonological decision, (b) orthographic decision, (c) speeded naming, (d) WM span, (e) print exposure, and (f) The Nelson–Denny Vocabulary and Comprehension Test. Participants also read several full-length, narrative texts and their sentence reading times (RTs) were recorded.

The initial step in constructing the multilevel model was to analyze the level-1 data (i.e., sentence RTs for each participant). Three text characteristics were used in the analysis: (a) number of function words–a crude index of grammatical complexity, (b) number of new argument nouns–a measure that is sensitive to the introduction of new entities into the discourse model, and (c) number of repeated argument nouns–an index of anaphoric reference. The second step was to identify the latent variable structure for the level-2 variables, measured at the participant level. Performance on the individual difference tests was factor analyzed. The analysis yielded five factors: (a) decoding speed–RTs on the naming, phonological, and orthographic decision tasks; (b) decoding accuracy–accuracy on the naming, phonological and orthographic decision tasks; (c) print exposure–performance on Author and Magazine Recognition Tests; (d) verbal ability–vocabulary and comprehension subsections of the Nelson-Denny reading test; and (e) WM capacity–performance on operation span and reading span tests.

The final step in the analysis was to regress the level-1 coefficients on the five individual-differences factors (level-2 latent variables). The model showed that individual differences in the coefficient relating RTs to the number of function words in a sentence was influenced by verbal ability alone, suggesting that readers who were high in overall verbal ability were less affected by grammatical complexity than readers who were low in verbal ability. The coefficient associated with number of new argument nouns was predicted by decoding speed alone, suggesting that the ability to encode new entities into the discourse model primarily depended on the ability to decode words rapidly. Finally, the coefficient relating to the number of repeated argument nouns was predicted by decoding speed and print exposure, suggesting that the ability to process anaphoric references depended on both rapid word decoding and reading practice.

Two findings in this study are notable. First, word-decoding speed was a unique predictor of sentence processing, whereas word-decoding accuracy was unrelated to performance. This is consistent with the evidence that we reviewed in the previous section suggesting that poor comprehenders have word-identification skills that are adequate for constructing quality sentence representations . Second, WM capacity was not a reliable predictor of any level-1 coefficient. One explanation for this is that sentence RT may be insensitive to the effects of WM capacity. Long et al. (2006) tested this explanation by conducting an analysis in which they examined the influence of the WM factor alone. They found that the coefficient associated with the number of function words in a sentence was predicted by WM capacity, but only when the other individual-difference factors were eliminated. Thus, WM capacity failed to predict the level-1 coefficients because it shares variance with the other factors. This finding is relevant to current theoretical debates about the nature of WM capacity and how it relates to reading comprehension, issues that we discuss in the next section.

In summary, *verbal efficiency theory* claims that slow and inaccurate word-level ability is associated with reading comprehension in adult readers as it is in children. The research that we have reviewed here suggests that adult readers have word-level processes that are accurate enough for the construction of reasonably good sentence-level representations.

Slow word-level processing, however, appears to be predictive of reading comprehension, independent of other factors such as general verbal ability and WM capacity.

3. INDIVIDUAL DIFFERENCES IN WORKING MEMORY

Reading comprehension, like most complex cognitive tasks, involves multiple processing steps. Successful performance requires the ready availability of task goals, task-relevant information, and the intermediate results of cognitive operations. WM is the theoretical construct used to refer to the system that is responsible for maintaining such information (Baddeley & Hitch, 1974; Cowan, 1988, 1995; Klapp, Marshburn, & Lester, 1983).

The hallmark characteristic of WM is its limited capacity. Although the existence of capacity limitations is uncontroversial, the factors responsible vary from theory to theory. These factors include constraints on the amount of activation available to the WM system (Just & Carpenter, 1992; Engle, Cantor, & Carullo, 1992; Lovett, Reder, & Lebiere, 1999), similarity-based interference (Schneider, 1999; Young & Lewis, 1999), processing speed (Kieras, Meyer, Mueller, & Seymour, 1999; Salthouse, 1996), lack of skill or knowledge for efficient encoding and retrieval (Ericsson & Kintsch, 1995; Ericsson & Delaney, 1999), and the ability to inhibit irrelevant information (Stoltzfus, Hasker, & Zacks, 1996; Rosen & Engle, 1998).

Two measures are commonly used to assess WM capacity: the reading-span task and the operation-span task. In the reading-span task, participants are asked to read aloud a set of unrelated sentences, presented one at a time, and to recall the final word of each sentence once the entire set has been presented. The operation span task is similar except that participants perform simple arithmetic problems rather than read aloud. In both tasks, span is the largest set of words that the participant can recall.

The role of WM in reading comprehension has been important in theoretical debates about the nature of WM and its limitations. In the next two sections, we describe theories that make different claims about how WM and comprehension are related. One class of theories attributes variation in comprehension to limitations in capacity; the other class attributes variation in both comprehension and WM to individual differences in skill and knowledge. (We describe a third type of WM model in the section on suppression ability; it attributes variation in performance on complex tasks, such as reading comprehension, to individual differences in controlled attention.)

3.1. Limitations Due to Capacity Constraints

In this section, we review two theories that attribute variation in reading comprehension to individual differences in WM capacity: the *capacity theory of comprehension* and the *separate-sentence-interpretation-resource (SSIR) theory*. These theories have important differences, but both claim that high-level interpretive processes involving the integration of ideas across sentences and the use of sentence meaning to make inferences are constrained by capacity limitations.

3.1.1. The capacity theory of comprehension

Just and Carpenter (1992) present one view of WM limitations in their *capacity theory of comprehension*. According to the theory, the storage and processing functions necessary for language are fueled by activation, a commodity that maintains knowledge elements in memory and supports computation. Activation is shared among storage and processing functions such that activation-consuming processes limit the amount of activation available to support storage and vice versa. The *capacity theory* attributes individual differences in reading comprehension to variation in capacity, the total amount of activation available to the system.

Support for *capacity theory* has been found in studies of the relation between language comprehension and performance on WM tasks–in particular, the reading span task devised by Daneman and Carpenter (1980). Reading span correlates with a number of verbal measures, including verbal SAT ($r=0.5$ to $r=0.6$) and the ability to answer questions about explicit information in a text ($r=0.7$ to $r=0.9$; Daneman & Carpenter, 1980; Masson & Miller, 1983). Reading span interacts with text complexity to influence RT. Reading time differences between low-span and high-span individuals are small for easy texts, but large for difficult ones (Just & Carpenter, 1992).

Several studies have reported a correlation between WM performance on the reading-span task and the speed and accuracy of syntactic processing (Just & Carpenter, 1992; King & Just, 1991; MacDonald et al., 1992; Pearlmutter & MacDonald, 1995). One of the first studies to document this relation examined how high-span and low-span readers process garden-path sentences. Just and Carpenter (1992) presented readers with sentences containing reduced relative (RR) clauses, such as <u>The defendant examined by the lawyer shocked the jury</u>. When the initial noun phrase was a plausible agent of the main verb (MV) interpretation (e.g., <u>The defendant</u> examined...), both high-span and low-span readers exhibited long gaze durations on the disambiguating information in the sentence (i.e., the word <u>by</u>). The performance of the two groups differed, however, when the initial noun phrase was an implausible agent of the MV interpretation (e.g., <u>The evidence</u> examined ...). The plausibility manipulation decreased processing time for high-span readers, but did not affect the performance of low-span readers. Just and Carpenter argued that only high-span readers had the WM capacity necessary to use information about plausibility during the comprehension process.

Other studies have reported similar results. King and Just (1991) found that low-span readers were slower and less accurate than high-span readers in processing difficult, object-relative sentences, such as <u>The senator that the reporter attacked admitted the error</u>. MacDonald et al. (1992) and Pearlmutter and MacDonald (1995) also found a relation between reading span and syntactic ambiguity resolution, although high-span, rather than low-span, readers showed slower processing of syntactically ambiguous relative to unambiguous sentences.

Similar results have been found in studies examining the relation between WM and discourse-level processes. For example, high-span, compared to low-span, readers are more accurate in finding the antecedent of a pronoun when the pronoun and its antecedent are separated by intervening sentences (Daneman & Carpenter, 1980). High-span readers are also more likely than low-span readers to show faster recognition of sentences that are thematically related (Cantor & Engle, 1993).

Figure 2 depicts hypothesized relations among WM capacity and other reader characteristics according to *capacity theory*. *Capacity theory* emphasizes the role of WM in comprehension. Capacity limitations should have direct effects on all comprehension processes, but these effects should be particularly strong for resource-consuming, sentence-level and discourse-level processes.

3.1.2. Separate-sentence-interpretation-resource (SSIR) theory

Waters and Caplan (1996) argue for a model of WM called the *SSIR theory*. Their model of WM is highly modularized. Part of the WM system is specialized for analyzing syntactic structure and using it to determine sentence meaning. This part of the system is dedicated to sentence interpretation and individuals do not differ with respect to its capacity. Another part of the system is devoted to activities that involve conscious controlled processing, activities that Waters and Caplan call "post-interpretive." These activities include making inferences to integrate ideas across sentences, using world knowledge in the interpretation of a text, remembering sentence content, and planning

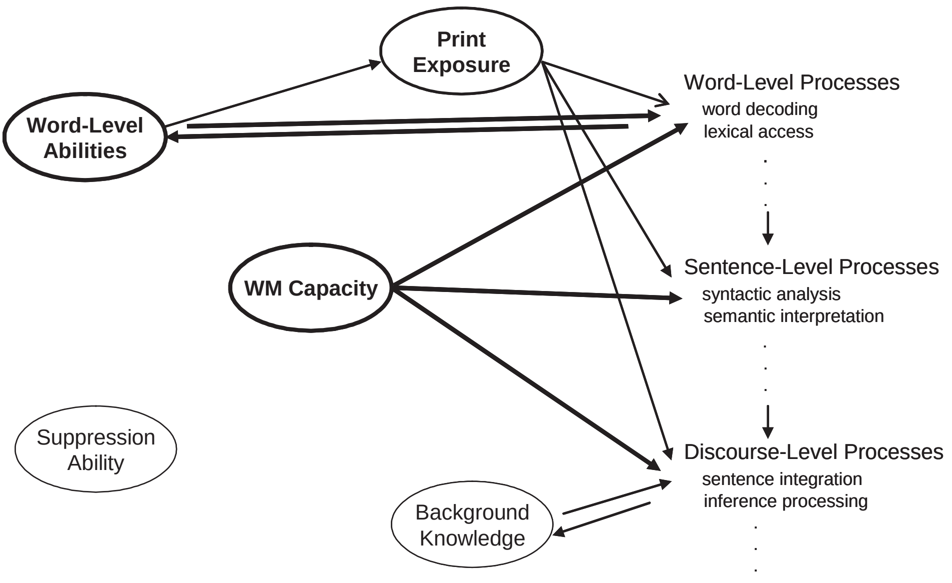

Figure 2. Hypothesized relations among the five reader characteristics according to the capacity theory of comprehension.

actions based on the meaning of sentences and texts. This part of the WM system shows variation across individuals and is the one that is tapped when individuals perform complex span tasks, such as reading span and operation span.

The *SSIR theory* has its foundation in neuropsychological data concerning the ability of patients to understand sentences containing complex syntactic structures (Caplan & Waters, 1995; Martin, 1995; Waters, Caplan, & Hildebrandt, 1991). Many patients have extremely limited verbal memory spans, but are able to use a variety of complex syntactic structures in deriving the meaning of sentences (see for a review Waters & Caplan, 1996). Thus, Waters and Caplan (1996) argue that WM must involve at least two systems. Brain damage can impair the system that underlies performance on span tasks, leaving intact the system that underlies sentence interpretation.

In addition to neuropsychological studies, Waters and Caplan (1996) have conducted studies of the syntactic processing abilities of normal adults and found no evidence for a correlation between reading span and syntactic parsing. For example, they examined the processing of sentences containing a temporary syntactic ambiguity, similar to those used by MacDonald et al. (1992). Although Waters and Caplan found that ambiguous sentences were more difficult to comprehend than were unambiguous ones, they found no processing-time differences as a function of reading span (see also, Clifton et al., 2003; Traxler, Williams, Blozis, & Morris, 2005). Similarly, Caplan and Waters (1999) found no differences between high and low-span readers in the processing of sentences with object-relative clauses like those used by King and Just (1991). These findings cast some doubt on the role of WM capacity in explaining individual differences at the sentence level. Nonetheless, the *SSIR theory* is similar to the *capacity theory* in attributing individual differences at the discourse level to a limited capacity WM system.

Figure 3 depicts hypothesized relations among WM capacity and other reader characteristics according to *SSIR theory*. In this figure, WM is partitioned into two pools of resources. One is devoted exclusively to word and sentence-level processing and shows no individual variation (denoted by a square in the figure). Individuals do differ, however, in the capacity of the WM system that is devoted to post-interpretive processing. Thus, the *SSIR theory*, like the *capacity theory*, predicts a strong relation between WM capacity and discourse-level processing.

3.2. Limitations Due to Poor Word-Level Ability and Insufficient Experience

A second view of WM limitations emphasizes the role of skill and practice in comprehension, rather than capacity, per se. This view is represented in two models of WM: a *connectionist-based account* proposed by MacDonald and Christiansen (2002) and the *long-term working memory (LTWM) model* proposed by Ericsson and Kintsch (1995). These two accounts differ in many respects, but both emphasize the importance of skill and experience in the relation between capacity and comprehension performance.

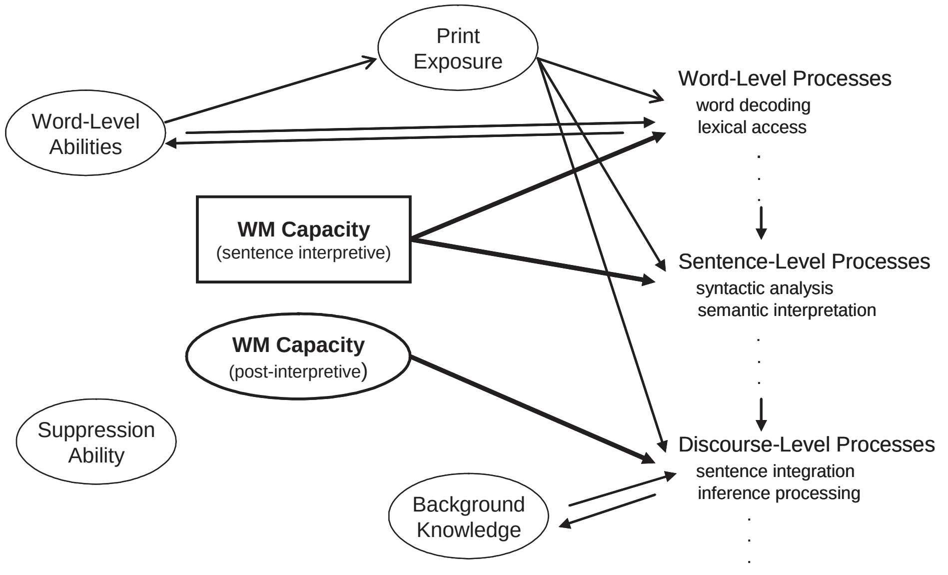

Figure 3. Hypothesized relations among the five reader characteristics according to the SSIR theory.

3.2.1. The connectionist-based account

The *connectionist-based account* of variation in WM is based on connectionist approaches to language processing. In a connectionist network, the capacity of the system arises from its architecture (i.e., the number of processing units, how activation passes through weights, etc.) and the network's experience (i.e., how often it has processed similar input in the past). In this view, capacity is not a separate pool of resources; it is a property of the processing network itself.

In the *connectionist-based account*, individual differences in performance on WM tasks arise from variation in two factors. First, individuals can vary with respect to basic sensory/perceptual abilities–primarily the ability to represent phonological information accurately. Second, individuals can vary in reading experience. The *connectionist-based account* emphasizes this second factor. Variation in practice can lead to individual differences that appear qualitative, such as differences in the nature of Frequency × Regularity interactions. Consider, for example, the Frequency × Regularity interaction that is found in word recognition. High-frequency words are recognized faster than low-frequency words and the effect is larger for words with an irregular than a regular orthography. Moreover, frequency and regularity interact with skill (Seidenberg, 1985). Good comprehenders exhibit regularity differences only in the low-frequency range. In contrast, poor comprehenders exhibit regularity differences for all words except those in the high-frequency range. Seidenberg (1985) attributes the Skill × Frequency × Regularity interaction to variation in reading experience. Good comprehenders, who read often, encounter irregular words more frequently than do poor comprehenders, who read less. Thus, good comprehenders have a broad frequency range of irregular words for which they can quickly compute the appropriate pronunciation. Poor comprehenders, in contrast, have sufficient experience only in computing the appropriate pronunciation of high-frequency irregular words. Thus, they show irregularity effects at all other word frequencies.

A similar explanation can be applied to the relation between WM capacity and sentence processing. Relative clauses are a low-frequency syntactic structure. Low-span readers are likely to encounter these structures infrequently. In addition, they should have particular difficulty understanding object-relative clauses because these clauses have an irregular word order (i.e., Noun-Noun-Verb as opposed to the canonical Noun-Verb-Noun).

The influence of frequency on ambiguity resolution was recently demonstrated in a study by Long and DeLey (2000). They examined how pronoun resolution is affected by the implicit causality inherent in certain verbs (e.g., the subject of the verb <u>annoy</u> performs some action or has some characteristic that "causes" a response from the grammatical object, whereas the object of the verb <u>praise</u> performs some action that "causes" a response from the grammatical subject). Knowledge about the implicit causality of a verb can be used to resolve an ambiguous pronoun (e.g., John praised Paul because <u>he</u> won the race).

Long and DeLey (2000) found that readers' use of implicit causality depended on important characteristics of both the reader and the stimuli. First, good comprehenders showed an effect of implicit causality when they encountered the pronoun, whereas poor comprehenders showed the effect at the end of the sentence. Second, good comprehenders showed an effect that was limited to verbs in which the implied cause of the event was the grammatical object of the sentence. In order to explore the locus of the effect, Long and DeLey examined the use of these verbs in a large corpus of natural text. They found that the "object verbs" were better predictors of the referent of a subsequent anaphor than were the "subject verbs." A *connectionist-based account* of these results would suggest that good comprehenders, who have considerable reading experience, encoded more information about the contextual use of these verbs than did poor comprehenders. Thus, good comprehenders expected the implied cause of an "object verb" to be the referent of a subsequent pronoun.

Figure 4 depicts hypothesized relations among reader characteristics and comprehension according to a *connectionist-based account* of WM. The figure is similar in some respects to the one illustrating *verbal efficiency theory* (see Figure 1). Word-level ability and print exposure are emphasized in both these figures. They differ, however, with respect to the role of WM capacity. According to the *connectionist-based account*, variation in performance on span tasks is not due to limitations in capacity, per se; but is due to the same factors that influence all language tasks: word-level ability and print exposure.

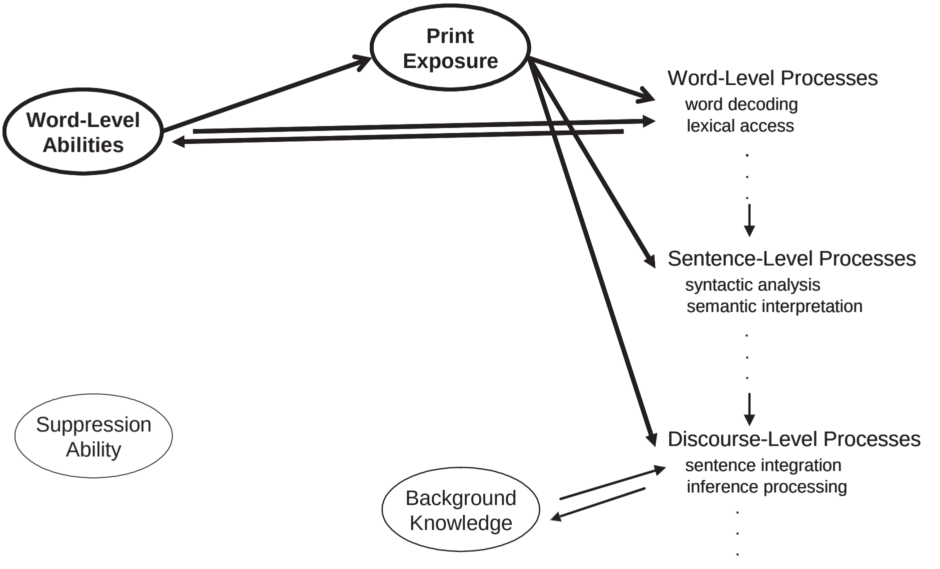

Figure 4. Hypothesized relations among the five reader characteristics according to the connectionist-based model of working memory.

3.2.2. *The long-term working memory (LTWM) Model*

Ericsson and Kintsch (1995) have argued that the standard definition of WM as a small capacity, temporary storage mechanism is too restrictive to account for skilled performance on complex tasks, such as text comprehension. They propose a model of WM that consists of the standard limited-capacity mechanism that they call short-term working memory (ST-WM), and a mechanism based on skilled storage and retrieval in long-term memory that they call long-term working memory (LTWM). In this model, the amount of information that can be actively maintained in LTWM is not limited by a fixed capacity. As individuals become skilled at a task, they develop mechanisms for encoding and retrieving information from long-term memory that meet the demands of the task.

This view is supported by evidence that individuals who exhibit large WM capacities do so only for skilled activities. Individuals who are skilled in mental calculation have large WM capacities as measured by digit span (Ericsson, 1985; Hatano, Amaiwa, & Shimizu, 1987; Jensen, 1990), but do not show large capacities for other types of materials. Experienced waiters and waitresses show large WM capacities for dinner orders, but their memory for other information is in the average range (Ericsson & Polson, 1988a, 1988b). Chess experts show superior WM for meaningful configurations of chess pieces, but not for random configurations (Chase & Simon, 1973).

Evidence for the role of LTWM in text comprehension has focused on the relative influence of domain expertise and general verbal ability on comprehension (Recht &

Leslie, 1988; Schneider, Körkel, & Weinert, 1989; Walker, 1987). Several studies have examined groups of readers who differ with respect to reading ability (e.g., high versus low performance on standardized reading tests) or general aptitude (e.g., high versus low performance on IQ tests) and with respect to domain knowledge (e.g., high versus low knowledge about baseball). In all of these studies, domain knowledge was the dominant factor in predicting comprehension performance. Ericsson and Kintsch (1995) argue that high-knowledge readers perform better than low-knowledge readers because their domain expertise gives them better strategies for encoding structures in long-term memory that can be accessed quickly and easily based on retrieval cues in ST-WM.

The same argument can be applied to why good comprehenders recall more information from texts than do poor comprehenders. Good comprehenders have strategies that are effective for encoding large and integrated structures in memory. These structures are activated when new, incoming information in a text provides cues to their retrieval. In contrast, poor comprehenders encode ideas from a text in isolation or in poorly integrated clusters. Thus, the retrieval cues in short-term memory activate small, relatively impoverished, structures from long-term memory.

Figure 5 depicts the role of LTWM and background knowledge in comprehension. The *LTWM model* is similar to the *connectionist-based account* in that it emphasizes the role of print exposure in text comprehension (see Figure 4). Reading experience helps comprehenders develop strategies for building text structures in long-term memory that can be

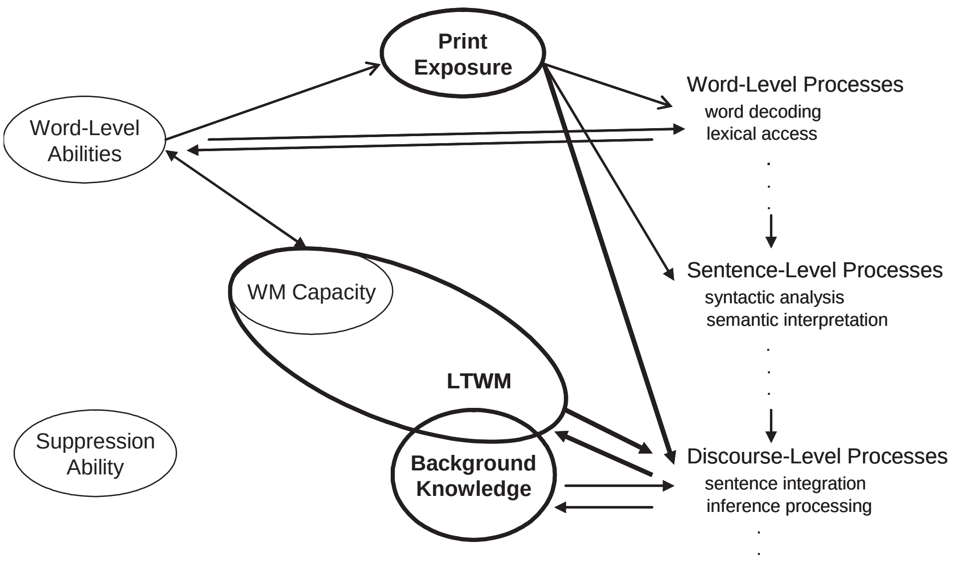

Figure 5. Hypothesized relations among the five reader characteristics according to the LTWM model.

accessed easily based on retrieval cues in short-term memory. The *LTWM model* is different from the *connectionist-based account* in that it includes a traditional view of a fixed-capacity WM system. Although this system is involved in the performance of novel tasks, it plays little role in the performance of skilled activities, such as reading comprehension.

4. INDIVIDUAL DIFFERENCES IN SUPPRESSION ABILITY

Suppression ability (also called cognitive inhibition) is an individual's skill at ignoring or inhibiting distracting information and overcoming interference from a prepotent response. Suppression appears to play an important role in constructing a coherent representation of a text. Readers often activate contextually irrelevant information during comprehension. Activated, but irrelevant, information has the potential to interfere with comprehension processes. Suppression reduces the interference from such information by dampening its activation.

Most measures of suppression assess an individual's ability to resist or overcome interference. Such measures include (a) Stroop Interference–participants receive words or other stimuli (e.g., xxxx) in colored print and they name the color as quickly as possible, (b) the Go/No-go Task–participants are asked to respond when one visual target appears (e.g., a circle), but not to respond when a different visual target appears (e.g., a square), and (c) the Eriksen Flanker Task–participants respond to a target letter that is presented with distractor letters (flankers) that are either the same as the target or different from the target (Eriksen & Hoffman, 1973; Yeh & Eriksen, 1984).

Suppression plays a prominent role in Gernsbacher's (1990) *structure building framework*. According to her framework, a reader's goal is to build a coherent mental representation or "structure." Readers begin the process by establishing a foundation based on some initial information. They develop their mental structure by adding new incoming information when it relates or coheres to this representation. When readers receive information that is unrelated to previous information, they shift to initiate a new substructure. Thus, a mental representation often consists of several branching structures.

According to the theory, mental structures are built out of previously stored memory traces; these traces are activated by incoming information. Activation is modulated by two different mechanisms: enhancement and suppression. Enhancement increases the activation of memory traces when their content is relevant to the mental structure being developed. Suppression dampens activation of the traces when their content is unrelated to the structure.

Gernsbacher and her colleagues have argued that failure to suppress activated, but irrelevant, information during comprehension underlies individual differences in comprehension skill (Gernsbacher, 1993; Gernsbacher & Faust, 1991, 1995; Gernsbacher & Robertson, 1995; Gernsbacher, Varner, & Faust, 1990). This failure can be seen when readers comprehend ambiguous words. Gernsbacher et al. (1990) had participants read short sentences that ended with a homograph (e.g., The man dug with a *spade*) and then judge whether a test probe fit the meaning of the sentence. The probes were presented either 100 or 850 ms after the offset of the sentence-final word. When the probe was related to the meaning of the sentence (e.g., garden), both good and poor comprehenders experienced facilitation. Likewise, when the probe was an inappropriate associate of the homograph (e.g., ace), both good and poor comprehenders had difficulty rejecting the probe as unrelated in the 100 ms condition. This finding suggests that the inappropriate meaning was activated at 100 ms, making it difficult to reject the test probe even though it was inappropriate in this context. In contrast, only the poor comprehenders had difficulty rejecting the probe at the 850ms delay. Gernsbacher et al. argued that good comprehenders suppressed the inappropriate sense of the homograph, whereas poor comprehenders failed to do so; thus, poor comprehenders experienced interference at the long delay.

Poor comprehenders' suppression problems have important implications for their ability to create coherent discourse representations. When readers encounter irrelevant information, they shift from mapping information onto the current structure to initiate a new substructure. Poor comprehenders' failure to suppress irrelevant information causes them to shift too often; they initiate new substructures when they should continue mapping information onto their current structure. Thus, they construct discourse representations that are less integrated than those constructed by good comprehenders.

Several experiments have been conducted to investigate the extent to which suppression is an automatic inhibitory mechanism or a controlled, strategic one (Gernsbacher & Faust, 1995; Long, Seely, & Oppy, 1999). Gernsbacher and Faust (1995) examined good and poor comprehenders' ability to suppress the irrelevant meanings of ambiguous words. They manipulated the proportion of trials on which suppression was needed and found that readers were more likely to inhibit irrelevant information when the proportion of conflict trials was high (i.e., when the target was a context-inappropriate associate of the ambiguous word) than when the proportion of such trials was low. In other words, readers inhibited irrelevant information when suppression had high utility.

Long et al. (1999) also found evidence that suppression is a strategic process. They had good and poor comprehenders read sentences that ended with a word that was unambiguous (e.g., The presence of the stranger upset the *baby*) and then respond to test probes that were backward associates of the sentence-final word (e.g., stork). If suppression is an automatic mechanism, then responses to the test word should be unaffected by the preceding sentence. The word *baby* does not activate the word *stork*, so suppression should not be triggered. If, however, suppression is a strategic process, it may be invoked as a consequence of the response conflict that readers experience when they compare *stork* to the preceding context. Long et al. found that both good and poor comprehenders experienced interference to the test probes when the interval between the test sentence and probe was short (100ms); however, only poor comprehenders experienced interference when the interval was long (850ms).

If suppression during comprehension is under readers' strategic control, why do poor comprehenders fail to execute it? One possibility is suggested by recent research investigating the relation between cognitive inhibition and individual differences in WM memory. Engle and his colleagues have described a view that attributes variation in WM capacity to limitations in the ability to inhibit task-irrelevant information and to maintain activation in the face of distracting or interfering events (Conway & Engle, 1994; Engle, Conway, Tuholski, & Shisler, 1995; Engle, Kane, & Tuholski, 1999; Engle, Tuholski, Laughlin, & Conway, 1999, Kane, Bleckley, Conway, & Engle, 2001; Kane & Engle, 2000; Rosen & Engle, 1997). According to their view, WM is a system comprised of activated memory traces, procedures and skills necessary to achieve and maintain activation, and controlled attention (Engle, Kane, & Tuholski, 1999). Controlled attention is involved in maintaining activation of task-relevant information, particularly in the presence of distraction or interference, and in inhibiting task-irrelevant information. The capacity of controlled attention is limited and is the primary source of individual differences in the performance of complex tasks, including reading span and reading comprehension.

Figure 6 depicts a view of comprehension skill in which skill at the sentence-level and discourse-level is heavily influenced by domain-general, controlled attention–in particular, the ability to suppress activated, but irrelevant, information. This view of WM capacity and its relation to comprehension is similar to *capacity theory* in that both attribute variation in sentence and discourse-level processes to limitations in a domain-general ability (see Figure 2). They differ, however, as to the nature of this ability. In *capacity theory*,

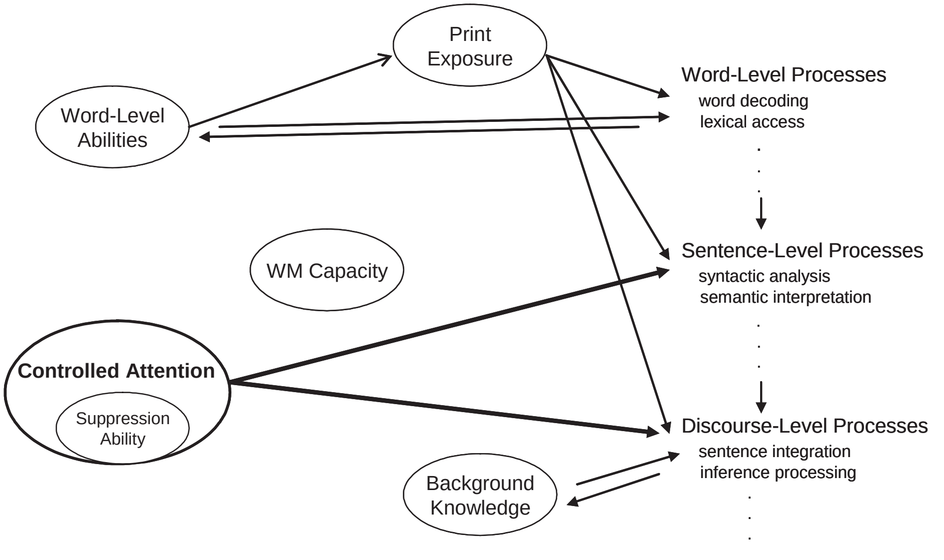

Figure 6. Hypothesized relations among the five reader characteristics according to a view of working memory that emphasizes the role of controlled attention in suppression ability and comprehension.

the limitation is in the amount of activation available to the system. In the *controlled-attention view*, variation in performance on both comprehension tasks and complex span tasks are due to individual differences in the ability to control attention, including the ability to suppress irrelevant information.

5. INDIVIDUAL DIFFERENCES IN PRINT EXPOSURE

Readers differ greatly in their enthusiasm for reading, in how much they value it, and in the time they spend engaged in the activity. Researchers have been interested in a variety of questions about how reading practices relate to comprehension ability and the acquisition of general world knowledge. One question has involved whether print exposure affects comprehension ability primarily by automating word-identification processes or whether print exposure also has important effects on vocabulary development, syntactic knowledge, and the acquisition of cultural and domain knowledge.

Print exposure can be assessed by means of questionnaires and interviews (Guthrie, 1981; Guthrie & Greaney, 1991; Walberg & Tsai, 1984); however, these techniques are susceptible to social desirability factors, primarily the tendency to report more time spent reading than actually occurs. Activity diaries, in which individuals record their daily activities, can provide more reliable results (Carp & Carp, 1981; Greaney, 1980; Rice, 1986); however, this technique can be expensive and time-consuming.

Stanovich and his colleagues have developed a checklist method of assessing print exposure that is immune to social desirability effects and is quickly and easily administered (Stanovich & Cunningham, 1992; Stanovich & West, 1989). The *Author Recognition Test* and the *Magazine Recognition Test* are both recognition checklists that assess participants' ability to discriminate author names and magazine titles from foils. Signal detection logic is applied such that correct responses are adjusted for guessing by examining the number of foils that are selected. Performance on these checklists correlates with measures of reading comprehension in both children and adults.

Stanovich and his colleagues have used regression techniques to examine the influence of print exposure separate from other reader characteristics, such as word-decoding ability, comprehension skill (e.g., performance on standardized measures of reading comprehension), and general cognitive ability (e.g., performance on IQ or reasoning tasks such as Raven's Matrices) (Cunningham & Stanovich, 1990, 1991; Stanovich, 1986; Stanovich & Cunningham, 1992; Stanovich & West, 1989; West & Stanovich, 1991; West, Stanovich, & Mitchell, 1993). They have found that print exposure is uniquely related to spelling ability, vocabulary, and general world knowledge after controlling for other reader characteristics.

Print exposure is likely to influence comprehension skill in at least three ways. First, individuals who read often are more likely to learn about rare words than are individuals who read seldom. This is because rare words appear more often in print than they do in speech. Hayes and Ahrens (1988) found that rare words (those that ranked lower than 10,000 in a frequency ordered list of words; Carroll, Davies, & Richman, 1971) occurred 50% more often in children's books than in adult conversation or prime-time television shows. Vocabulary growth, therefore, is likely to be accelerated in individuals who read often. Second, individuals are more likely to encounter complex syntactic structures in print than in speech. This is particularly true in genres such as newspapers where optional function words are often deleted due to space considerations. Finally, individuals who read often are likely to acquire more world knowledge than individuals who read seldom. Text comprehension is the primary means of knowledge acquisition in many domains.

Figure 7 depicts hypotheses about how print exposure may be related to other reader characteristics. Note that the relations among these characteristics are similar to those hypothesized in the *LTWM* model illustrated in Figure 5. Print exposure and background knowledge are emphasized in both figures. One difference is that Figure 7 emphasizes the relation between print exposure and word-level ability. Individuals who read often will learn more about words than individuals who read seldom and good word-level abilities will increase these individuals' enthusiasm for reading. The reciprocal relation between word-level ability and print exposure is also emphasized in *verbal efficiency theory* (see Figure 1). Finally, Figure 7 depicts a strong effect of print exposure on background knowledge via its effect on discourse-level processing. Individuals who read often will learn more from texts than individuals who read seldom; increasing their general world knowledge and domain expertise.

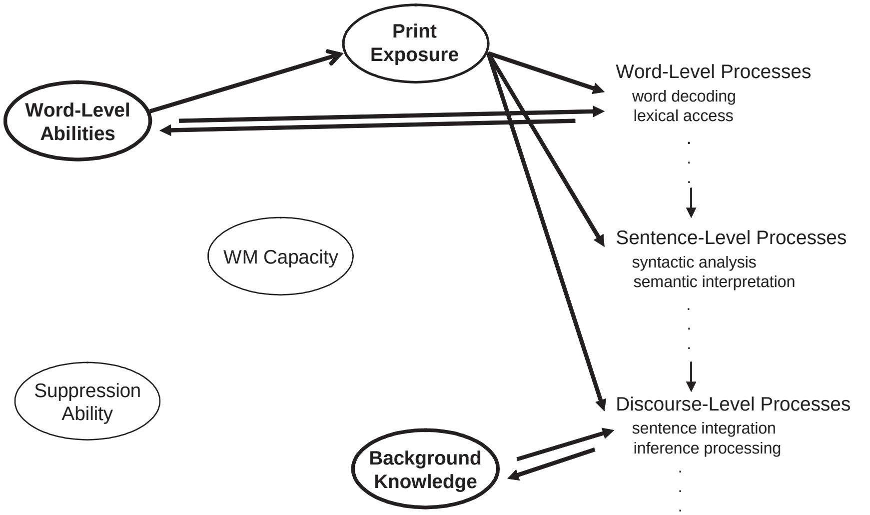

Figure 7. Hypothesized relations among the five reader characteristics according to a view of comprehension that emphasizes the role of print exposure.

6. INDIVIDUAL DIFFERENCES IN BACKGROUND KNOWLEDGE

The focus of our review to this point has been on reader characteristics that discriminate good comprehenders from poor ones. Variability in comprehension performance, however, can be seen even among very skilled readers. One of the earliest findings in the field of text comprehension was that readers who have relevant knowledge about the topic of a text understand it and remember it better than do readers who lack such knowledge (Bartlett, 1932; Bransford & Johnson, 1972). Experts–readers who have extensive domain knowledge–access a richly interconnected network of learned facts when reading a text relevant to their domain of expertise (Chi, Feltovich, & Glasser, 1981, Chiesi, Spilich, & Voss, 1979; Means & Voss, 1985). Moreover, experts employ more effective reading strategies than do novices (Afflerbach, 1986; Lundeberg, 1987) and are faster and more efficient at retrieving information from their knowledge domain (Ericsson & Smith, 1991).

The comprehension advantage associated with background knowledge has been well documented in two different paradigms. In one, participants read texts that contain numerous vague referring expressions. Recall for the text improves when readers are given relevant contextual knowledge, such as a title that denotes the topic of the passage (e.g., "Washing Clothes") (Alba, Alexander, Hasher, & Caniglia, 1981; Bransford & Johnson, 1972; Summers, Horton, & Diehl, 1985). In a second paradigm, participants read coherent texts that contain information about a specific domain. Those who are knowledgeable about the domain recall more information from the text than do those who are less knowledgeable (Schneider, Körkel, & Weinert, 1989; Spilich, Vesonder, Chiesi, & Voss, 1979; Sulin & Dooling, 1974). For example, Spilich et al. (1979) found that baseball "experts" recalled more information from baseball texts than did "novices." Moreover, experts recalled more propositions relating to actions and events that were closely associated with the goal structure of a baseball game than did novices. Schneider et al. (1990) reported similar results using soccer as the knowledge domain.

Recently, Long and her colleagues have argued that high-knowledge readers construct qualitatively different text representations than do low-knowledge readers. High-knowledge readers construct discourse models in which text ideas are integrated with each other and with a large network of relevant prior knowledge (Long & Prat, 2002; Long, Wilson, Hurley, & Prat, in press). These models support recall, problem-solving, generalization, and knowledge-based inferences. Low-knowledge readers, in contrast, construct text representations that are coherent at the sentence-level, but they lack the knowledge necessary to construct coherent discourse models. Thus, low-knowledge readers can recognize ideas from a text, but cannot use their representations to perform tasks that require conscious, reflective access to a discourse model.

Long and Prat (2002) used a recognition-memory paradigm to examine qualitative differences in high-knowledge and low-knowledge readers' text representations. Many memory researchers believe that recognition involves at least two component processes: recollection and familiarity. The nature of these two processes differs somewhat across dual-process models (for a review see Yonelinas, 2002). For example, Yonelinas and his colleagues argue that recollection involves retrieval of specific information about a studied item, such as information about the context in which the item appeared (Dobbins, Kroll, & Liu, 1998; Yonelinas, 1997, 1999, 2001, 2002). Familiarity, in contrast, involves an assessment of the similarity (perceptual and conceptual) between a test item and a memory trace. Rajaram (1996) has argued that recollection reflects elaborative and distinctive processing that occurs at study, whereas familiarity reflects the fluency of processing that occurs at test. Wixted and Stretch (2004) have argued that both recollection and familiarity are continuous variables reflecting memory strength and that the two are combined into a single memory signal. Although these models differ in critical ways, they share the core assumption that recollection and familiarity are distinct processes and can be empirically dissociated.

According to Long and Prat (2002), the processes involved in constructing sentence-level representations give rise to familiarity at test, whereas the processes involved in constructing a discourse model give rise to recollection. Familiarity arises from the perceptual and semantic processing that occurs when participants encode a to-be-learned item. A substantial amount of this type of processing occurs when readers comprehend sentences in texts, even when they do not possess domain-relevant knowledge. Thus, familiarity should support recognition of text ideas even in the absence of the elaborative processing involved in constructing a discourse model.

In contrast, discourse-level processing involves forming associative relations between text ideas and prior knowledge. If a text idea activates extensive knowledge during comprehension, a network of connections will be formed that integrates the idea with the reader's prior knowledge. When the text idea is presented at test, it will resonate with its item representation in memory, reactivating the network of contextual information that was constructed during comprehension. Retrieval of contextual information about the study context will give rise to an experience of recollection. In addition, some text ideas may evoke conscious inferences when readers have extensive knowledge about a topic. For example, readers who are knowledgeable about a particular genre of stories, such as horror stories, may make an explicit prediction in response to a character's action (e.g., if the character says, "I'm going outside, I'll be right back," the reader may consciously predict that the character will be eaten by the monster). If the action is presented at test, the reader may retrieve the inference that was associated with it at study, leading to an experience of recollection.

These hypotheses were tested using the remember/know paradigm developed by Tulving (1985). Participants made judgments concerning the nature of their memory for recognized items, responding "remember" to items that were accompanied by recollection of details about the item's prior occurrence, and responding "know" to items that were recognized from the study episode, but were not accompanied by recollection. Readers were tested to assess their knowledge about the science-fiction saga Star Trek. They then read a short story about Star Trek and received a recognition test consisting of sentences from the story that they read as well as distractor sentences from a Star Trek story that they did not read. In addition, they read a chapter from an introductory psychology textbook and received a subsequent recognition test.

Long and Prat (2002) found no effect of prior knowledge on overall recognition for either the Star Trek story or for the Psychology chapter. They did find an effect, however, when they examined remember and know responses. High-knowledge readers were more likely to report a vivid, conscious experience of recollection in response to text ideas than were low-knowledge readers, but only for the Star Trek items. Long and Prat found similar effects when they examined recollection and familiarity by means of the process-dissociation procedure, a procedure that assesses the extent to which individuals can remember the specific context in which an item appeared.

Similar results were found in a study by Long et al. (in press). They examined the influence of both domain knowledge and text coherence on readers' memories for text ideas. Previous research has shown that the influence of text coherence on comprehension depends critically on the reader's prior knowledge (McNamara, 2001; McNamara & Kintsch, 1996; McNamara, Kintsch, Songer, & Kintsch, 1996). Somewhat surprisingly, manipulations that decrease coherence can improve text comprehension and recall. This occurs when readers use their background knowledge to fill conceptual gaps in the text. Only high-knowledge readers, however, benefit from low-coherence texts because only they have the knowledge that is necessary to establish coherence among text ideas.

Long et al. (in press) examined the interaction of prior knowledge and text coherence on recollection and familiarity in recognition. If recollection is a consequence of processing at the discourse-level, then high-knowledge readers should have higher recollection estimates than low-knowledge readers. Moreover, high-knowledge readers should have higher recollection estimates in response to low-coherence than to high-coherence texts. Low-coherence texts are more likely than high-coherence texts to involve retrieval of relevant domain knowledge during comprehension, leading to a more elaborate discourse model at encoding and to the experience of recollection at test. Long et al. found support for these hypotheses in experiments involving both the remember/know task and the process-dissociation procedure.

The role of background knowledge in comprehension is emphasized in the *LTWM model* (see Figure 5) and in research on individual differences in print exposure (see Figure 7). In Figure 5, background knowledge is essential for building retrieval structures in LTWM that expand a reader's ability to hold large amounts of information in an accessible form. In Figure 7, background knowledge is facilitated by print exposure. Individuals who read often are exposed to more information about the world than are individuals who read seldom and they are more likely to create coherent discourse models that expand their knowledge base.

7. CONCLUSIONS

What is it that skilled adult readers do when they comprehend a text that less-skilled readers fail to do? The answer to this question is fairly clear. Good comprehenders construct quality representations of individual sentences and then reinterpret, reorganize, and integrate their sentence representations in light of prior knowledge that is relevant to the text–that is, they construct coherent discourse models. Poor comprehenders, in contrast, understand individual sentences reasonably well, but fail to integrate their sentence representations into a coherent whole. They represent text ideas in isolation or in clusters, loosely organized by theme.

Why do poor comprehenders fail to execute the high-level interpretive processes that result in a coherent discourse model? The answer to this question is unclear even after decades of research. We do know that good and poor comprehenders differ in ways that are strongly correlated with comprehension performance. We still do not understand, however, the exact nature of these correlations. What accounts for the correlation between complex span tasks and comprehension performance? Is the relation between span and comprehension secondary to deficits in word-level ability? Do good and poor comprehenders differ primarily with respect to their ability to construct effective retrieval structures and store them in LTWM?

One of the obstacles in answering the questions posed above is methodological. Individual differences in reading are typically studied using quasi-experimental designs (e.g., Gernsbacher & Faust, 1991, 1995; Just & Carpenter, 1992; Long & DeLey, 2000; Long et al., 1994, 1997; McNamara & Kintsch, 1996; Pearlmutter & MacDonald, 1995). Readers are grouped according to some reader characteristic (e.g., performance on a span task) and then participate in an experiment in which some text variable is manipulated. Such studies have provided important information about how reading is affected by various combinations of reader and text characteristics, but they also have important limitations. One limitation is that quasi-experimental designs necessarily involve small numbers of variables. One of our goals in this chapter has been to illustrate the difficulty in understanding the role of one reader characteristic in comprehension when that characteristic is correlated with other reader characteristics.

In our view, we are fast approaching the limit of what can be learned about individual differences in comprehension from small quasi-experiments or simple regression studies. Substantial progress will depend on the use of more sophisticated modeling approaches (e.g., factor analysis, multilevel modeling), approaches that can be used to test the different relations among reader characteristics that we have described in this chapter.

Research on individual differences in the ability to construct coherent discourse models is important for understanding the nature of reading ability and disability. We hope that our review has also shown that such research is important for understanding how language-specific processes interact with more domain-general abilities and for understanding the nature of controlled attention, working memory, and the development of expertise.

REFERENCES

Afflerbach, P. (1986). The influence of prior knowledge on expert readers' importance assignment processes. *National Reading Conference Yearbook*, *35*, 30–40.

Alba, J. W., Alexander, S. G., Hasher, L., & Caniglia, K. (1981). The role of context in the encoding of information. *Journal of Experimental Psychology: Human Learning & Memory*, *7*, 283–292.

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In: G. H. Bower (Ed.). *The psychology of learning and motivation: Advances in research and theory* (Vol. 8, pp. 47–89). New York, NY: Academic Press.

Bartlett, F. C. (1932). *Remembering*. Cambridge: Cambridge University Press.

Bell, L. C., & Perfetti, C. A. (1994). Reading skill: Some adult comparisons. *Journal of Educational Psychology*, *86*, 244–255.

Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning & Verbal Behavior*, *11*, 717–726.

Caplan, D., & Waters, G. S. (1995). Aphasic disorders of syntactic comprehension and working memory capacity. *Cognitive Neuropsychology*, *12*, 637–649.

Caplan, D., & Waters, G. S. (1999). Verbal working memory and sentence comprehension. *Behavioral and Brain Sciences*, *22*, 77–126.

Carp, F. M., & Carp, A. (1981). The validity, reliability and generalizability of diary data. *Experimental Aging Research*, *7*, 281–296.

Carroll, J. B., Davies, P., & Richman, B. (1971). *Word frequency book*. Boston, MA: Houghton Mifflin.

Chase, W. G., & Simon, H. A. (1973). The mind's eye in chess. In: W. G. Chase (Ed.), *Visual information processing* (pp. 215–218). New York: Academic Press.

Chi, M., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physicsproblems by experts and novices. *Cognitive Science*, *5*, 121–152.

Chiesi, H. L., Spilich, G. J., & Voss, J. F. (1979). Acquisition of domain-related information in relation to high and low domain knowledge. *Journal of Verbal Learning & Verbal Behavior*, *18*, 257–273.

Clifton, C. Jr., Traxler, M. J., Mohamed, M. T., Williams, R. S., Morris, R. K., & Rayner, K. (2003). The use of thematic role information in parsing: Syntactic processing autonomy revisited. *Journal of Memory and Language*, *49*, 317–334.

Conway, A. R. A., & Engle, R. W. (1994). Working memory and retrieval: A resource dependent inhibition model. *Journal of Experimental Psychology: General*, *123*, 354–373.

Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information-processing system. *Psychological Bulletin*, *104*, 163–191.

Cowan, N. (1995). *Attention and memory: An integrated framework*. New York: Oxford University Press.

Cunningham, A. E., & Stanovich, K. E. (1990). Assessing print exposure and orthographic processing skill in children: A quick measure of reading experience. *Journal of Educational Psychology*, *82*, 733–740.

Cunningham, A. E., & Stanovich, K. E. (1991). Tracking the unique effects of print exposure in children: Associations with vocabulary, general knowledge, and spelling. *Journal of Educational Psychology*, *83*, 264–274.

Curtis, M. E. (1980). Development of components of reading skill. *Journal of Educational Psychology*, *72*, 656–669.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning & Verbal Behavior*, *19*, 450–466.

Dobbins, I. G., Kroll, N. E. A., & Liu, Q. (1998). Confidence-accuracy inversions in scene recognition: A remember-know analysis. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *24*, 1306–1315.

Engle, R. W., Cantor, J., & Carullo, J. J. (1992). Individual differences in working memory and comprehension: A test of four hypotheses. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *18*, 972–992.

Engle, R. W., Conway, A. R. A., Tuholski, S. W., & Shisler, R. J. (1995). A resource account of inhibition. *Psychological Science*, *6*, 122–125.

Engle, R. W., Kane, M. J., & Tuholski, S. W. (1999). Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence, and functions of the prefrontal cortex. In: A. Miyake, & P. Shah (Eds), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 102–134). New York, NY: Cambridge University Press.

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A. R. A. (1999). Working memory, short-term memory, and general fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General*, *128*, 309–331.

Ericsson, K. A. (1985). Memory skill [Special issue]. *Canadian Journal of Psychology*, *39*, 188–231.

Ericsson, K. A., & Delaney, P. F. (1999). Long-term working memory as an alternative to capacity models of working memory in everyday skilled performance. In: A. Miyake, & P. Shah (Eds), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 257–297). New York, NY: Cambridge University Press.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review*, *102*, 211–245.

Ericsson, K. A., & Polson, P. G. (1988a). An experimental analysis of the mechanisms of a memory skill. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *14*, 305–316.

Ericsson, K. A., & Polson, P. G. (1988b). A cognitive analysis of exceptional memory for restaurant orders. In: M. T. H. Chi, R. Glaser, & M. J. Farr (Eds). *The nature of expertise* (pp. 23–70). Hillsdale, NJ: Erlbaum.

Ericsson, K. A., & Smith, J. (1991). Prospects and limits of the empirical study of expertise: An introduction. In: K. A. Ericsson, & J. Smith (Eds). *Toward a general theory of expertise: Prospects and limits* (pp. 1–38). New York, NY: Cambridge.

Eriksen, C. W., & Hoffman, J. E. (1973). The extent of processing of noise elements during selective encoding from visual displays. *Perception & Psychophysics*, *14*, 155–160.

Frederiksen, J. R. (1981). Sources of process interactions in reading. In: A. M. Lesgold, & C. A. Perfetti (Eds). *Interactive processes in reading* (pp. 361–386). Hillsdale, NJ: Erlbaum.

Garnham, A., Oakhill, J. V., & Johnson-Laird, P. N. (1982). Referential continuity and the coherence of discourse. *Cognition*, *11*, 29–46.

Gernsbacher, M. A. (1990). *Language comprehension as structure building*. Hillsdale, NJ: Erlbaum.

Gernsbacher, M. A. (1993). Less skilled readers have less efficient suppression mechanisms. *Psychological Science*, *4*, 294–298.

Gernsbacher, M. A., & Faust, M. E. (1991). The mechanism of suppression: A component of general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *17*, 245–262.

Gernsbacher, M. A., & Faust, M. E. (1995). Skilled suppression. In: F. N. Dempster & C. J. Brainerd (Eds), *Interference and inhibition in cognition (pp. 295–327).* San Diego, CA: Academic Press.

Gernsbacher, M. A., & Robertson, R. R. W. (1995). Reading skill and suppression revisited. *Psychological Science*, *6*, 165–169.

Gernsbacher, M. A., Varner, K. R., & Faust, M. E. (1990). Investigating differences in general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *16*, 430–445.

Greaney, V. (1980). Factors related to amount and time of leisure time reading. *Reading Research Quarterly*, *15*, 337–357.

Guthrie, J. T. (1981). Reading in New Zealand: Achievement and volume. *Reading Research Quarterly*, *17*, 6–27.

Guthrie, J. T., & Greaney, V. (1991). Literacy acts. In: R. Barr, M. L. Kamil, P. Mosenthal, & P. D. Pearson (Eds). *Handbook of reading research* (Vol. 2, pp. 68–96). New York, NY: Longman.

Hatano, G., Amaiwa, S., & Shimizu, K. (1987). Formation of a mental abacus for computation and its use as a memory device for digits: A developmental study. *Developmental Psychology*, *23*, 832–838.

Hayes, D. P., & Ahrens, M. G. (1988). Vocabulary simplification for children: A special case of “motherese?” *Journal of Child Language*, *15*, 395–410.

Jackson, M. D., & McClelland, J. L. (1979). Processing determinants of reading speed. *Journal of Experimental Psychology: General*, *108*, 151–181.

Jensen, A. R. (1990). Speed of information processing in a calculating prodigy. *Intelligence*, *14*, 259–274.

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review*, *99*, 122–149.

Kane, M. J., Bleckley, M. K., Conway, A. R. A., & Engle, R. W. (2001). A controlled attention view of working-memory capacity. *Journal of Experimental Psychology: General*, *130*, 169–183.

Kane, M. J., & Engle, R. W. (2000). Working-memory capacity, proactive interference, and divided attention: Limits on long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *26*, 336–358.

Kieras, D. E., Meyer, D. E., Mueller, S., & Seymour, T. (1999). Insights into working memory from the perspective of the EPIC architecture for modeling skilled perceptual-motor and cognitive human performance. In: A. Miyake, & P. Shah (Eds). *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 183–223). New York, NY: Cambridge.

King, J., & Just, M. A. (1991). Individual differences in syntactic processing: The role of working memory. *Journal of Memory and Language, 30*, 580–602.

Klapp, S. T., Marshburn, E. A., & Lester, P. T. (1983). Short-term memory does not involve the “working memory” of information processing: The demise of a common assumption. *Journal of Experimental Psychology: General*, *112*, 240–264.

Long, D. L., & Chong, J. L. (2001). Comprehension skill and global coherence: A paradoxical picture of poor comprehenders’ abilities. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *27*, 1424–1429.

Long, D. L., & De Ley, L. (2000). Understanding anaphors in story dialogue. *Memory & Cognition*, *28*, 731–738.

Long, D. L., & Golding, J. M. (1993). Superordinate goal inferences: Are they automatically generated during comprehension? *Discourse Processes*, *16*, 55–73.

Long, D. L., Oppy, B. J., & Seely, M. R. (1994). Individual differences in the time course of inferential processing. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *20*, 1456–1470.

Long, D. L., Oppy, B. J., & Seely, M. R. (1997). Individual differences in readers' sentence and text-level representations. *Journal of Memory and Language*, *36*, 129–145.

Long, D. L., Oppy, B. J., & Seely, M. R. (1999). The strategic nature of less skilled readers' suppression problems. *Discourse Processes*, *27*, 281–302.

Long, D. L., & Prat, C. S. (2002). Memory for Star Trek: The role of prior knowledge in recognition revisited. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *28*, 1073–1082.

Long, D. L., Prat, C. S., Blozis, S. A., Widaman, K. F., & Traxler, M. J. (2006). A multilevel model of sentence reading time. In preparation.

Long, D. L., Wilson, J., Hurley, R., & Prat, C. S. (in press). Assessing Text Representations with Recognition: The Interaction of Domain Knowledge and Text Coherence. *Journal of Experimental Psychology: Learning, Memory, & Cognition*.

Lovett, M. C., Reder, L. M., & Lebiere, C. (1999). Modeling working memory in a unified architecture: An ACT-R perspective. In: A. Miyake, & P. Shah (Eds). *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 135–182). New York, NY: Cambridge.

Lundeberg, M. A. (1987). Metacognitive aspects of reading comprehension: Studying understanding in legal case analysis, *Reading Research Quarterly*, *22*, 407–432.

Martin, R. C. (1995). Working memory doesn't work: A critique of Miyake et al.'s capacity theory of aphasic comprehension deficits. *Cognitive Neuropsychology*, *12*, 623–636.

MacDonald, M. C., & Christiansen, M. H. (2002). Reassessing working memory: Comment on Just and Carpenter (1992) and Waters and Caplan (1996). *Psychological Review*, *109*, 35–54.

MacDonald, M. C., Just, M. A., & Carpenter, P. A. (1992). Working memory constraints on the processing of syntactic ambiguity. *Cognitive Psychology*, *24*, 56–98.

Masson, M. E., & Miller, J. A. (1983). Working memory and individual differences in comprehension and memory of text. *Journal of Educational Psychology*, *75*, 314–318.

McNamara, D. S. (2001). Reading both high-coherence and low-coherence texts: Effects of text sequence and prior knowledge. *Canadian Journal of Experimental Psychology*, *55*, 51–62.

McNamara, D. S., & Kintsch, W. (1996). Learning from texts: Effects of prior knowledge and text coherence. *Discourse Processes*, *22*, 247–288.

McNamara, D. S., Kintsch, E., Songer, N. B., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, *14*, 1–43.

Means, M. L., & Voss, J. F. (1985). Star Wars: A developmental study of expert and novice knowledge structures. *Journal of Memory & Language*, *24*, 746–757.

Olson, R. K., Kliegl, R., Davidson, F., & Foltz, G. (1985). Individual and developmental differences in reading disability. In: G. E. MacKinnon, & T. Waller (Eds). *Reading research: Advances in theory and practice* (pp. 1–64). San Diego, CA: Academic Press.

Palmer, J., MacLeod, C. M., Hunt, E., & Davidson, J. (1985). Information processing correlates of reading. *Journal of Memory & Language*, *24*, 59–88.

Pearlmutter, N. J., & MacDonald, M. C. (1995). Individual differences and probabilistic constraints in syntactic ambiguity resolution. *Journal of Memory & Language*, *34*, 521–542.

Perfetti, C. A. (1985). *Reading ability*. New York, NY: Oxford.

Perfetti, C. A. (1989). There are generalized abilities and one of them is reading. In: L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 307–335). Hillsdale, NJ: Erlbaum.

Perfetti, C. A. (1991). Representation and awareness in the acquisition of reading competence. In: L. Rieben, & C. A. Perfetti, (Eds). *Learning to read: Basic research and its implications* (pp. 33–44). Hillsdale, NJ: Erlbaum.

Perfetti, C. A. (1994). Psycholinguistics and reading ability. In: M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 849–894). San Diego, CA: Academic Press.

Perfetti, C. A., Beck, I., Bell, L. C., & Hughes, C. (1987). Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first grade children. *Merrill-Palmer Quarterly*, *33*, 283–319.

Perfetti, C. A., & Lesgold, A. M. (1977). Discourse comprehension and sources of individual differences. In: P. A. Carpenter, & M. A. Just (Eds). *Cognitive processes in comprehension* (pp. 141–183). Hillsdale, NJ: Erlbaum.

Rajaram, S. (1996). Perceptual effects on remembering: Recollective processes in picture recognition memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *22*, 365–377.

Ratcliff, R., & McKoon, G. (1978). Priming in item recognition: Evidence for the propositional structure of sentences. *Journal of Verbal Learning & Verbal Behavior*, *17*, 403–417.

Recht, D. R., & Leslie, L. (1988). Effect of prior knowledge on good and poor readers' memory of text. *Journal of Educational Psychology*, 80, 16–20.

Rice, G. E. (1986). The everyday activities of adults: Implications for prose recall. *Educational Gerontology*, *12*, 173–186.

Rosen, V. M., & Engle, R. W. (1997). The role of working memory capacity in retrieval. *Journal of Experimental Psychology: General*, *126*, 211–227.

Rosen, V. M., & Engle, R. W. (1998). Working memory capacity and suppression. *Journal of Memory & Language*, *39*, 418–436.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, *103*, 403–428.

Schneider, W. (1999). Working memory in a multilevel hybrid connectionist control architecture (CAP2). In: A. Miyake, & P. Shah (Eds). *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 340–374). New York, NY: Cambridge.

Schneider, W., Körkel, J., & Weinert, F. E. (1989). Domain-specific knowledge and memory performance: A comparison of high- and low-aptitude children. *Journal of Educational Psychology*, *81*, 306–312.

Seidenberg, M. S. (1985). The time course of phonological code activation in two writing systems. *Cognition*, *19*, 1–30.

Spilich, G. J., Vesonder, G. T., Chiesi, H. L., & Voss, J. F. (1979). Text processing of domain-related information for individuals with high and low domain knowledge. *Journal of Verbal Learning & Verbal Behavior*, *18*, 275–290.

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, *21*, 360–406.

Stanovich, K. E., & Cunningham, A. E. (1992). Studying the consequences of literacy within a literate society: The cognitive correlates of print exposure. *Memory & Cognition*, *20*, 51–68.

Stanovich, K. E., & West, R. F. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly*, *24*, 402–433.

Stoltzfus, E. R., Hasher, L., & Zacks, R. T. (1996). Working memory and aging: Current status of the inhibitory view. In: J. T. E. Richardson, R. W. Engle, L. Hasher, R. H. Logic, E. R. Stoltzfus, & R. T. Zacks (Eds), *Working memory and human cognition* (pp. 66–88). New York, NY: Oxford.

Sulin, R. A., & Dooling, D. J. (1974). Intrusion of a thematic idea in retention of prose. *Journal of Experimental Psychology*, *103*, 255–262.

Summers, W. V., Horton, D. L., & Diehl, V. A. (1985). Contextual knowledge during encoding influences sentence recognition. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *11*, 771–779.

Traxler, M. J., Williams, R. S., Blozis, S. A., & Morris, R. K. (2005). Working memory, animacy, and verb class in the processing of relative clauses. *Journal of Memory and Language*, *53*, 204–224.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology*, *26*, 1–12.

Vogel, S. A. (1975). *Syntactic abilities in normal and dyslexic children*. Baltimore: University Park Press.

Walberg, H. J., & Tsai, S. (1984). Reading achievement and diminishing returns to time *Journal of Educational Psychology*, *76*, 442–451.

Walker, C. H. (1987). Relative importance of domain knowledge and overall aptitude on acquisition of domain-related information. *Cognition and Instruction*, *4*, 25–42.

Waters, G. S., & Caplan, D. (1996). The capacity theory of sentence comprehension: Critique of Just and Carpenter (1992). *Psychological Review*, *103*, 761–772.

Waters, G., Caplan, D., & Hildebrandt, N. (1991). On the structure of verbal short-term memory and its functional role in sentence comprehension: Evidence from neuropsychology. *Cognitive Neuropsychology*, *8*, 81–126.

West, R. F., & Stanovich, K. E. (1991). The incidental acquisition of information from reading. *Psychological Science*, *2*, 325–330.

West, R. F., Stanovich, K. E., & Mitchell, H. R. (1993). Reading in the real world and its correlates. *Reading Research Quarterly*, *28*, 35–50.

Wixted, J. T., & Stretch, V. (2004). In defense of the signal detection interpretation of remember/know judgments. *Psychonomic Bulletin & Review*, *11*, 616–641.

Yeh, Y., & Eriksen, C. W. (1984). Name codes and features in the discrimination of letter forms. *Perception & Psychophysics*, *36*, 225–233.

Yonelinas, A. P. (1997). Recognition memory ROCs for item and associative information: The contribution of recollection and familiarity. *Memory & Cognition*, *25*, 747–763.

Yonelinas, A. P. (1999). The contribution of recollection and familiarity to recognition and source-memory judgments: A formal dual-process model and an analysis of receiver operating characterstics. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *25*, 1415–1434.

Yonelinas, A. P. (2001). Consciousness, control, and confidence: The 3 Cs of recognition memory. *Journal of Experimental Psychology: General*, *130*, 361–379.

Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory & Language*, *46*, 441–517.

Young, R. M., & Lewis, R. L. (1999). The Soar cognitive architecture and human working memory. In: A. Miyake, & P. Priti (Eds). *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 224–256). New York, NY: Cambridge.

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