

## Individual Differences in Readers' Sentence- and Text-Level Representations

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Poor reading comprehension is often associated with a failure to make appropriate inferences during reading. Do less skilled readers fail to make inferences because they fail to construct accurate propositional representations? We conducted two experiments to investigate individual differences in readers' sentence- and text-level representations. In Experiment 1, we found no differences in the two groups' ability to perform a task that is sensitive to the underlying propositional structure of sentences. However, in Experiment 2, we found large differences in the extent to which skilled and less-skilled readers integrated ideas from different parts of a text. We suggest that an important processing bottleneck among less skilled college-aged readers occurs at the discourse level. © 1997 Academic Press

Poor reading comprehension is often associated with a systematic failure to make appropriate inferences during reading. Less skilled readers have difficulty making inferences to integrate ideas in a text, to answer questions about it, and to identify main ideas and themes (Garnham, Oakhill, & Johnson-Laird, 1982; Long & Golding, 1993; Long, Oppy, & Seely, 1994; Oakhill, 1983, 1984, 1993, 1994; Oakhill & Yuill, 1986; Oakhill, Yuill, & Donaldson, 1990; Oakhill, Yuill, & Parkin, 1988; Yuill, Oakhill, & Parkin, 1989). One of the aims of research on individual differences in comprehension has been to explain the inference problems exhibited by these readers.

The present research was supported by a University of California, Davis, Faculty Development Award to the first author. We thank the editor and three anonymous reviewers for their helpful comments on an earlier draft of this article. Address reprint requests to Debra Long, Department of Psychology, University of California, Davis, CA 95616, E-mail: dlong@ucdavis.edu.

The most straightforward explanation of less skilled readers' inference problems is that they result from deficits in basic linguistic abilities, such as word decoding or syntactic analysis (Cromer, 1970; Perfetti & Lesgold, 1977; Perfetti, 1985, 1989, 1994; Vogel, 1975). Readers are unlikely to make inferences to integrate or to elaborate the ideas in a text if they fail to construct an accurate propositional representation of it. This explanation is supported by evidence that skilled and less skilled readers differ on a broad range of component reading abilities. For example, less skilled readers generally have slower and less efficient word decoding skills than do skilled readers (see Perfetti, 1985, for a review). Perfetti (1985) has argued that word recognition speed and accuracy play a central role in comprehension ability. According to his verbal-efficiency hypothesis, the component processes involved in reading compete for limited resources. Slow and inefficient word recognition processes limit the rate at

which higher sentence- and text-level processes can be executed.

There is some evidence, however, that less skilled readers' inference problems are not caused by deficits in basic linguistic processes alone. Oakhill and her colleagues have examined the inferential abilities of good and poor comprehenders with similar word recognition skills (Garnham et al., 1982; Oakhill, 1983, 1984, 1993; Oakhill & Yuill, 1986; Yuill & Oakhill, 1991). Specifically, they identified readers who differed in their ability to answer questions about texts, but not in their ability to read words aloud or to understand the meanings of isolated words.

They found a number of differences between good and poor comprehenders. Poor comprehenders (a) had difficulty answering questions that required an inference even when the text was available during questioning (Oakhill, 1984), (b) were less likely than good comprehenders to use context to interpret a text (Oakhill, 1983), (c) had difficulty making inferences to identify the correct referent of a pronoun (Oakhill & Yuill, 1986), and (d) benefited less than good comprehenders from referential continuity in stories (Garnham et al., 1982)

Although such findings suggest that inference problems occur in spite of accurate word recognition skills, they leave open the possibility that these problems are secondary to deficits in other component reading abilities. Less skilled readers may have accurate word recognition skills, but poor syntactic or semantic skills. Alternatively, they may have accurate but very slow word recognition processes. Thus, word recognition may consume resources needed to execute other component processes (Perfetti & Roth, 1981).

To determine whether inference problems are secondary to basic linguistic deficits, we need to address the following question: Are there individuals who systematically fail to make inferences even though they have adequate reading ability and sufficient knowledge to do so? Before answering this question, we need to define "adequate" reading ability. Unfortunately, there is no measure that as-

esses adequate ability relative to some minimum level of competence. Rather, it is typically assessed relative to the performance of skilled readers. If less skilled readers perform worse than skilled readers on some measure of basic linguistic skill (e.g., phonological awareness, word identification, etc.), then researchers often assume that these readers lack the ability to build accurate sentence-level representations. This assumption, however, is seldom tested directly and may not be warranted. Less skilled readers may construct reasonably accurate sentence-level representations in spite of deficits in one or more linguistic abilities. If so, then their failure to make inferences may be due to more general comprehension problems (e.g., deficits in inferential abilities, inefficient suppression mechanisms) or capacity limitations (e.g., limited working memory capacity, slow knowledge access).

Recently, we conducted a study to examine the accuracy of less skilled readers' sentence-level representations as well as their ability to make appropriate inferences during reading (Long et al., 1994). Specifically, we contrasted skilled and less skilled readers' ability (a) to execute a process necessary to represent the meaning of a sentence (i.e., to select the context-appropriate sense of an ambiguous word) and (b) to make an inference related to the sentence topic. We predicted that skilled readers would make topic-related inferences that less skilled readers would not make. However, we were primarily interested in less skilled readers' ability to select the context-appropriate sense of an ambiguous word (i.e., to execute sense selection processes). We argued that sense selection is dependent on a reasonably accurate propositional representation of the sentence context. If less skilled readers fail to execute sense selection processes, this would indicate deficits in their ability to construct accurate representations of sentences. Therefore, their failure to make topic-related inferences should be attributed solely to deficits in lower-level linguistic skills. In contrast, if less skilled readers show the ability to quickly and accurately select the context-ap-

appropriate sense of an ambiguous word, this would suggest that they constructed an adequate sentence-level representation. Thus, their failure to make topic-related inferences should be attributed to problems other than linguistic skill deficits alone.

In Long et al. (1994), subjects read sentences that ended with homograph primes and responded to lexical decision targets. The lexical decision targets were (a) context-appropriate associates of the primes, (b) context-inappropriate associates of the primes, (c) words related to the topic of the sentence, (d) words unrelated to the topic of the sentence, and (e) nonwords. We predicted faster responses to appropriate than to inappropriate associates once readers selected the context-appropriate sense of the homograph. Similarly, faster responses to words related to the topic of the sentence than to unrelated words were predicted once readers made a topic-related inference. We examined the time course of sense selection and inferential processing by presenting the targets at different stimulus onset asynchronies (SOAs).

We found that skilled readers responded faster in the lexical decision task to appropriate than to inappropriate topic words within 500 ms of processing, whereas less skilled readers showed no response differences at prime-target SOAs as long as 1000 ms. In contrast, we found that both groups responded faster to appropriate than to inappropriate associates of the homograph primes within 300 ms of processing. We also found that skilled and less skilled readers had similar knowledge about the sentence topics. We asked both groups to provide a single-word description of the topic of each sentence; we found no differences in their responses. We concluded that less skilled readers failed to make topic-related inferences even though they had (a) the ability to execute a process that depends on an adequate sentence-level representation and (b) relevant knowledge about the sentence topics.

The purpose of the present study was to extend our research examining less skilled readers' sentence- and text-level representa-

tions. Do less skilled readers construct accurate sentence-level representations even though they fail to make appropriate inferences during reading? In Experiment 1, we examined the propositional structure of less skilled readers' representations of sentences. Specifically, we investigated less skilled readers' ability to make connections among concepts that appear in the same proposition and their ability to elaborate their sentence-level representations with topic-related information. In Experiment 2, we focused on less skilled readers' representations of longer segments of connected discourse. Specifically, we investigated their ability to integrate propositions that are relatively distant in the surface structure of a story and their ability to make inferences about story topics.

#### EXPERIMENT 1

In our previous study (Long et al., 1994), we concluded that less skilled readers constructed adequate sentence-level representations even though they failed to make topic-related inferences. Our conclusion was based on evidence that both skilled and less skilled readers constructed representations that were consistent with the context-appropriate senses of homographs. However, our findings are not entirely consistent with other research on less skilled readers' sense selection abilities (Gernsbacher, 1993; Gernsbacher & Faust, 1991; Gernsbacher & Robertson, 1995; Gernsbacher, Varner, & Faust, 1990). For example, Gernsbacher et al. (1990) demonstrated differences in skilled and less skilled readers' ability to reject the context-inappropriate meanings of ambiguous words. In their task, subjects read a sentence that either did or did not end with a homograph (e.g., "He dug with the spade" vs "He dug with the shovel"). Subsequently, they judged whether or not a test word (e.g., *ace*) fit the meaning of the sentence. When a test word was presented immediately after the sentence, Gernsbacher et al. found that both skilled and less skilled readers exhibited interference. That is, both groups were slower to reject the probe *ace* after reading "He dug with the spade" than

after reading "He dug with the shovel." When the test word was presented after a delay, however, only the less skilled readers were slow to reject the test word. Gernsbacher et al. argued that less skilled readers continued to experience interference at the delay because they failed to suppress the inappropriate meaning of the homograph.

The inconsistency between our findings and those reported by Gernsbacher et al. (1990) may be due to methodological differences. The two studies used different measures of activation (i.e., lexical decision vs meaning-fit judgment) as well as different comparisons among test items. Gernsbacher et al. examined judgment times to inappropriate associates relative to unrelated controls. In contrast, we examined decision latencies to appropriate associates relative to inappropriate associates. This latter comparison provides no information about the extent to which less skilled readers actually suppressed the homograph's inappropriate meaning. It tells us only that inappropriate associates were less activated than were appropriate associates. It may be that even partial activation of an inappropriate associate is sufficient to produce interference on the meaning-fit judgment task.

If this is the case, then our findings and those reported by Gernsbacher et al. (1990) may be more compatible than they initially appear. If less skilled readers suppress the inappropriate meanings of homographs partially, but not completely, then we would expect findings similar to those described above. Less skilled readers should show interference on the meaning-fit judgment task because the inappropriate meaning of a homograph is partially activated. In addition, they should show faster responses to appropriate than to inappropriate associates on tasks like lexical decision. This is because the inappropriate meaning has been partially, although not completely, suppressed.

We conducted the present study to provide additional information about less skilled readers' ability to construct accurate sentence- and text-level representations. First, we asked whether these readers construct memory rep-

resentations that incorporate both the appropriate and inappropriate meanings of ambiguous words or only the appropriate meanings. Less skilled readers' representations may include inappropriate meanings because they fail to suppress this information during comprehension. Second, we conducted the study to investigate the accuracy of their sentence-level representations more directly than before. In our previous study (Long et al., 1994), we assessed the accuracy of their representations indirectly by examining their ability to execute sense-selection processes in response to a single ambiguous word. In the present study, we assessed the accuracy of less skilled readers' sentence-level representations more directly by examining their ability to construct representations that reflect the underlying propositional structure of sentences. Finally, we examined readers' text-level representations. We asked whether both skilled and less skilled readers construct memory representations that incorporate topic-related information.

We adopted a procedure used previously by Ratcliff and McKoon (1978) to investigate the propositional structure of simple sentences. They presented sentences to subjects for study and tested their recognition for a list of single words. The critical manipulation involved the order of pairs of items in the test list. A test word in the list was preceded by a test word from the same proposition or by a test word from a different proposition in the same sentence. They found strong evidence for the propositional structure of sentences in memory. Subjects were faster to recognize a target that was preceded by a prime from the same proposition relative to a prime from a different proposition.

We used a similar procedure in Experiment 1. Skilled and less skilled readers received a list of brief two-sentence passages for study and then received a recognition test for lists of single words. The passages were adapted from the materials that were used in Long et al. (1994). We included Ratcliff and McKoon's (1978) priming manipulation to investigate (a) the propositional structure of the

TABLE 1

SAMPLE PASSAGES AND EXAMPLE PRIME-TARGET PAIRS

Condition	Prime	Target
The townspeople were amazed to find that all the buildings had collapsed except the <i>mint</i> . Obviously, the architect had foreseen the danger because the structure withstood the natural disaster.		
Propositional priming pairs		
Same-proposition	disaster	structure
Different-proposition	danger	structure
Associate priming pairs		
Appropriate-associate	buildings	money
Inappropriate-associate	buildings	candy
Topic priming pairs		
Appropriate-topic	structure	earthquake
Inappropriate-topic	structure	breath
The guest ate garlic in his dinner, so the waiter brought a <i>mint</i> . The worried guest soon felt more comfortable socializing with the others.		
Propositional priming pairs		
Same-proposition	guest	garlic
Different-proposition	waiter	garlic
Associate priming pairs		
Appropriate-associate	waiter	candy
Inappropriate-associate	waiter	money
Topic priming pairs		
Appropriate-topic	guest	breath
Inappropriate-topic	guest	earthquake

*Note.* Subjects saw only one prime-target pair for each passage.

sentences in memory, (b) the activation of the context-appropriate associates of the homographs, and (c) the activation of words related to the topics of the sentences. Table 1 contains two sample passages and examples of the prime-target pairs. We constructed three types of priming pairs: (1) *propositional priming pairs* consisted of a target (e.g., structure) that was preceded by a prime from the same proposition (e.g., disaster) or by a prime from a different proposition in the same sentence (e.g., danger), (2) *associate priming pairs* consisted of a target that was either the appropriate (e.g., money) or the inappropriate associate (e.g., candy) of the homograph and was preceded by a prime from the sentence containing the homograph (e.g., buildings), and

(3) *topic priming pairs* consisted of a target that was either the topic of a passage (e.g., earthquake) or was an unrelated word (e.g., breath) and was preceded by a prime from the final sentence of the passage (e.g., structure). It should be noted that the correct response to the associates and to the topic and unrelated words is "no." These items do not appear in the sentences. However, subjects' ability to reject these items may depend on the extent to which the items activate information in the sentences. For example, subjects may be slower to reject the appropriate than the inappropriate associate. This would occur if the appropriate associate had more features in common with the meaning of the sentence stored in memory than did the inappropriate one.

If less skilled readers fail to make inferences because they fail to store accurate propositional representations in memory, then they may show a different propositional priming effect than skilled readers. That is, they may exhibit less facilitation than skilled readers when a target is primed by a word from the same proposition. Similarly, they may show little interference in response to the appropriate associates. If they do not incorporate the context-appropriate sense of the homograph as part of their representation of the sentence, then they should have little difficulty rejecting the item at test.

Alternatively, less skilled readers may construct accurate propositional representations, but fail to elaborate their representations with topic-related information. If so, then skilled and less skilled readers should show similar propositional priming effects and similar interference effects for the appropriate associates, but different interference effects for the topic-related words. This leads to an interesting and somewhat counterintuitive prediction. That is, less skilled readers should be better than skilled readers at rejecting the topic-related words.

### Method

*Subjects.* Subjects were 172 undergraduate psychology students who received course

credit for their participation. All subjects spoke English as their first language and none had a diagnosed learning disability. We discarded data from 6 subjects due to large numbers of recognition errors. We used performance on the verbal portion of the Scholastic Aptitude Test (SAT) to identify groups of skilled and less skilled readers (the top and bottom third of subjects, respectively). The verbal SAT is not an explicit measure of reading ability; however, it predicts performance on a variety of reading comprehension tests (Daneman & Carpenter, 1980; Hunt, Lunneborg, & Lewis, 1975; Wood, 1982). Skilled readers' verbal SAT scores ranged from 590 to 710 ( $M = 638, n = 51$ ); less skilled readers' scores ranged from 200 to 440 ( $M = 374, n = 51$ ). The two groups were distributed in approximately equal numbers across our counterbalancing conditions.

*Materials.* The study materials consisted of 56 two-sentence passages used previously by Till, Mross, and Kintsch (1988) and by Long et al. (1994). Till et al. (1988) constructed the passages in pairs written around an ambiguous noun that appeared in both passages (see the pair of passages in Table 1). The homograph appeared at the end of either the first or the second sentence of the passage, and its meaning was unambiguously specified by the context. The homographs had approximately equally strong associates to each of their senses. These associates were used as the set of associate test items and were appropriate or inappropriate depending on the sentence context. The topic test items were the modal responses made by a group of pilot subjects in Till et al.'s study. Subjects were asked to "write down a word reflecting their understanding of what the paragraph was about" (p. 286). The appropriate-topic word for one passage of a pair served as the inappropriate-topic word for the other passage in the pair. The characteristics of the associate and topic words (e.g., number of syllables, word frequency) can be found in Till et al. (p. 286).

We analyzed the Till et al. passages to determine their underlying propositional structure. We defined a proposition as a relation

(verb or modifier) and its arguments (see Kintsch, 1974). We then adapted the passages to ensure that each passage contained a sentence that had a least two propositions with a noun-verb-noun structure (e.g., *While the maid folded the laundry, the baby grabbed the iron*). Strictly speaking, every sentence also contained a third proposition that was a conjunction of the other two and several sentences contained propositions in which an adjective modified a noun in the sentence. In addition to the Till et al. passages, the study materials consisted of 42 two-sentence passages used by Long et al. (1994). These passages were also adapted in the manner described above. The total set of 90 passages was divided into 15 lists: 14 experimental and 1 practice. Each list contained six passages.

A recognition test followed each study list. The test consisted of six prime-target pairs (one prime-target pair of each type) interleaved among 10 filler items. One prime-target pair was associated with each passage in the study list. The six prime-target pairs were defined as follows (see Table 1): (1) the same-proposition priming pair consisted of a noun preceded by another noun from the same proposition; (2) the different-proposition priming pair consisted of a noun preceded by a noun from a different proposition in the same sentence; (3) the appropriate-associate priming pair consisted of the appropriate associate of the homograph preceded by a noun from the same sentence as the homograph; (4) the inappropriate-associate priming pair consisted of the inappropriate associate of the homograph preceded by a noun from the same sentence as the homograph; (5) the appropriate-topic priming pair consisted of the topic word for the passage preceded by a noun from the final sentence of the passage; (6) the inappropriate-topic priming pair consisted of the inappropriate topic word for the passage preceded by a noun from the final sentence of the passage. The homograph never appeared in the list of test words. The study-test lists were counterbalanced across versions of a computer program such that each passage was associated once with each of the six priming pairs.

*Procedure.* We used the same study-test recognition memory procedure used by Ratcliff and McKoon (1978). Each study list consisted of six passages. The passages were all two sentences long and were presented individually for 14 s. Each study list was followed by a recognition test. The recognition test consisted of a list of 22 single words, including the 6 priming pairs defined above. The priming pairs were interleaved among 10 filler items (3 true and 7 false). Each test list was preceded by an asterisk that appeared on the screen for two seconds. The asterisk was followed by three filler items. The priming pairs were presented randomly in the remainder of the list, separated by intervening filler items. Finally, a filler item followed the last priming pair in the list. Subjects pressed a "yes" key if a test word had appeared in one of the preceding sentences and a "no" key if it had not appeared. We recorded their responses and reaction times to the test words. Subjects received 14 study-test trials in random order. These trials were preceded by a practice trial.

### Results and Discussion

We performed separate  $2(\text{skill}) \times 2(\text{priming})$  repeated measures ANOVAs on errors and reaction times to targets in the propositional, associate, and topic priming pairs. Only correct responses were included in analyses of the reaction time data. All analyses were performed with subjects treated as a random variable ( $F_1$ ) and again with items treated as a random variable ( $F_2$ ). Post hoc analyses were conducted using the error term from the overall analysis. All effects were tested at a significance level of  $p < .05$  unless otherwise indicated. Mean errors and mean response times to targets in the six priming conditions appear in Table 2.

*Propositional priming pairs.* The analysis of errors to targets in the same- and different-proposition priming pairs revealed no reliable main effects or interactions (all  $F_s < 1$ ). However, our analysis of the reaction time data indicated that both skilled and less skilled readers responded faster to targets in the same-

TABLE 2

EXPERIMENT 1: MEAN RESPONSE TIMES (IN MILLISECONDS) AND MEAN ERRORS AS A FUNCTION OF PRIMING CONDITION AND READING SKILL

Priming condition	Reading skill			
	Skilled		Less skilled	
	RT	% error	RT	% error
Propositional				
Same	941	23	948	24
Different	982	23	991	22
Associate				
Appropriate	1197	36	1200	34
Inappropriate	1077	12	1109	18
Topic				
Appropriate	1183	27	1060	15
Inappropriate	1037	8	1046	14

than in the different-proposition condition,  $F_1(1,100) = 6.22$ ;  $F_2(1,26) = 4.09$ .

*Associate priming pairs.* The analysis of errors to associate targets revealed that both skilled and less skilled readers made more errors to appropriate than to inappropriate associates of the homographs,  $F_1(1,100) = 132.49$ ;  $F_2(1,26) = 43.50$ . We found a similar pattern in our analysis of the reaction time data. Both skilled and less skilled readers exhibited slower responses to appropriate than to inappropriate associates,  $F_1(1,100) = 13.70$ ;  $F_2(1,26) = 11.18$ .

*Topic priming pairs.* Our analysis of the error data revealed a main effect of priming,  $F_1(1,100) = 28.41$ ;  $F_2(1,26) = 20.67$ . This was modified by a reliable skill  $\times$  priming interaction,  $F_1(1,100) = 22.00$ ;  $F_2(1,26) = 32.19$ . Skilled readers made more errors to appropriate than to inappropriate-topic words ( $F_1(1,100) = 54.81$ ;  $F_2(1,26) = 72.81$ ), whereas less skilled subjects showed no differences (both  $F_s < 1$ ). Our analysis of the reaction time data revealed the same pattern. We found a reliable main effect of priming,  $F_1(1,100) = 15.15$ ;  $F_2(1,26) = 11.61$ , that was modified by a reliable skill  $\times$  priming interaction in the subjects analysis ( $F_1(1,100) = 3.87$ ) and a marginally reliable interaction in the

items analysis ( $F_2(1,26) = 3.37, p = .07$ ). Skilled readers exhibited slower responses to appropriate than to inappropriate topic words ( $F_1(1,100) = 16.41; F_2(1,26) = 15.11$ ), whereas less skilled readers exhibited no differences ( $F_1(1,100) = 2.11; F_2(1,26) = 1.69$ ).

These findings suggest that skilled and less skilled readers' sentence representations were similar in at least two respects. First, both groups showed evidence for the propositional structure of their representations. They exhibited faster responses to targets presented in same- than in different-proposition priming pairs. This pattern is consistent with Ratcliff and McKoon's (1978) evidence that sentences are stored in memory as connected propositions. Second, both groups showed evidence for sense selection. They had greater difficulty rejecting contextually appropriate than inappropriate associates of homographs. This suggests that the appropriate associates were consistent with information stored in both skilled and less skilled readers' sentence representations.

This latter finding sheds some additional light on less skilled readers' sense selection abilities. As we discussed previously, Gernsbacher et al. (1990) reported evidence that less skilled readers fail to suppress the inappropriate meanings of ambiguous words during the comprehension process. Although this may indeed be the case, our results suggest that these inappropriate meanings do not become a permanent part of less skilled readers' memory representations. Less skilled readers had difficulty rejecting context-appropriate associates, but had no difficulty rejecting inappropriate associates. Thus, they appeared to construct reasonably accurate sentence-level representations in spite of any difficulty they may have had suppressing activated, but irrelevant, information during reading.

Although skilled and less skilled readers' responses to propositional and associate priming pairs were similar, their responses to topic priming pairs were very different. In most reading-related tasks, skilled readers perform better than do less skilled readers; interestingly, we found the opposite pattern here.

Skilled, but not less skilled, readers exhibited interference in response to the appropriate-topic words. Skilled readers were slower to reject targets in appropriate- than in inappropriate-topic priming pairs, whereas less skilled readers showed no differences. In addition, skilled readers were slower to reject the appropriate topic words than were less skilled readers and they made more errors.

The interference effect exhibited by skilled readers has at least two possible explanations. First, skilled readers may have inferred the topic of the sentence during comprehension and included it as part of their memory representation. Thus, they experienced difficulty at test because the topic word closely matched information stored in memory. Second, skilled readers may have made the inferential connection between the topic word and the corresponding sentence at test. That is, presentation of the prime may have activated information about the passage. When the topic word appeared, subjects computed a backward association between the test word and their representation of the passage. Both of these possibilities are consistent with the claim that skilled readers make topic-related inferences that less skilled readers do not make. Skilled readers' inferential abilities worked to their disadvantage in this task because they were required to reject information that was consistent with their memory representations.

The results of Experiment 1 provide converging evidence to support the claim that less skilled readers construct reasonably accurate sentence-level representations even though they fail to make topic-related inferences (Long et al., 1994). Skilled and less skilled readers perform similarly on tasks that assess (a) the propositional structure of their sentence representations, (b) their ability to select contextually appropriate meanings of ambiguous words, (c) the time course by which they execute sense selection processes (Long et al., 1994), and (d) their knowledge about the topics of brief passages (Long et al., 1994).

In the research described here and in Long et al. (1994), we focused on the accuracy of less skilled readers' representations of brief

passages. Our goal in the following experiment was to extend this research by examining less skilled readers' memory representations of longer segments of connected discourse.

## EXPERIMENT 2

The results of the previous experiment suggest that less skilled readers have reasonably accurate propositional representations of simple sentences. Do they also construct accurate representations of longer segments of connected discourse? Oakhill and her colleagues examined skilled and less skilled readers' representations of connected discourse and found significant differences (Garnham et al., 1982; Oakhill, 1984; Oakhill & Yuill, 1986; Oakhill et al. 1988). In particular, they found that less skilled readers failed to integrate information from different parts of a text. This finding may help explain why these readers fail to make topic-related inferences. Such inferences are often based on information about the text as a whole. If readers fail to build integrated text representations, then they are unlikely to elaborate them with topic-related information. Our purpose in Experiment 2 was to examine less skilled readers' ability to integrate story ideas and to make inferences about story topics.

In this experiment, we contrasted skilled and less skilled readers' ability to make connections (a) among propositions that are relatively distant in the surface structure of a story and (b) between two stories that share the same theme. This experiment is similar to one conducted by Seifert, McKoon, Abelson, and Ratcliff (1986) to investigate memory connections among thematically related episodes. Seifert et al. had subjects read a set of stories. Each story was based on a thematic abstraction unit (TAU). TAUs are the structures of goals and plans expressed by common adages (e.g., cutting your nose off to spite your face; every cloud has a silver lining). Examples of three TAU-based stories appear in the Appendix. The first two stories (Stories A and B) are based on the TAU *the cure is worse than the disease*. The third story (Story C) is based on the TAU *the blind leading the blind*. In Seifert et al.'s procedure, subjects read pairs

of stories that were either based on the same TAU (e.g., Stories A and B) or based on different TAUs (e.g., Stories B and C). After reading each pair of stories, subjects responded true or false to a list of test sentences about them. Subjects responses and reaction times were recorded.

Seifert et al. (1986) used a priming procedure to examine memory connections between story pairs. The priming conditions are also depicted in the Appendix. A target test sentence expressed the conclusion of the second story in the pair (e.g., the conclusion of Story B). The conclusion was preceded by one of four different types of priming test sentences. In the *same-theme condition*, the pair of stories was based on the same TAU and the prime expressed the conclusion of the first story in the pair (e.g., the conclusion of Story A). In the *different-theme condition*, the stories were based on different TAUs and the prime expressed the conclusion of the first story (e.g., the conclusion of Story C). Seifert et al. hypothesized that time to verify the target test statement would be facilitated when the prime and target statements came from stories that shared the same TAU. They also included two conditions to examine memory connections within a story. In the *within-story condition*, the target was preceded by a prime that expressed the setup (i.e., the initiating circumstances) of the same story (e.g., the conclusion of Story B was preceded by the setup of Story B). In the *between-story condition*, the target was preceded by the setup of the first story (e.g., the conclusion of Story B was preceded by the setup of Story C). They predicted that subjects would make a memory connection between the setup and conclusion of the same story. This would lead to faster verification times in the same- than in the different-story condition.

Seifert et al. (1986) found facilitation for targets in the same-relative to the different-theme condition. However, they found this effect only when subjects were instructed to attend to the thematic similarity of the stories. In addition, they found facilitation for targets in the within- relative to the between-story

condition. They argued that the setup and conclusion of a story were connected in memory. This connection facilitated subjects' ability to verify the conclusion when it was preceded by the setup from the same story.

We replicated Seifert et al.'s (1986) procedure in Experiment 2. Subjects rated the thematic similarity of pairs of stories and then responded true or false to a set of test statements about them. We recorded subjects' responses and reaction times in response to the test sentences. This procedure bears some similarity to the one that we used in Experiment 1. Subjects read passages and then verified a list of test items. In addition, the priming manipulation was similar. We examined subjects' responses to targets that were preceded by closely related or more distantly related primes. However, this procedure differed from that used in Experiment 1 in several important respects: (1) Subjects read stories rather than brief two-sentence passages, (2) The test list consisted of sentences rather than single words, and (3) We examined memory connections among ideas within and between stories rather than connections within and between propositions in a single sentence.

Our goal in this experiment was to examine differences in the priming effects exhibited by skilled and less skilled readers. If the two groups construct similar representations of stories, then they should exhibit a similar story-priming effect. That is, both groups should exhibit faster responses to targets in the within- than in the between-story condition. However, if less skilled readers fail to integrate the different parts of a story, then the two groups should show a different priming effect. Skilled readers should show priming as a function of story condition, whereas less skilled readers should show no priming effect.

We also examined skilled and less skilled readers' responses to targets in the two theme conditions. If the two groups differ in their ability to incorporate thematic information into their story representations, then they should show different thematic priming effects. Skilled readers should respond faster to targets in the same-than in the different-theme

condition, whereas less skilled readers should show no differences. This latter finding would be particularly interesting if we found that less skilled readers failed to show story-priming effects even though they produced thematic ratings that demonstrated their sensitivity to the thematic similarity of the stories.

### *Method*

*Subjects.* Subjects were 160 undergraduate psychology students who received course credit for their participation. All subjects spoke English as their first language and none had a diagnosed learning disability. Groups of skilled and less skilled readers were identified using the procedure described in Experiment 1. Skilled readers had verbal SAT scores ranging from 590 to 780 ( $M = 670, n = 52$ ); less skilled readers had scores ranging from 200 to 480 ( $M = 380, n = 52$ ).

*Materials.* We wrote 64 stories similar to those used by Seifert et al. (1986). These stories were based on eight thematic patterns: "Every cloud has a silver lining," "Too many cooks spoil the broth," "Cutting your nose off to spite your face," "The pot calling the kettle black," "The cure is worse than the disease," "Closing the barn door after the horse is gone," "Counting your chickens before they are hatched," "The blind leading the blind." The stories averaged seven sentences in length (see the Appendix for example stories). In addition, we wrote two practice stories that were similar in length and style to the experimental stories.

We constructed four test sentences for each of the stories. Two of these sentences were true about the story. One of these referred to the story's initiating circumstances. We defined the initiating circumstances of a story as a statement from the story that described the character's goal or described an event or state that initiated this goal. The other true sentence referred to the story's conclusion. We defined the conclusion of a story as a statement that described the outcome of a character's goal attempt. These two sentences had no content words in common. The other two sentences were false, clearly contradicting information

in the story. Test sentences all averaged 10 words in length.

*Procedure.* We selected half of the stories in each thematic category as target stories. These stories always appeared as the second story in a pair of stories. We used the remainder of the stories as fillers (i.e., the first story in a pair of stories). Subjects were told that they would read pairs of stories and would answer questions about them. They were instructed to think about the theme of each story and to decide whether a pair of stories shared the same theme. We included these instructions for two reasons. First, Seifert et al. (1986) found that readers made a thematic connection between two stories only when it was required to perform the task. Second, the similarity ratings provided important information about less skilled readers' conscious understanding of the thematic connections between stories.

Each subject received 16 pairs of stories. Target stories in the same-theme condition were paired with a filler story based on the same theme (4 of the 16 pairs of stories). Stories in the different-theme, the within-story, and the between-story conditions were paired with filler stories based on a different theme. Subjects read the stories at their own pace. They began the experiment by pressing the space bar. An asterisk appeared on the screen for two seconds. The asterisk was followed by the first story in the pair. When subjects finished the story, they pressed the space bar to continue and the next story appeared. When they finished the second story, they pressed the space bar again. A string of question marks (???) appeared for 2 s and then subjects received the list of test sentences. The target stories were counterbalanced across versions of a computer program so that they appeared an equal number of times in each condition.

Each pair of stories was followed by a list of eight test sentences. Each list was composed of a priming pair positioned randomly among the other test sentences. The priming pair never appeared in either the first or the last position in a list. Each test sentence was presented individually. Subjects pressed a key

TABLE 3

EXPERIMENT 2: MEAN RESPONSE TIMES (IN MILLISECONDS) AND MEAN ERRORS AS A FUNCTION OF PRIMING CONDITION AND READING SKILL

Priming condition	Reading skill			
	Skilled		Less skilled	
	RT	% error	RT	% error
Story				
Within	2245	3	3014	4
Between	2528	6	2972	9
Theme				
Same	2311	5	3142	4
Different	2600	3	3107	5

labeled "yes" if the sentence was true about one of the preceding stories and pressed a key labeled "no" if it was false. This is somewhat different than the task used in Experiment 1 in which subjects responded "yes" if the word had appeared in one of the previous passages. In this task, subjects responded "yes" if the test sentence was consistent with the information in the story. We recorded their responses and reaction times to the test sentences.

Each study-test trial was followed by a rating judgment. Subjects were asked to rate the thematic similarity of the two stories on a 6-point scale (1 = very different, 6 = very similar). The 16 study-test trials were presented in random order. These trials were preceded by a practice trial to familiarize subjects with the task.

### Results and Discussion

We performed separate 2(skill)  $\times$  2(priming) repeated measures ANOVAs on the errors and reaction times to targets in the story and thematic priming conditions. Only correct responses were included in our analyses of the reaction time data. Mean response times and errors to targets in the four priming conditions appear in Table 3.

*Story priming conditions.* Our analysis of errors to targets in the within- and between-

story conditions revealed no reliable main effects or interactions (all  $F_s < 1$ ). However, our analysis of the reaction time data indicated that skilled readers responded faster than did less skilled readers to targets in both priming conditions,  $F_1(1,102) = 28.95$ ;  $F_2(1,6) = 131.37$ . This effect was modified by a reliable skill  $\times$  priming interaction,  $F_1(1,102) = 4.56$ ;  $F_2(1,6) = 9.43$ . Skilled readers responded faster to targets in the within- than in the between-story condition ( $F_1(1,102) = 6.88$ ;  $F_2(1,6) = 14.24$ ), whereas less skilled readers showed no differences (both  $F_s < 1$ ).

*Thematic priming conditions.* We found no reliable effects in the analysis of errors to targets in the thematic priming conditions. Our analysis of the reaction time data revealed that skilled readers responded faster than did less skilled readers to targets in both priming conditions,  $F_1(1,102) = 30.65$ ;  $F_2(1,6) = 148.31$ . This effect was modified by a reliable skill  $\times$  priming interaction,  $F_1(1,102) = 3.89$ ;  $F_2(1,6) = 8.71$ . Skilled readers responded faster to targets in the same- than in the different-theme condition ( $F_1(1,102) = 6.14$ ;  $F_2(1,6) = 13.86$ ), whereas less skilled readers exhibited no differences in the two conditions (both  $F_s < 1$ ).

*Overall errors.* We analyzed differences in skilled and less skilled readers' overall errors to positive and negative items. Although the error rates were low, we found a reliable main effect of skill in both analyses ( $F(1,102) = 6.24$  and  $F(1,102) = 8.00$ , respectively). Less skilled readers made more errors on positive trials than did skilled readers ( $M = 5\%$  and  $M = 3\%$ , respectively). Similarly, less skilled readers made more errors than did skilled readers on negative trials ( $M = .07$  and  $M = .05$ , respectively).

*Thematic similarity ratings.* Both skilled and less skilled readers rated stories in the same-theme condition as more similar ( $M = 4.43$  and  $M = 4.26$ , respectively) than stories in the different-theme condition ( $M = 2.31$  and  $M = 2.58$ , respectively),  $F(1,102) = 338.62$ . In addition, the two groups showed no differences in their ratings of stories in either condition (both  $F_s < 1$ ).

The purpose of this experiment was to in-

vestigate skilled and less skilled readers' ability to construct representations that include connections among elements within a story. Our data indicate that skilled readers made within-story connections that were not made by less skilled readers. Skilled readers exhibited faster responses to targets in the within- than in the between-story priming condition, whereas less skilled readers showed no response differences. One explanation for less skilled readers' failure to make the within-story connections is that they failed to recall the information on which these connections were based. However, the error data suggest that this was not the case. Although they made more errors than did skilled readers, their error rates were very low. This is consistent with Oakhill's (1982) claim that less skilled readers recall the ideas in a text even though they fail to form connections among them (see also Oakhill et al., 1988).

Not only did less skilled readers fail to make within-story connections, they also failed to make connections between stories that were thematically related. Thematic similarity had no effect on less skilled readers' responses to the target sentences. In contrast, skilled readers exhibited a thematic priming effect, faster responses to targets in the same- than in the different-theme condition. Less skilled readers' failure to form memory connections among related stories is particularly interesting in light of data suggesting that they were sensitive to the stories' thematic similarity. We found no difference between less skilled and skilled readers' ratings; both groups gave higher similarity ratings to stories in the same- than in the different-theme condition. Thus, less skilled readers appeared to recognize the thematic similarity of the stories, but failed to incorporate this knowledge into their memory representations.

#### GENERAL DISCUSSION

Are there readers who systematically fail to make inferences even though they have adequate reading ability and sufficient knowledge to do so? The results of these and several other studies converge to suggest that the answer to

this question is "yes." (Long et al., 1994; Oakhill, 1982, 1984, 1994; Oakhill et al., 1988). When we examined skilled and less skilled readers' representations of simple sentences and brief passages, we saw remarkable similarities. Both groups (a) exhibited evidence for the propositional structure of their sentence representations, (b) constructed representations that were consistent with the context-appropriate senses of ambiguous words, and (c) accomplished sense selection within the same time frame (Long et al., 1994).

This situation changed, however, when we examined skilled and less skilled readers' text-level representations. We found differences in their ability to integrate information from different parts of a story and their ability to elaborate their representations with topic-related information. Skilled, but not less skilled, readers made connections between the setup and conclusion of a story. In addition, skilled readers made topic-related inferences in response to brief passages that less skilled readers did not make. These differences occurred in spite of similarities in skilled and less skilled readers' knowledge about the texts. Both groups provided similar responses when they were asked to identify the topics of brief passages and to rate the similarity of thematically related stories. Thus, less skilled readers appeared to possess adequate knowledge about the passage topics even though they failed to incorporate this knowledge into their text-level representations.

We should mention that the less skilled readers who participated in our experiments were not a well-defined group. We identified these readers on the basis of their performance on the verbal SAT, a measure that is correlated with reading ability, but one that is also sensitive to other factors. This makes it likely that we included at least two types of less skilled readers in our study. One type is commonly called "garden variety" poor readers. These readers score low on measures of reading ability as well as measures of overall ability (e.g., IQ tests). The second type conforms to the traditional definition of dyslexia. These readers score low on measures of reading ability,

but score average or above average on measures of overall ability. If dyslexics have reading problems that are different from those of garden variety poor readers, then this raises the possibility that our results apply to one group and not to the other. Although this may certainly be the case, recent evidence has challenged the theoretical and empirical distinction between these two groups (Bell & Perfetti, 1994; Stanovich, 1994a, 1994b). Bell and Perfetti (1994) found negligible differences in the component reading abilities exhibited by adult dyslexics and garden variety poor readers. Similarly, Stanovich (1994a) found little empirical evidence to support the distinction among reading-disabled children. Dyslexics cannot be distinguished from garden variety poor readers on the basis of (a) word recognition subskills, (b) core information processing deficits, or (c) neuroanatomical profiles. Further research will be necessary to determine whether the performance patterns that we have reported here are characteristic of both types of less skilled readers.

We have argued that the less skilled readers in this study constructed reasonably accurate sentence-level representations and possessed adequate knowledge about the topics of our texts. Why then did they fail to elaborate their representations with topic-related information? One possibility is that these readers have some deficit that is specific to the ability to make inferences. However, this claim is not entirely supported by our results. As we mentioned above, less skilled readers provided appropriate topic words for the passages and recognized the thematic similarity of stories. This suggests that they *can* make such inferences; they are simply less likely than skilled readers to do so during comprehension.

Recently, Pearlmutter and MacDonald (1995) reported an analogous finding in a study of working memory capacity and syntactic ambiguity resolution. They examined the use of probabilistic constraints in ambiguity resolution as a function of individual differences in reading span. High and low span subjects were asked to rate the relative plausibility of various interpretations of a syntacti-

cally ambiguous verb. Their judgments reflected comparable sensitivity to the probabilistic information. However, the likelihood that subjects used this information during comprehension increased as a function of reading span. High span subjects read syntactically ambiguous sentences more slowly than nonambiguous control sentences, whereas low span subjects showed no reading time differences. Thus, low span readers possessed knowledge about the relative plausibility of alternative interpretations of syntactic ambiguities, but failed to use this knowledge during comprehension.<sup>1</sup>

Pearlmutter and MacDonald (1995) proposed an explanation for low span readers' failure to use probabilistic constraints during reading that may also explain less skilled readers' failure to integrate story ideas and to make inferences during reading. They suggest that access to knowledge about contextual constraints can be viewed as the activation of combinatorial frequency information. Consider one of their examples. The verb *cooked* has three alternative interpretations in the phrase *The soup cooked*: (1) past tense/active voice/intransitive (e.g., "The soup cooked in the pot but was not ready to eat"), (2) past tense/active voice/transitive (e.g., "The soup cooked the vegetables"), and (3) past participle/passive voice/transitive (e.g., "The soup cooked in the pot was delicious"). They suggest that syntactic plausibility is the relative frequency of these interpretations in the context of the subject noun phrase. That is, plausi-

bility is a function of the frequency of the alternative interpretations of *cooked* in the context of the inanimate noun phrase, *The soup*. According to their view, reading skill, and in particular reading experience, influences the speed with which readers can compute such contextual constraints (e.g., the frequency of a particular interpretation of *cooked* in the context of an inanimate noun phrase like *the soup*). High span readers compute these constraints rapidly and efficiently because they have done so frequently in the past. In contrast, low span subjects compute these constraints slowly because they have encountered them less frequently. Thus, low span readers show sensitivity to these constraints in tasks that allow sufficient computation time (e.g., plausibility judgments), but not in more demanding on-line tasks (e.g., reading time).

We can extend Pearlmutter and MacDonald's (1995) argument to explain less skilled readers' failure to make knowledge-based inferences. Consider the first passage in Table 1. The speed with which subjects can access knowledge about *earthquakes* in the context of this passage may be related to their previous experience computing connections among ideas such as buildings, collapse, danger, natural disasters, and earthquakes. Less skilled readers may eventually access such information; however, they may not do so soon enough to influence their performance on time-constrained tasks.

Although this explanation for less skilled readers' inference problems is speculative, it is consistent with several processing limitation accounts of poor comprehension (Just & Carpenter, 1992; Perfetti, 1985, 1989, 1994; Perfetti & Lesgold, 1977). For example, Perfetti (1985) has argued that inefficient verbal skills in combination with working memory limitations give rise to processing bottlenecks. In particular, he has emphasized the bottleneck that results from inefficient processes at the word-level. However, inefficient word recognition processes alone do not appear to explain the inference problems exhibited by college-aged less skilled readers. Although they may have less efficient word recognition skills than

<sup>1</sup> It may seem odd that Pearlmutter and MacDonald (1995) found differences in ambiguity resolution as a function of reading span, whereas we found no differences as a function of reading skill. However, Pearlmutter and MacDonald's materials differed from ours in one very important respect. In their study, disambiguating information always followed the ambiguous word, whereas this information always preceded the ambiguity in our studies. Just and Carpenter (1992) have argued that less skilled readers do not have the working memory resources to hold multiple interpretations in memory. Thus, they are forced to choose an interpretation immediately. This is no problem when the disambiguating context precedes the ambiguity, but may lead to difficulty when the context follows it.

do skilled readers, this did not influence their ability to perform tasks that were sensitive to the underlying structure of their propositional representations. Differences between the two groups were observed only on tasks that were sensitive to more elaborative processing. We suggest that an important bottleneck among less skilled adult readers occurs at the discourse level. These readers have word- and sentence-level skills that are sufficient to construct fairly accurate propositional representations of sentences. However, they fail to execute processes necessary to integrate ideas from different parts of a text and to make inferences to elaborate their text representations. Further research will be necessary to determine whether frequency of exposure to language constraints is a major source of individual differences in inferential processing.

#### APPENDIX

##### *TAU 1: "The Cure Is Worse Than the Disease"*

###### *Story A*

Jenny was born with a small red birthmark on her jaw. No one had ever noticed it but she was afraid that it was visible in strong sunlight. She went to a dermatologist and insisted that he do something to remove the mark. The doctor told her that laser treatment might remove some of the redness. Jenny decided to undergo the treatment even though her health insurance would not pay the cost and she would have to take a second job. Although the treatment did make the mark a little less red, it was incredibly painful and left a noticeable scar.

###### *Story B*

John was a handsome young executive and was proud of his good looks. He was especially fond of his full head of dark, wavy hair. Therefore, he was very worried about the few strands of gray hair that were appearing. He heard about a cream that was supposed to prevent premature graying. John used the cream and had an unfortunate allergic reaction. All

of his hair fell out and his scalp broke out in blotchy sores.

##### *TAU 2: "The Blind Leading the Blind"*

###### *Story C*

Matt got in his car to go to work one morning, but the car wouldn't start. Matt knew nothing about cars, so he started back toward the house to call a mechanic. On his way, he spotted his neighbor, Scott. Scott used to be a car mechanic before he was fired for incompetence. Matt asked Scott to take a look at his car and see if he could spot the problem. Scott opened up the hood of Matt's car and tinkered around for awhile. Scott finally got the car started. Unfortunately, the car blew up two days later.

##### *Example Test Sentences*

###### *Same-Theme Condition*

Prime: Conclusion from Story A—TAU 1  
 "The treatment reduced the redness but left a noticeable scar."

Target: Conclusion from Story B—TAU 1  
 "His hair fell out and his scalp broke out in blotchy sores."

###### *Different-Theme Condition*

Prime: Conclusion from Story C—TAU 2  
 "The car blew up two days later."

Target: Conclusion from Story B—TAU 1  
 "His hair fell out and his scalp broke out in blotchy sores."

###### *Within-Story Condition*

Prime: Setup from Story B—TAU 1  
 "John was very worried about his few strands of gray."

Target: Conclusion from Story B—TAU 1  
 "His hair fell out and his scalp broke out in blotchy sores."

###### *Between-Story Condition*

Prime: Setup from Story C—TAU 2  
 "Matt's car wouldn't start one morning."

Target: Conclusion from Story B—TAU 1

“His hair fell out and his scalp broke out in blotchy sores.”

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(Received October 13, 1995)

(Revision received March 19, 1996)