

Updating a Mental Model: Maintaining Both Local and Global Coherence

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In 2 experiments we investigated whether readers experience comprehension difficulty when they read texts in which local coherence is maintained but global incoherence is introduced. Ss read passages containing an elaborate description of a main character presented early in the text that was inconsistent with actions carried out by the main character later in the text. In Experiment 1, reading times for critical sentences were significantly longer when the earlier description and the critical sentences were inconsistent. In Experiment 2, resolution of global inconsistencies improved memory for the regions of the text that involved the inconsistencies. The results are discussed within a mental model approach to comprehension in which readers attempt to maintain both local and global coherence.

Most current models of reading comprehension assume that readers generate at least two levels of representation of a text, a text-based representation and a situational or mental model (e.g., Johnson-Laird, 1983; Just & Carpenter, 1987; van Dijk & Kintsch, 1983). Because of limited-capacity constraints, the construction of these levels of representation is assumed to be an incremental process in which text is processed over a series of cycles, with only a small portion of text processed on each cycle (e.g., Garnham & Oakhill, 1992; Kintsch & van Dijk, 1978; Sanford & Garrod, 1981; van Dijk & Kintsch, 1983). On the basis of the reader's comprehension strategy, a subset of information is selected and maintained in focus (or short-term memory) to facilitate the integration or mapping of new information onto the existing representation (e.g., Fletcher, 1981; 1986). Because the ease and success of this mapping process is heavily dependent on the selection of an effective strategy for maintaining information in focus, considerable research has addressed the type of strategies that readers may use (e.g., Fletcher, 1981; 1986; Glenberg, Meyer, & Lindem, 1987). A primary goal for models of comprehension is to specify the relation between the comprehension strategies and the mapping process.

The mapping process can be broken down into processes designed to establish both local and global coherence (e.g., Glenberg & Langston, 1992; Kintsch & van Dijk, 1978; McKoon & Ratcliff, 1992; O'Brien & Albrecht, 1992; van Dijk & Kintsch, 1983). Local coherence involves connecting the currently processed information with the immediately

preceding context (i.e., information in short-term memory, generally the previous one to three sentences), whereas global coherence involves establishing connections between currently processed information and information occurring much earlier in the text that should no longer (on the basis of local coherence strategies) be available in short-term memory but is relevant to the currently processed information (e.g., McKoon & Ratcliff, 1992). The goal of the present article is to further examine comprehension strategies and maintenance of global coherence during comprehension.

Models of comprehension differ in the degree to which they hypothesize that readers establish local and global coherence (e.g., Fletcher & Bloom, 1988; Garnham, Oakhill, & Johnson-Laird, 1982; Glenberg & Langston, 1992; McKoon & Ratcliff, 1992; O'Brien & Albrecht, 1992). Several models propose that readers are primarily concerned with maintaining local coherence; readers use global information and establish global coherence only under special circumstances, such as when local coherence strategies fail (e.g., Fletcher & Bloom, 1988; McKoon & Ratcliff, 1992). For example, McKoon and Ratcliff proposed the minimalist hypothesis, which states that readers establish connections between the currently processed information and propositions that are in short-term memory. Readers will only establish connections between the currently processed information and information from long-term memory when there is a local coherence break or when global information (or world knowledge) is readily available. McKoon and Ratcliff tested this hypothesis by having subjects read passages that contained either global or local inconsistencies. In the globally inconsistent passages, the target sentence was always locally coherent. That is, it could always be integrated with the immediately preceding sentences but was inconsistent with the global goal information that was presented several sentences earlier. For example, in an initial sentence subjects read, "[Curtis's] arm was healing from an injury and needed a workout before the big match" (McKoon & Ratcliff, 1992, p. 450). Then following three intervening sentences they read, "So Curtis decided to go home and study videotapes of his serve instead" (McKoon & Ratcliff, 1992, p. 450). In the locally inconsis-

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tent passages, the target sentence was inconsistent with the immediately preceding sentence. For example, after several introduction sentences, subjects read "Diane's bike was broken and she couldn't afford a new one. So she went to the grocery store to buy grapefruit and yogurt" (McKoon & Ratcliff, 1992, p. 450). In this condition, there was a local coherence break, and global goal information was necessary to establish coherence (i.e., Diane was trying to lose weight). McKoon and Ratcliff found faster recognition times to global goal information following inconsistent passages, but only when there was a local coherence break. McKoon and Ratcliff interpreted these results as support for the claim that readers do not automatically establish or maintain global coherence.

In contrast to models that emphasize the maintenance of local coherence, several other models suggest that readers routinely check and establish both local and global coherence (e.g., Garnham et al., 1982; Glenberg & Langston, 1992; O'Brien & Albrecht, 1992; Trabasso & Sperry, 1985). According to these models, readers map incoming information onto information active in memory (i.e., local processing) and onto relevant information no longer active in memory (i.e., global processing; e.g., Glenberg & Langston, 1992; O'Brien & Albrecht, 1992). For example, Sanford and Garrod (1981; Garrod & Sanford, 1988; 1990) proposed a model in which a subset of information is maintained in explicit focus and other information relevant to the discourse situation is maintained in implicit focus; incoming information is mapped onto information that is currently held in active memory (i.e., in explicit focus) and onto information that is relevant to the situation (i.e., in implicit focus).

More recently, Glenberg and Langston (1992) extended this process model to describe other discourse phenomena and to incorporate general models of memory. Specifically, they proposed that representational elements (or tokens) are maintained in focus (or "foregrounded") and serve as discourse pointers to information no longer active in memory.¹ Information that is in focus primes contextually relevant information in long-term memory through a resonance process (e.g., Gillund & Shiffrin, 1984; Hintzman, 1986). Thus, when incoming text is integrated with information in focus, contextually relevant information in long-term memory is also connected to new information. In this way, new information is mapped onto relevant information in both active memory and long-term memory. As Glenberg and Langston pointed out, such a mechanism is quite powerful because it allows the reader to check and maintain coherence at both a local level (e.g., against information in focus) and a global level (e.g., against relevant information in long-term memory). This contrasts with the minimalist hypothesis and many text-based strategies, which check global coherence only when local coherence strategies have failed.

An important test of models that emphasize maintenance of global coherence is demonstrating that readers are sensitive to global inconsistencies when local coherence is maintained. Recently, O'Brien and Albrecht (1992) found that global inconsistencies are detected even when local coherence is maintained. They presented subjects with passages in which an initial sentence placed a protagonist in a particular

location (e.g., inside or outside a building). After several background sentences, subjects read a second sentence that was either consistent with or in violation of the initially stated location of the protagonist. The passages were written so that the second location sentence could be integrated with the immediately preceding text without making reference to the initially stated location of the protagonist. That is, the second location sentence was locally coherent but globally incoherent. O'Brien and Albrecht found that when the second location sentence violated the initially stated location of the protagonist, subjects experienced comprehension difficulty even though the second sentence was locally coherent.

Although O'Brien and Albrecht's (1992) results support models emphasizing the maintenance of global coherence, their results are inconsistent with other models, such as the minimalist hypothesis. The present set of experiments was designed to further examine whether readers attempt to maintain global coherence. Previous work has demonstrated that readers remain sensitive to the location of the protagonist as well as to information that is spatially relevant to the main character of a text (e.g., Glenberg et al., 1987; Morrow, Bower, & Greenspan, 1989; Morrow, Greenspan, & Bower, 1987; O'Brien & Albrecht, 1992). However, the memory representation (e.g., a mental model) is assumed to contain more than just spatial-location information. The representation should also include information concerning other aspects of the protagonist such as attitudes, beliefs, and physical characteristics. Experiment 1 was designed to determine whether readers attempt to map newly learned information relevant to the character of the protagonist onto the established representation of the protagonist even when the characteristics of the protagonist are no longer in focus (i.e., the foreground). In Experiment 2, we examined the impact on subsequent recall of attempting to map information that is inconsistent with the protagonist.

Experiment 1

The passages used in Experiment 1 began with the introduction of a main character followed by an elaboration of some characteristic of the main character. Immediately following this, there was a shift in topic back to the story line in the introduction; the main character was mentioned and referred to throughout the remainder of the passage, but there

¹ The information pointed to in long-term memory and the information in implicit focus seem to serve the same function; they provide relevant information onto which new information can be mapped during construction of the memory representation. Although the information in implicit focus is not as active as information in explicit focus, the information is more active than other situation-irrelevant information from long-term memory. Further research is required to determine whether the information in implicit focus is more available because (a) it has a higher level of activation than other irrelevant information or (b) it is easier to retrieve via the discourse pointers. In the remainder of this article, we use the term *implicit focus* to refer to situation-relevant information that is not maintained in explicit focus (i.e., active in memory).

was no reference to the elaborated characteristic until the critical sentences were encountered. In the critical sentences, the main character was described as engaging in some action that was consistent, inconsistent, or unrelated to the earlier elaboration.

For example, consider the first passage in the Appendix. The critical sentences are "He quickly ran and picked the boy up. Bill carried the boy over to the curb." In the consistent condition the main character, Bill, is described as young, strong, and in top physical shape. The action of running into the street is highly consistent with the physical attributes provided earlier in the text. In the inconsistent condition Bill is described as very old and weak. Given this description of Bill, it is unlikely that he would be capable of running into the street and lifting the young boy. However, it is important to note that there are no constraints making this action impossible for Bill to complete, just very unlikely. Finally, in the neutral condition some aspect of the surrounding situation is elaborated (e.g., the neighborhood where Bill lived) rather than some characteristic of Bill, which thereby leaves the critical sentences neutral with respect to the characteristics of Bill.

According to strategies that emphasize local coherence, information from the elaboration section should affect reading times for the critical sentences only if that information is (a) in short-term memory when the critical sentence is encountered or (b) required to resolve a local coherence break involving the critical sentences. We ensured that neither condition existed in the current set of materials by analyzing each passage using both the leading-edge strategy (e.g., Kintsch & van Dijk, 1978) and the current-state selection strategy (e.g., Fletcher & Bloom, 1988). When we used the leading-edge strategy, each passage was broken down into propositions and cycled through the process model proposed by Kintsch and van Dijk (1978). For the current-state selection strategy, each passage was broken down into idea units and cycled through the process model proposed by Fletcher and Bloom.² Although the resulting representational structure for the elaboration sections differed across conditions for each passage, the analyses confirmed that the elaborated information was not predicted to be available when the critical sentences were encountered. Also, the analyses ensured that the critical sentences could always be integrated with the current contents of active memory.³

Local coherence of the critical sentences was also checked with the criterion proposed by McKoon and Ratcliff (1992); each pair of critical sentences along with the sentence that preceded them were checked to ensure that they could stand on their own, that is, that they could be understood without making reference to earlier parts of the passage. On the basis of these different measures of local coherence, the current set of passages maintained local coherence when the critical sentences were encountered and the elaboration information was not predicted to be available when the critical sentences were encountered. If local coherence is sufficient for comprehension, then readers should not experience difficulty integrating information from the critical sentences with information in active memory; reading times for the critical sentences

following the consistent, inconsistent, and neutral elaborations should not differ.

Alternatively, if readers maintain coherence at both a local and a global level, readers should notice global inconsistencies. For example, readers may adopt a strategy in which the protagonist is maintained in explicit focus. Whenever new information relevant to the protagonist is encountered, it is checked against or mapped onto the information currently in explicit focus and the relevant information in implicit focus. If this strategy is correct, then readers should maintain the protagonist in explicit focus while maintaining the characteristics of the protagonist in implicit focus. In conditions where the established characteristics of the protagonist are inconsistent with the later actions of the protagonist, the reader should have difficulty mapping those actions onto the characteristics in implicit focus, and comprehension difficulty should occur; reading times for the critical sentence following the inconsistent elaboration should be longer than reading times for the critical sentence following the consistent and neutral elaborations.

Method

Subjects. Subjects were 30 University of New Hampshire undergraduate students enrolled in Introductory Psychology. Subjects received class credit for their participation.

Materials. The materials were 18 narrative passages. Two example passages are presented in the Appendix. Each passage was divided into five sections; introduction, elaboration, filler information, two critical sentences, and conclusion. Each passage began with two to three introductory sentences that served to introduce the main character and the situation. Immediately following the introduction, one of three elaboration conditions was presented: consistent, inconsistent, or neutral. The elaboration conditions were composed of two to five sentences with average word lengths of 44.61, 44.89, and 44.83 words for the consistent, inconsistent, and neutral conditions, respectively. The consistent elaboration section contained characteristics of the protagonist that would support the execution of the actions described in the two critical sentences. The inconsistent elaboration section presented characteristics that conflicted with the execution of these

² When the leading-edge strategy was used, the number of propositions that could be input on any one cycle varied between four and seven. The short-term memory buffer was set at three propositions. These parameter estimates are within the range proposed by Kintsch and Vipond (1979) and Miller and Kintsch (1980). With the current-state selection strategy, the number of propositions active in memory at any one time is determined by the text. The last causal antecedent without a causal consequence was maintained on each processing cycle. When this criterion was used, the number of propositions maintained at any one time varied between one and three.

³ In addition, the text analyses were conducted to ensure that there were no coherence breaks when the critical sentences were encountered. On the basis of the analyses, three passages were predicted to have coherence breaks when the critical sentences were encountered. However, the coherence breaks were predicted to occur in all conditions and could be resolved with a proposition or idea unit from the preceding cycle. An examination of the data revealed the same pattern of results for the passages with coherence breaks and the passages without coherence breaks.

actions. Finally, the neutral elaboration section did not contain any information relevant to characteristics of the main character, but rather, elaborated on some other component of the text situation.

After the elaboration, there were six filler sentences that shifted the focus of the passage away from the elaborated characteristics but continued the story line developed in the introductory sentences. The filler was included to ensure that at a local level, the propositions containing the characteristics of the protagonist were no longer in active memory. After the filler sentences, the two critical sentences occurred. The mean lengths of the first and second critical sentences were 38.5 and 38.3 characters, respectively. The second critical sentence always immediately followed the first critical sentence and was included to detect possible carryover effects from the first critical sentence.

Finally, the last section of each passage was the conclusion, which was composed of two to three sentences. Passages ranged in length from 20 to 24 lines, with a mean of 22.67 lines. Each line was no longer than 53 characters and ended with a complete word (although not necessarily with a complete phrase or sentence). Three material sets were constructed; each set contained six passages in each of the three conditions. Across the three sets, each passage occurred in each of the three conditions. For each passage, the only difference across conditions was in the elaboration sections. A comprehension question followed each passage to ensure that subjects were carefully reading each passage for comprehension. The questions did not address information concerning characteristics of the protagonist.

Procedure. Subjects were randomly assigned to one of three stimulus sets. Each subject participated individually in a session that lasted approximately 35 min. All materials were presented on a video monitor controlled by a Zenith Z-100 microcomputer. Subjects were instructed to rest their right thumbs on a line-advance key, their right index fingers on a *yes* key, and their left index fingers on a *no* key. Each trial began with the word *Ready* at the center of the display. When subjects were ready to read a passage, they pressed the line-advance key. Each press of the key erased the current line and presented the next line. Comprehension time was the time between key presses. Each subject was instructed to read at a normal, comfortable pace. At the end of each passage, a press of the line-advance key presented the cue *Questions* for 2,000 ms. This was followed by a comprehension question. Subjects were instructed to respond to the question by pressing either the *yes* or *no* key. Subjects were instructed that answering the question was the most important part of their task and that they should be prepared to answer as quickly and as accurately as possible. On those trials where subjects made errors, the response was followed by the word *Error* for 750 ms. There were three practice passages at the beginning of each session to ensure that subjects understood the procedure.

Results and Discussion

The reading times for the critical sentences were recorded. Reading times that were three standard deviations from the mean were discarded. This eliminated approximately 1.0% of the data. In both experiments reported in this article, F_1 refers to tests against an error term based on subject variability and F_2 refers to tests against an error term based on item variability. All analyses reported are significant at the .05 alpha level unless otherwise indicated. All planned comparisons used the Bonferroni procedure with a familywise

error rate of .05 to protect against an increased probability of Type I errors.

The reading times for the critical lines are presented in Table 1. Separate analyses of variance (ANOVAs), were conducted on the first and second critical sentences. Because the pattern of results for the first and second critical sentences did not differ, they are presented together. Critical sentences were read more slowly when they followed the inconsistent elaboration than when they followed the consistent and neutral elaborations: $F_1(2, 54) = 17.26$, $MS_e = 50,771.39$, $F_2(2, 30) = 11.09$, $MS_e = 50,471.35$, (first sentence); $F_1(2, 54) = 7.82$, $MS_e = 32,718.11$, $F_2(2, 30) = 5.22$, $MS_e = 29,123.10$ (second sentence). Planned comparisons confirmed that reading times were longer after inconsistent elaboration than they were after both consistent, $t(29) = 5.02$ (first sentence), $t(29) = 4.10$ (second sentence), and neutral elaborations, $t(29) = 4.03$ (first sentence), and $t(29) = 2.67$ (second sentence). The small reading time advantage for the consistent over the neutral elaboration was not significant ($t < 1.0$).

Despite the fact that the passages were always locally coherent, subjects experienced comprehension difficulty when the critical sentences were in the inconsistent condition. These results support previous findings which showed that strategies that rely primarily on local coherence may not completely capture the nature of comprehension strategies used by readers (e.g., Glenberg & Langston, 1992; O'Brien & Albrecht, 1992; van Dijk & Kintsch, 1983). The current findings are more compatible with a strategy in which the reader checks both local and global coherence in an attempt to construct a single coherent representation (e.g., a mental model) around the main character (e.g., Garrod & Sanford, 1988). When the reader encounters new information relevant to the main character, that information is mapped onto information in explicit focus and onto other information already known about the main character that is in implicit focus. When new information is inconsistent with the established representation, comprehension difficulty will occur, even when local coherence is maintained.

Experiment 2

The reading time results from Experiment 1 confirmed that subjects experienced comprehension difficulty in the inconsistent condition. O'Brien and Myers (1985) found that when readers experience comprehension difficulty that can be resolved, there is a benefit in subsequent recall for the inconsistent information and for information occurring before the

Table 1
Mean Reading Times (in Milliseconds) for Critical Sentences 1 and 2 as a Function of Passage Condition in Experiment 1

Critical sentence	Passage condition		
	Consistent	Inconsistent	Neutral
First	2,010	2,319	2,039
Second	1,971	2,143	1,997
<i>M</i>	1,990	2,231	2,018

inconsistency (see also Keenan, Baillet, & Brown, 1984; Myers, Shinjo, & Duffy, 1987). O'Brien and Myers suggested that the memory benefit was the result of readers' attempting to resolve the difficulty by reprocessing earlier parts of the text; reprocessing produces greater integration and a larger number of retrieval routes, which lead to better memory performance.

In Experiment 2 we investigated the impact of presenting inconsistent information about characteristics of the main character on subjects' ability to recall that information. The design for Experiment 2 was identical to that of Experiment 1 with the addition of an incidental recall phase. As in Experiment 1, subjects should experience comprehension difficulty when reading passages in the inconsistent condition. On the basis of O'Brien and Myers's (1985) reprocessing hypothesis, specific predictions can be made about the effect of inconsistent information on recall performance. If the comprehension difficulty occurs because of a disruption in the mapping process between the critical sentences and global information, then only information relevant to the comprehension difficulty should be affected in subsequent recall. That is, only the critical sentences and the descriptions of the main character that occurred much earlier in the passages should be affected in recall; no other portions of the passage should be affected. Because local coherence was maintained in all conditions, a comprehension strategy based on local coherence could not predict the comprehension difficulty effects established in Experiment 1. Thus, no a priori predictions concerning recall performance based on a local coherence strategy can be made.

Method

Subjects. The subjects were 45 University of New Hampshire undergraduates enrolled in Introductory Psychology who received course credit for their participation.

Materials. The materials were the same set of passages used in Experiment 1.

Procedure. The procedure was the same as in Experiment 1 with the following exceptions. Subjects were not told about the recall phase; they were simply told that the experiment was composed of two parts. After subjects completed the reading phase of the experiment, they were given recall booklets. Each page of the booklet provided a recall cue for a particular passage. The cue for each passage was a phrase or paraphrase from the introduction of the passage. For example, the recall cue for the first passage in the Appendix was "Bill taking his morning walks." The passages were recalled in the same order that they were read. Subjects were instructed to recall all that they could about each passage; once the subjects finished the recall exercise for a given passage and turned the page, they were asked not to return to the previous pages.

Results

Reading times. As in Experiment 1, reading times that were more than three standard deviations from the mean were discarded, which eliminated less than 2% of the data.

The reading times for the critical sentences are presented in Table 2. Separate ANOVAs for the first and second critical sentences produced the same pattern of results

Table 2
Mean Reading Time (in Milliseconds) for Critical Sentences 1 and 2 as a Function of Passage Condition in Experiment 2

Critical sentence	Passage condition		
	Consistent	Inconsistent	Neutral
First	1,983	2,293	2,054
Second	1,911	2,053	1,965
<i>M</i>	1,947	2,173	2,009

and are presented together. As in Experiment 1, critical sentences were read more slowly when they followed inconsistent elaborations than when they followed consistent or neutral elaborations: $F_1(2, 84) = 19.28$, $MS_e = 61,529.62$, $F_2(2, 30) = 15.01$, $MS_e = 33,402.90$ (first sentence); $F_1(2, 84) = 6.17$, $MS_e = 37,418.60$, $F_2(2, 30) = 3.76$, $MS_e = 23,074.88$ (second sentence). Planned comparisons confirmed that reading times for the critical sentences were longer after the inconsistent elaboration than they were after both the consistent, $t(44) = 5.45$ (first sentence), $t(44) = 3.58$ (second sentence) and neutral elaborations, $t(44) = 4.04$ (first sentence), $t(44) = 2.15$ (second sentence). Although reading times that followed the consistent elaboration were shorter than reading times that followed the neutral elaboration, this difference did not reach significance, $t(44) = 1.81$, $p > .07$ (first sentence), and $t(44) = 1.24$, $p > .22$ (second sentence).

Recall. Each passage was broken down into idea units (e.g., Trabasso & Sperry, 1985). A lenient scoring criterion was used such that subjects were given credit for an idea unit if their recall captured the meaning of the respective idea unit. Two independent raters scored the recall; interrater reliability was .90. The disagreements in recall were resolved by two additional raters. The idea units for each passage were grouped into the following regions: introduction, elaboration, filler, Critical Sentence 1, Critical Sentence 2, and closing. Because each passage was composed of a different number of idea units, all analyses were conducted on the proportion of idea units recalled. Table 3 presents the proportion of idea units recalled as a function of condition and region of the passage. Separate ANOVAs were performed on

Table 3
Mean Proportion of Idea Units Recalled as a Function of Passage Condition and Location in the Passage in Experiment 2

Location in the passage	Passage condition		
	Consistent	Inconsistent	Neutral
Introduction	.266	.288	.300
Elaboration	.318	.352	.289
Filler information	.287	.307	.288
Critical sentence 1	.678	.774	.622
Critical sentence 2	.344	.326	.363
Close	.287	.280	.271
Total proportion recall	.307	.328	.300
Proportion of passages showing recall	.930	.948	.944

each region of the passage and the overall proportion of units recalled.

Across the three conditions, there were no reliable differences in the proportions of passages from which subjects showed some recall ($p > .55$). However, there was significant variability in the proportions of total number of idea units recalled across the three conditions, $F_1(2, 84) = 4.18$, $MS_e = 0.002$. Planned comparisons confirmed that a larger proportion of idea units were recalled from passages in the inconsistent condition than from passages in either the consistent, $t(44) = 2.08$, or neutral conditions, $t(44) = 2.70$. The total proportions of idea units recalled in the consistent and neutral conditions did not differ reliably, $t(44) = 0.58$, $p > .50$.

When examining the individual regions of the passages, we found that there were no reliable differences in the proportions of idea units recalled from the introductory portion of the passages, the filler sentences, the second critical sentence, or the closing sentences ($p > .20$ in all cases). However, there was significant variability in recall of elaboration regions, $F_1(2, 84) = 6.17$, $MS_e = 0.007$, and of the first critical sentence, $F_1(2, 84) = 9.08$, $MS_e = 0.029$. Specifically, the elaboration region was better recalled in the inconsistent condition than in either the consistent, $t(44) = 2.20$, or neutral conditions, $t(44) = 3.39$. Although the consistent elaboration region was recalled better than the neutral elaboration region, the difference did not reach significance, $t(44) = 1.49$, $p > .14$. Similarly, a greater proportion of the first critical sentences were recalled after the inconsistent elaboration than after the consistent, $t(44) = 2.89$, or neutral, $t(44) = 3.80$, elaborations. Recall of the critical sentences was better after the consistent elaboration than after the neutral elaboration, but this difference did not reach significance, $t(44) = 1.59$, $p > .11$.

Discussion

The present results replicate and extend the findings of Experiment 1. Reading times for critical sentences that followed the inconsistent elaboration were longer than reading times for the same sentences when they followed either consistent or neutral elaboration. The differences in reading times for the second critical sentence followed the same pattern, but as in Experiment 1, the differences across conditions were reduced. The increased reading times on both the first and second critical sentences in the inconsistent condition suggest that readers were attempting to resolve the inconsistency by reprocessing earlier parts of the text and that this processing carried over into the second critical sentence.

The recall results offer additional evidence that subjects were reprocessing earlier parts of text to integrate the target sentences. Because the inconsistency centered around the elaboration and the first critical sentence, the reprocessing and subsequent memory benefit should have occurred primarily for those two sections of the passages. As the recall results confirmed, there were more units recalled from the elaboration region and the first critical sentence after the inconsistent condition than from the same regions after the consistent and neutral conditions. Furthermore, according to

the reprocessing hypothesis, the increase in reading time for the first critical sentence in the inconsistent condition should be accompanied by an increase in recall for information from the elaboration region. We explored this possibility by computing the correlation between reading time for the first critical sentence and recall of the elaboration region separately for each of the elaboration conditions. The correlation for the inconsistent condition reached significance, $r(43) = .36$, $p < .05$, but the correlations for the consistent and neutral conditions did not ($r < .20$).

The recall results also suggest that the increased reading times for the second critical sentence may be partly due to carryover effects. Unlike the first critical sentence, the second critical sentence received significantly longer reading times after the inconsistent elaboration, but there was no increase (in fact there was a slight decrease) in the proportion of units recalled. Taken together, the reading times and the recall for the first and second critical sentences suggest that comprehension difficulties that can be resolved can improve memory for the portions of text that initiate and are involved in reprocessing (i.e., the first critical sentence and the elaboration). But, because of the high-capacity demands of such reprocessing, memory for text immediately following the initial point of comprehension difficulty may actually suffer (i.e., the second critical sentence).

Although the current results are consistent with the claim that readers are reprocessing earlier parts of the text in an attempt to resolve the inconsistency, the results do not demonstrate that readers have actually resolved the inconsistency. It is possible that when the inconsistency is encountered, readers tag the information involved in the inconsistency, and that at retrieval, the tagged information is more easily recalled. However, in either case, some form of reprocessing (i.e., resulting in a greater number of connections or in tagging inconsistent information) seems necessary in the inconsistent condition.

General Discussion

The current set of results add to a growing body of literature that suggests that in comprehending narrative texts, readers attempt to maintain coherence at both a local and a global level (e.g., Garrod & Sanford, 1988; 1990; Gernsbacher, 1990; Glenberg & Langston, 1992; Huitema, Dopkins, Klin, & Myers, 1993; O'Brien & Albrecht, 1992; van Dijk & Kintsch, 1983). In both Experiments 1 and 2 subjects experienced comprehension difficulty when they read critical sentences that were inconsistent with already established characteristics of the protagonist. This difficulty occurred even though the critical sentences were locally coherent and the critical characteristics of the protagonist were not available according to local coherence strategies such as the leading-edge strategy (Kintsch & van Dijk, 1978), the current-state-selection strategy (Fletcher & Bloom, 1988), or the minimalist hypothesis (McKoon & Ratcliff, 1992).

The comprehension difficulty occurred presumably because readers recognized the inconsistency between an established characteristic of the protagonist (e.g., Bill was old

and weak) and the critical sentence (e.g., "Bill quickly ran and picked the boy up."), and they needed to engage in some sort of inferential process to attempt to reestablish coherence. That readers had difficulty comprehending the critical sentences in the inconsistent conditions is consistent with the claim that readers attempt to construct a single coherent mental model around the main character or thematic subject (e.g., Garrod & Sanford, 1988; 1990); readers maintain the protagonist (or main character) in explicit focus (i.e., in the foreground) while information relevant to the protagonist is maintained in implicit focus. Incoming information is then used to update the model, which includes the possibility of updating information that is in either explicit or implicit focus. The current findings further support the assumption that along with maintaining the protagonist (or main character) in the foreground of the model, readers also have access to the characteristics or to a general profile of the main character.

Although it would be tempting to conclude that readers have the entire general profile in the foreground during comprehension, the current results do not allow such a conclusion to be drawn. It is possible that readers "foreground" only a subset of information but then check new information against all previously encountered information. For example, Glenberg and Langston (1992) recently proposed that only a subset of information is held in focus and that these elements serve as discourse pointers to information no longer active in memory. When new information is introduced that updates information in focus, it also primes all contextually relevant information in long-term memory through a resonance process. Thus, it is possible that readers hold only some of the general characteristics of the protagonist in focus; when the protagonist is described as engaging in some action, a check between this action and the perceived potential of the individual is carried out. For example, when the reader is told that "Bill carried him to the side of the road," all information relevant to Bill should resonate to varying degrees. Features in the verb *carried* should resonate with and increase the activation of the physical characteristics of "Bill," and thus increase the likelihood that the reader will attempt to map the current information onto the relevant physical characteristics. Or, if a character is described as being a vegetarian and at some later point the reader learns that the character ordered a hamburger, features contained in "ordering a hamburger" should resonate with and prime all information relevant to the eating habits of the character. The reader would need to map "ordering a hamburger" onto the fact that the character was a vegetarian. If we assume that there is such a mechanism, the reader should have access to information in focus as well as to all relevant information from long-term memory, which should thereby allow the reader to maintain both local and global coherence.

The current results also fit nicely with recent work of Gernsbacher and her colleagues (e.g., Gernsbacher, Goldsmith, & Robertson, 1992; Gernsbacher & Robertson, 1992). They found that readers were sensitive to the emotional states of discourse characters, even when those emotional states were never explicitly mentioned. On the basis

of this work and other work being done on developing a mental model, the evolving picture seems to be that in the comprehension of narratives, readers construct a representation around the main character and have access to a general profile of the main character that may include emotional states (e.g., Gernsbacher et al., 1992; Gernsbacher & Robertson, 1992), goal information (e.g., Huitema et al., 1993), location information (e.g., Bower & Morrow, 1990; Morrow et al., 1989; O'Brien & Albrecht, 1992), as well as other information associated with the main character (e.g., Glenberg et al., 1987). Again, this contrasts with a local coherence strategy in which only explicitly stated information from the immediately preceding sentences should be available to influence comprehension (McKoon & Ratcliff, 1992).

Although the current results are consistent with a mental model view of inferencing, they run counter to the minimalist hypothesis recently proposed by McKoon and Ratcliff (1992). Under the minimalist hypothesis, readers should engage in inferential or elaborative processes only when attempting to maintain local coherence or when the information necessary to draw the inference or elaboration is readily available. As long as a text is locally coherent, readers need not draw an inference. A particular sentence is considered to be locally coherent as long as it makes sense in the context of the immediately preceding sentences and does not require contact with earlier parts of a text. On the basis of this criterion for coherence, the critical sentences in the current set of experiments were always locally coherent; they could always be integrated with the immediately preceding sentences, and they never required contact with the earlier presented characteristics of the protagonist. Thus, according to the minimalist hypothesis, the critical sentences should not have been any more difficult to comprehend in the inconsistent condition than they were in either the consistent or neutral conditions.

However, there are two conditions under which the minimalist position could account for these results. First, if we assume that the characteristics of the protagonist are readily available, then the critical sentences could produce comprehension difficulty in the inconsistent condition. But both the leading-edge strategy and the current-state-selection strategy, which are sensitive to local coherence, predicted that this information was not active in memory. Also, according to the local coherence strategy defined by the minimalist position, only the one or two immediately preceding sentences should have been active. Given these criteria, information from the elaboration section should not have been readily available. It should be noted that the use of these criteria constrain the definition of readily available to information that is active in memory. Without such constraints, the minimalist position becomes circular; "readily available" defines any information that a reader makes contact with in the course of comprehension.

A second possibility is that subjects were engaging in some sort of special processing strategy because of specific goals induced by the experiment. However, we can think of no

specific goals that subjects might have had, other than attempting to comprehend the passages, which presumably takes place in most reading situations.⁴

The current set of results appear to contradict McKoon and Ratcliff's (1992) finding that readers do not generally detect global inconsistencies. However, there is one important difference in the way in which the inconsistencies were presented in the two studies. For example, in the current study, readers initially learned that Bill was old and frail and then later read that Bill ran into the street to save a boy. Similarly, in McKoon and Ratcliff's materials, subjects learned that Curtis's arm needed a workout and later read that Curtis had gone home to watch videotapes. However, in McKoon and Ratcliff's materials, the inconsistent action in the target sentence was justified by the immediately preceding sentence. That is, subjects learned immediately before the target sentence that Curtis's opponent did not want to play tennis, which provided a reason or justification for Curtis to go home and watch videotapes. Justifying the action in the target sentence may reduce the degree to which readers perceive the target action as inconsistent with the global goals of the protagonist. Or, it may be that the justification eliminated the inconsistency altogether, in which case there was no global inconsistency to be detected. In contrast, in the present set of materials, there was no information in the filler section of the passages that could serve to justify the inconsistent actions described in the target sentences. Thus, the current set of results confirm that readers attempt to maintain global coherence even when a text is locally coherent. A similar demonstration has been provided by Huitema et al. (1993). That readers attempt to maintain global coherence when it is not necessary (i.e., local coherence is maintained) is inconsistent with the minimalist hypothesis.

Finally, the recall results after Experiment 2 confirmed that subjects were attempting to integrate the critical sentence

⁴ However, one possible strategy is that subjects become increasingly sensitive to inconsistencies as they progress through the experiment. Such a strategy should produce differences in the size of the inconsistency effect for passages from the beginning and the end of the experiment. To ensure that the inconsistency effect did not emerge over time, we analyzed the passages from the first and second half of the experiments separately. For Experiment 1, the mean reading times for the consistent, inconsistent, and neutral passages in the first critical sentence were 2,035, 2,385, and 2,083 ms for the first half of the passages and 1,950, 2,258, and 1,984 ms for the second half of the passages, respectively. Mean reading times for the second critical sentence were 1,982, 2,200, and 2,033 ms for the first half of the passages and 1,957, 2,083, and 1,966 ms for the second half of the passages. The reading times from Experiment 2 produced the same pattern of results. The mean reading times for the consistent, inconsistent, and neutral passages in the first critical sentence were 2,074, 2,360, and 2,076 ms for the first half of the passages and 1,888, 2,220, and 1,976 ms for the second half of the passages, respectively. Mean reading times for the second critical sentence were 1,909, 2,083, and 2,014 for the first half and 1,896, 1,999, and 1,913 ms for the second half. For both Experiments 1 and 2, the size of the inconsistency effect was the same for the first and second halves of the experiment, which provides additional support for the claim that the readers were not adopting special strategies during the experiment.

with the section of the passage that provided a description of the characteristics of the protagonist. Recall of these two sections increased when the critical sentence was inconsistent with the earlier presented characteristics. Several researchers have suggested that when information is encountered that is difficult but not impossible to integrate, the reader will reprocess earlier portions of a text in an attempt to integrate that information (e.g., Duffy, Shinjo, & Myers, 1990; Keenan et al., 1984; Myers et al., 1987; O'Brien & Myers, 1985).

O'Brien and Myers (1985) indicated that one possible concern was that it was difficult to predict exactly when readers would experience this sort of difficulty and which portions of a passage would be affected most from this reprocessing. However, by examining global coherence strategies along the lines proposed by Glenberg and Langston (1992), we may be able to further define when readers will experience comprehension difficulty and to predict more precisely which portions of a text should be affected by that difficulty.

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(Appendix follows on next page)

Appendix

Example Passages from Experiments 1 and 2

The consistent, inconsistent, and neutral conditions were created by using the first, second, and third sets of sentences set off by square brackets. The first and second critical sentences are italicized.

Example Passage 1

Bill had always enjoyed walking in the early morning and this morning was no exception. During his walks, he would stop to talk with some of his neighbors.

[Bill had just celebrated his twenty-fifth birthday. He felt he was in top condition and he worked hard to maintain it. In fact, he began doing additional workouts before and after his walks. He could now complete a 3 mile run with hardly any effort.]

[Bill had just celebrated his eighty-first birthday. He didn't feel as strong as he was twenty years ago. In fact, Bill began using a cane as he hobbled along on his morning walks. He could not walk around the block without taking numerous breaks.]

[The neighborhood in which Bill lived was very small and friendly. Everyone greeted him as he walked by each morning. Bill especially liked to walk during the spring just when all of the flowers and trees were beginning to bloom. He found it new and refreshing.]

Today, Bill stopped to talk with Mrs. Jones. They had been friends for quite sometime. They were talking about how hot it had been. For the past three months there had been record breaking high temperatures and no rain. Soon there would be mandatory water rationing. As Bill was talking to Mrs. Jones, he saw a young boy who was lying in the street hurt. *He quickly ran and picked the boy up. Bill carried the boy over to the curb.* While Bill helped the boy, Mrs. Jones ran into her house to call the boy's mother and an ambulance. He kept the boy calm and still until help arrived.

Example Passage 2

Today, Mary was meeting a friend for lunch. She arrived early at the restaurant and decided to get a table. After she sat down, she started looking at the menu.

[This was Mary's favorite restaurant because it had fantastic junk food. Mary enjoyed eating anything that was quick and easy to fix. In fact, she ate at McDonalds at least three times a week. Mary never worried about her diet and saw no reason to eat nutritious foods.]

[This was Mary's favorite restaurant because it had fantastic health food. Mary, a health nut, has been a strict vegetarian for 10 years. Her favorite food was cauliflower. Mary was so serious about her diet that she refused to eat anything which was fried or cooked in grease.]

[This was Mary's favorite restaurant because it had a nice quiet atmosphere. Mary frequently ate at the restaurant and had recommended it to all of her friends. She especially liked the cute tables and the country style table cloths on them. It made her feel right at home.]

After about ten minutes, Mary's friend arrived. It had been a few months since they had seen each other. Because of this they had a lot to talk about and chatted for over a half hour. Finally, Mary signaled the waiter to come take their orders. Mary checked the menu one more time. She had a hard time deciding what to have for lunch. *Mary ordered a cheeseburger and fries. She handed the menu back to the waiter.* Her friend didn't have as much trouble deciding what she wanted. She ordered and they began to chat again. They didn't realize there was so much for them to catch up on.

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