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The Representation and Comprehension of Place-on-the-Page and Text-Sequence Memory

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Readers' memories for the physical location and sequence of information in a text were measured to further explore how they are represented in memory and their relation to comprehension. Participants read a biography or an expository essay and were tested on their comprehension of the text, memory for the location of information on a page of text (place on the page), and temporal memory for the sequence of information in a text (text sequencing). Results suggest that (a) readers store a substantial amount of text-sequencing information, (b) memory for text-sequencing information is strongly related to comprehension, (c) memory for place on the page is very weak, and (d) memory for place-on-the-page and text-sequencing information appear to be distinct. Our results indicate that text-sequence information is part of the textbase or situation model, whereas place-on-the-page information is a surface-level memory.

Given the complexity of text memories, it is essential to understand how elements of a text contribute to forming a memory for that text. One potentially important element is the order of information in a text. For example, Ohtsuka and Brewer (1992), Hopper (1979), Mandler (1986), and Zwaan and Radvansky (1998) provided evidence that memory for text is naturally organized in a way that matches the order of information in a text. Furthermore, if the narrated order of events does not match the chronological order, then a text becomes more difficult to comprehend. This is known as the iconicity assumption.

Other markers of order, sequence, and time are also coded in language, such as tense and aspect (Binnick, 1991; Celce-Murcia & Larsen-Freeman, 1999). Information about the order of events can be represented in several manners. One way is

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to remember the actual location of parts of the text. This is referred to as memory for "place on the page" (Zechmeister, McKillip, Pasko, & Bespalec, 1975, p. 43). A second way is to remember the sequence of information in the text. This is referred to as memory for "text-sequencing" (Rothkopf, 1971, p. 608).

Interestingly, remembering the sequence or location of information does not require the meaning of that information to be stored. Consider the following scenario as an example: A student is engrossed in a multiple-choice (MC) exam and, for one of the questions, remembers where the answer is located in the textbook (e.g., on the top left of a page, or in the second section of the chapter) but cannot recall the information needed to answer the question. In this example, both memory for place on the page and text sequencing can be used to answer the question, "Where was it in the text?" Of interest here is whether memory for place on the page and text sequence are distinct representations in memory and whether each type of memory is related to comprehension.

Most empirical work related to place-on-the-page and text-sequence memories shows that memory for specific location information (place on the page) is slightly above chance and that memory for sequence information is generally better than memory for location (Rothkopf, 1971; Zechmeister & McKillip, 1972; Zechmeister et al., 1975). Researchers have not, however, addressed the nature of the representational format of place-on-the-page and text-sequence memories. We examine the representation of these types of memory using van Dijk and Kintsch's (1983; Kintsch, 1998) levels of text representation.

van Dijk and Kintsch (1983; Kintsch, 1998) described texts as being represented at three levels: a surface level, a textbase, and a situation model. A surface-level representation includes memory for the wording and physical characteristics such as the type font, color, and possibly the location of information in a passage (Fletcher, 1994; Fletcher & Chrysler, 1990; Masson, 1984; Rothkopf, 1971). The surface level is considered the most superficial (i.e., carries little or no meaning) and temporary of the three levels of representation (van Dijk & Kintsch, 1983). The textbase consists of a series of connected meaning units called propositions. In minimal form, propositions consist of a pair of concepts (e.g., Gentleman, Beer) and a relational unit (e.g., SPILLED) that describes how the two concepts are related. The concepts in a proposition can refer to other propositions. The textbase represents the meaning of individual propositions and a group of propositions, as well as how propositions are related (Kintsch, 1974, 1998; Kintsch & Vipond, 1979). The situation model is an integration of a reader's prior knowledge about the events described by a text with the surface-level and textbase-level representations (Graesser, Millis, & Zwaan, 1997; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). In addition to general knowledge, the situation model includes inferences and other thoughts generated by comprehension processes (Graesser et al., 1997; Zwaan & Radvansky, 1998). The situation model has also been described as representing the gist, the theme, or in some cases the script of the text (Johnson-Laird, 1983; O'Brien & Albrecht, 1992). The situation is roughly analogous to Johnson-Laird's (1983) notion of mental models (Graesser et al., 1997; Zwaan & Radvansky, 1998).

Memory for the location of information on a page can be described as a surface memory because it represents memory for physical characteristics of the text. As a result, there should be little relation between memory for location and comprehension. In contrast, sequence information often contributes to the meaning of a text, such as in cause–effect relations; therefore, sequence information qualifies as a textbase- or situation-level memory. Sequence memory should, therefore, be related to comprehension. Sequence information is not always necessary for comprehending local elements of a text. For example, when reading a list of unrelated examples, the order (sequence) of the examples is not important. Understanding the global sequence is still important because the examples need to be related to information that proceeded or follows the examples.

The outcome of research addressing whether surface-level representations are included in memory and whether they facilitate comprehension is inconclusive. For example, Bransford and Franks (1971) and Sachs (1967) suggested that the surface form of a sentence is simply a vehicle for conveying meaning. They argued that surface features are held temporarily and then purged to make room for the next segment of text and that memory for surface features reflects an ability to reconstruct them from the meaning of the text. More recently, Tardif and Craik (1989) and Fletcher (1994) also argued that memories for surface features are reconstructed based on meaning. Finally, Fischer (1999) provided evidence that memory for the location of individual words decays within 3 sec and then can only be reconstructed using item memory.

There is also evidence that readers do store surface features in memory. Several studies have been conducted in which individuals read a text and then reread the identical text or a paraphrased version of the text (Anderson, 1974; Raney, Therriault, & Minkoff, 2000; Tardif & Craik, 1989). Paraphrasing changes the surface form without substantially changing the meaning. In all cases, repetition effects were obtained for identical and paraphrased texts, but individuals processed the identical texts slightly faster than the paraphrased texts. This implies that repeating the surface form facilitates processing (also see Kolers, 1976). Note, however, that this type of surface memory reflects memory for exact wording, not memory for the location of the words.

MEMORY FOR PLACE-ON-THE-PAGE AND TEXT-SEQUENCING INFORMATION

Studies involving memory for place-on-the-page and text-sequence information are important for two reasons. First, they directly address whether readers store location and sequence information. As just described, recent studies have examined memory for surface form in terms of wording, but not location, and very little research has explored sequence. Second, they provide information regarding when and how this information might facilitate memory and comprehension. Here we review the major studies.

In an often-cited study, Rothkopf (1971) had participants read a 12-page text (roughly 3,000 words) and then tested their ability to recall details from the text (fill-in-the-blank questions) and their knowledge of where these details were located on a page. To indicate locations, participants were given a template of a page with eight horizontal divisions and were asked to indicate in which section of the page the answer to each question was located. They also indicated in which quartile of the text they believed the answer was contained (i.e., pages 1–3, pages 4–6, pages 7–9, or pages 10–12). This was referred to as memory for text sequence. For fill-in-the-blank questions that were answered correctly, they correctly answered 20.6% of the corresponding place-on-the-page questions (chance was 12.5% because the template had eight regions). In other words, individuals answered 2 to 3 more questions than expected by chance on the 32-question test. Participants recalled text-sequencing information more accurately than place-on-the-page information, but mean accuracy cannot be determined from the figures presented in his article. Participants did equally well on the text-sequencing questions whether they got the fill-in-the-blank question correct or not. Rothkopf concluded that readers have some incidental memory for the location of information on a page of text and that spatial information might be used as a mnemonic for organizing information in memory.

Zechmeister et al. (1975) also evaluated memory for place on the page. Their participants correctly answered 38.5% of the location questions (chance was 25% because their template had four regions). Memory for place-on-the-page information was better for correctly answered questions than for incorrectly answered questions. Zechmeister et al. also manipulated whether participants were told (cued) that they would be asked to recall the location of information. Participants who were told about the location questions did not perform better than those who were not told about the questions, which led Zechmeister et al. to conclude that readers automatically use spatial information. They stated, "Visually mediated spatial memory is a fundamental attribute when text material is encoded, and may be of mnemonic value when the information needs to be recalled" (p. 43). In essence, spatial elements of a text can be used as an index or table of contents when accessing the content of a text.

Christie and Just (1976) explicitly examined the organizational value of memory for spatial location. They proposed that if individuals use spatial information to access the answer to a question, then they should be able to look back in the text to the sentence that contains the answer to that question. To determine if this is true, participants' eye movements were recorded while reading normal passages or passages with sentence order randomized. The participants then answered questions while the texts were still displayed. For normal passages, participants initially fixated (looked back to) the sentence needed to answer the question 31% of the time. For scrambled passages, they initially fixated on the correct sentence 19% of the time. Chance was approximately 9%. Like Zechmeister et al. (1975), Christie and Just concluded that location information was used as an index to content information. This is consistent with recent work by Murray and McGlone (1997). They had participants read an expository text that did or did not begin with a topic overview (a listing of upcoming topics). Sections of the texts that were related to the topic overviews were read faster and remembered better than sections of the texts that were not mentioned in the topic overviews. Murray and McGlone concluded that providing a topic list facilitates memory. If readers construct a topic list based on location or sequence, this too could aid recall.

Our experiment was designed to more completely examine readers' memories of place-on-the-page and text-sequencing information, to determine how comprehension influences these two types of memory, and to explore whether place-on-the-page and text-sequence memories qualify as a surface-, textbase-, or situation-level memories. To do this, we combined elements of the methodologies used by Rothkopf (1971), Zechmeister et al. (1975), and Christie and Just (1976).

Participants read a text and then answered MC questions, place-on-the-page questions, and text-sequencing questions about the text; they also rated how confident they were in their answers. Our primary prediction involves the relation between comprehension and memory. We view place-on-the-page memory as a surface memory; therefore, memory for place-on-the-page information should not be strongly related to comprehension. We view text-sequence memory as part of the textbase or situation model; therefore, memory for text-sequence information should be strongly related to comprehension. One way we examined the relation between comprehension and memory was by manipulating text difficulty. Participants read a biography about William James that was written at an 11th-grade level (based on Boring, 1950) or an expository essay about the extinction of the dinosaurs that was written at an 8th-grade level (based on Gould, 1984). If memory for place-on-the-page and text-sequencing information is related to comprehension, then memory performance should be poorer for the more difficult text by Boring. We predict that text difficulty will not influence memory for place-on-the-page information, whereas text difficulty will influence memory for text-sequence information.

To examine the influence of text structure on memory, we presented readers with a normal text or a scrambled version of a text (paragraph order was randomized). Scrambling the passages should partially disrupt comprehension processes (Roberts & Kreuz, 1993). As a result, scrambling the text is expected to reduce memory for text-sequence information. Scrambling the text is not expected to affect memory for place-on-the-page information because place-on-the-page memory is not expected to be dependent upon comprehension.

We also evaluate whether storing location and sequence information is under voluntary control. There is a debate about the automatic encoding of spatial and temporal order information. Hasher and Zacks (1979, 1984) provided evidence that events are automatically encoded using order information. In contrast, Naveh-Benjamin (1987, 1988, 1990) argued against the automatic encoding of both spatial and temporal order. We evaluated whether storing location and sequence information is automatic by telling (cueing) some of the participants exactly what type of questions they would be asked. Cueing has never been used to study memory for text sequencing in this manner. Because text-sequencing information is often needed to comprehend a text, we expect memory for this information to be a natural part of text memory. Consequently, cueing is expected to have no effect on text-sequencing memory.

METHODS

Participants

One hundred twenty undergraduates from the University of Illinois at Chicago participated for course credit. All were native English speakers and were unaware of the purpose of the experiment.

Materials

Each participant read one of the two texts. The first was based on an expository essay written by Gould (1984) that described the proper use of the scientific method for evaluating theories about the extinction of dinosaurs. The essay scored 7.8 on the Flesch–Kincaid Grade Level, which indicates that the text is roughly written at an 8th-grade level. The second text was based on a biography of William James by Boring (1950). The biography scored 11.3 on the Flesch–Kincaid Grade Level (Flesch, 1974). Each text was 3,000 words in length and was printed on 12 single-spaced pages with 24 lines of text per page.

Participants also completed a test booklet that consisted of MC questions, text-sequence questions, and place-on-the-page questions (as described later). Each test booklet contained 20 sections with 3 questions per section. The first question in each section was an MC question. For 15 of the questions, the answer was located in only one paragraph of the text. For the remaining 5 questions, the answer could be found in more than one location. These 5 questions were included to allow more general comprehension questions to be asked. After answering a question, participants rated their confidence in their answer on a 4-point scale ranging from 1 (*low*) to 4 (*high*). Rothkopf (1971) used this same confidence scale.

The second question in each section was a text-sequencing question. Participants indicated in which quartile of the entire text the answer to the corresponding MC question was located. The choices were the first quarter (pages 1–3), the second quarter (pages 4–6), the third quarter (pages 7–9), and the fourth quarter (pages 10–12). After answering the text-sequencing question, they rated their confidence in their decision on a 4-point scale ranging from 1 (*low*) to 4 (*high*).

The third question in each section was a place-on-the-page question. Participants indicated where on a page they believed the answer to the MC question was located using a template of a page of text that was divided into four vertical regions with the regions labeled A, B, C, and D. After answering the place-on-the-page question, they rated their confidence in their decision on a 4-point scale ranging from 1 (*low*) to 4 (*high*).

Design and Procedure

The experiment was based on a 2 (text: Gould or Boring) × 2 (order: normal or scrambled) × 2 (instruction: cue or no cue) between-subjects design. As described next, the paragraphs in the passage were presented normally or scrambled (paragraph order randomized), and the instructions were manipulated to cue participants to remember the location of information in the text or not. Participants were randomly assigned (in blocks) to one of the four conditions.

In Condition 1, participants read the normal (nonscrambled) version of an essay and were not cued to remember the spatial location of information. Before reading the text, they were verbally presented the following instructions. The portions in braces varied across conditions and are described next.

> {You will be reading a text written by Stephen Gould about Dinosaurs and the scientific method.} Your job is to learn as much information about the passage as you can, but do not dwell too much on any particular section. Please read at your own pace, but avoid going back over material once you have read it. After you are done reading, please raise your hand. You will then be given a test covering what you have just read. [The test is composed of multiple-choice questions.] Do you have any questions?

If the participant read the Boring text, then the first sentence was "You will be reading a biography written by Edwin Boring about Williams James's contributions to Psychology."

In Condition 2, participants read the normal version of the Gould or Boring texts but were told that they would be specifically asked about the location of information in the text. The instructions were identical to those given in the first condition up to the sentence that described the test [the portion in brackets]. This portion of the instructions read as follows:

> [The test is composed of multiple-choice questions about what you have just read and questions that ask you where specific information is located in the text. For example, you will be asked relative to the entire passage where information is located and what place it may have been on its particular page.]

In Condition 3, participants received the instructions for Condition 1 (not cued about location questions) but read the scrambled version of a text. In Condition 4, participants received the instructions for Condition 2 (cued about location questions) but read the scrambled version of a text.

Participants were given the normal or scrambled version of one of the texts and the appropriate verbal instructions (everyone in a group received the same instructions). After reading a text, they were given a test booklet and told they had 30 min to complete it. All participants completed the test booklet within the allotted time.

Development of Testing Materials

We compare performance to chance; therefore, it is necessary to ensure that performance did not exceed statistical chance when the texts had not been read. Twenty-two participants completed the test about Gould's essay, and 22 different participants completed the test about the Boring biography without reading the texts. Results indicated that estimated chance levels were slightly higher than statistical chance (25%) for all three question-types. Estimated chance is defined as the percentage of correctly answered questions when the texts have not been read. Statistical chance is defined as the percentage of correctly answered questions when performance is based upon random guessing without the benefit of prior knowledge (i.e., true random guessing).

The questions were modified several times and retested until estimated chance levels were reduced to approximately statistical chance levels. For the 20 MC questions, estimated chance performance was 5.6 questions correct (28%), whereas statistical chance equals 5 questions correct (25%). For the 15 text-sequence questions, estimated chance performance was 4.6 questions correct (30.9%), whereas statistical chance equals 3.75 questions correct (25%). For the 15 place-on-the-page questions, estimated chance performance was 3.9 questions correct (25.7%), whereas statistical chance equals 3.75 questions correct (25%). Given that estimated chance was similar to statistical chance, we can be confident that any increased performance is attributable to knowledge gained from reading the text. Even though estimated chance levels were similar to statistical chance, comparisons are based on estimated chance values.

RESULTS

The results are presented in two sections. First, analyses of raw scores are described. These analyses provide information about performance on the MC, text-sequence, and place-on-the-page questions as a function of passage type, cueing about the test, and text organization (i.e., normal or scrambled paragraph order). The second and theoretically more interesting analyses are based on conditional performance, which was defined as the change in performance on text-sequence and place-on-the-page questions as a function of whether corresponding MC questions were answered correctly. Conditional analyses provide information about the relation between comprehension and memory for text-sequencing and place-on-the-page information.

Analyses of Raw Scores

The accuracy data were initially analyzed using separate three-way, between-subjects analyses of variance (ANOVAs) for each question type (MC, text sequencing, and place on the page). These ANOVAs were based on the factors type of text (Gould or Boring), cue (cued or not cued), and text organization (normal or scrambled). Analyses of MC questions were based on all 20 questions. Analyses of text-sequence and place-on-the-page questions were based on the 15 questions that had answers in only one location (paragraph) within a text. Questions with answers in more than one location were not included because there was more than one correct answer to these questions. Table 1 provides a summary of mean performance for all three types of questions.

Analysis of performance on MC questions indicated a statistically significant difference between the two texts, $F(1, 112) = 7.185$, $p < .008$ ($MSE = 1298.93$, $\eta^2 = .06$). Participants performed better on the Gould text ($M = 12.2$) than the Boring text ($M = 10.6$). This difference reflects the fact that the Gould text was written at a lower grade level (7.8) than the Boring text (11.3). All other tests of main effects, two-way, and three-way interactions were not significant (all Fs < 1.15, all ps > .28). Analyses of text-sequence performance indicated a significant difference between the two texts, $F(1, 112) = 30.17$, $p < .001$ ($MSE = 475.73$, $\eta^2 = .21$). Performance was better for the Gould text ($M = 6.7$) than the Boring text ($M = 4.6$). All other tests of main effects and interactions were not significant (all Fs < 1.32, all ps > .25). Analyses of place-on-the-page questions did not produce any significant effects (all Fs ≤ 2.34, all ps ≥ .128). Overall performance on the Gould text ($M = 4.0$) and the Boring text ($M = 4.0$) was identical.

To determine if performance exceeded chance, the number of correct answers on each test was compared to chance using one-sample t tests. Performance on the MC test exceeded chance for the Gould text ($M = 12.2$), $t(59) = 14.32$, $p < .001$, and

TABLE 1
Mean Performance for Multiple-Choice, Text-Sequence, and Place-on-the-Page Questions

	Question Type					
	Multiple Choice		*Text Sequence*		*Place on the Page*	
	M	%	*M*	%	*M*	%
Both texts combined						
Maximum	20.0		15.0		15.0	
Estimated chance	5.6	28.0	4.6	30.9	3.9	25.7
Overall	11.4	57.0	5.7	38.0	4.0	26.7
No cue	11.4	57.0	5.9	39.3	4.3	28.7
Cue	11.5	57.5	5.5	36.7	3.8	25.3
Normal	11.4	57.0	5.5	36.7	3.9	26.0
Scrambled	11.4	57.0	5.9	39.3	4.2	28.0
Gould text only						
Maximum	20.0		15.0		15.0	
Estimated chance	4.7	31.6	4.6	30.9	4.0	26.7
Overall	12.2	61.0	6.7	44.7	4.0	26.7
No cue	12.0	60.0	7.1	47.3	4.2	28.0
Cue	12.5	62.5	6.3	42.0	3.8	25.3
Normal	12.4	62.0	6.6	44.0	3.7	24.7
Scrambled	12.1	60.5	6.8	45.3	4.4	29.3
Boring text only						
Maximum	20.0		15.0		15.0	
Estimated chance	3.7	24.3	4.6	30.9	3.7	24.6
Overall	10.5	52.5	4.6	30.7	4.0	26.7
No cue	10.7	53.5	4.6	30.7	4.3	28.7
Cue	10.4	52.0	4.7	31.3	3.8	25.3
Normal	10.4	52.0	4.3	28.7	4.0	26.7
Scrambled	10.7	53.5	5.0	33.3	4.0	26.7

Note. Estimated chance indicates test performance when the texts had not been read.

the Boring text ($M = 10.5$), $t(59) = 12.69$, $p < .001$. Performance on text-sequencing questions was reliably greater than chance for the Gould text ($M = 6.7$), $t(59) = 7.97$, $p < .001$, but not for the more difficult, Boring text ($M = 4.6$), $t(59) = -.068$, $p > .946$. Recall that performance is being compared to our estimated chance values, which are more conservative than statistical chance. Performance on text-sequencing questions for the Boring text did exceed statistical chance, $t(59) = 3.21$, $p < .002$. This was the only instance in which performance shifted from not significantly greater than chance to significantly greater than chance as a function of using our estimated chance assessments. Performance on place-on-the-page questions did not exceed chance for the Gould text ($M = 4.0$), $t(59) = -.081$, $p > .936$, or the Boring text ($M = 4.0$), $t(59) = 1.52$, $p > .131$.

Conditional Analyses

Recall that performance on text-sequencing questions was expected to vary as a function of comprehension. The raw performance scores are not made conditional upon comprehension; therefore, they do not address the relation between comprehension and memory. This relation was tested here in two ways. First, performance on the MC questions was correlated with performance on the text-sequence and place-on-the-page questions. This tests whether general comprehension influences text-sequence and place-on-the-page memory. Second, we examined the difference in performance on text-sequence and place-on-the-page questions when the corresponding MC questions were answered correctly and incorrectly. This tests for a relation between the knowledge needed to answer a specific MC question and memory for the corresponding text-sequence and place-on-the-page information. One potential objection to the conditional analyses of place-on-the-page questions is that overall performance did not exceed chance (i.e., no main effect). This is true, but performance might be better when the reader has knowledge about the material to be remembered (i.e., an interaction between memory and knowledge), as has been shown in prior research (Rothkopf, 1971). Conditional analyses can be used to evaluate this possibility.

The only variable that influenced raw scores was text type; therefore, only text type was included as a factor in the conditional analyses. Collapsed across passages, performance on text-sequence questions was significantly correlated with performance on MC questions ($r = .482, p < .01$). Individually, there were statistically significant correlations for both the Gould text ($r = .452, p < .01$) and the Boring text ($r = .410, p < .01$). In contrast, there was no correlation between performance on place-on-the-page and MC questions when the passages were combined ($r = .138, p > .133$) or evaluated individually (for the Gould text, $r = .132, p > .316$; for the Boring text, $r = .157, p > .230$).

Because memory for place on the page and text sequence both relate to the order of information in a text, we also examined the correlation between performance on text-sequence and place-on-the-page questions. Collapsed across texts, performance on text-sequence and place-on-the-page questions was not correlated ($r = .053, p > .56$). No relation was found when the texts were examined individually either (for the Gould text, $r = -.053, p > .687$; for the Boring text, $r = .174, p > .183$).

Correlational analyses provide evidence for a relation between performance on text-sequencing and MC questions but not between place-on-the-page and MC questions. These correlations do not necessarily indicate that the participants were more likely to answer the same text-sequencing and MC questions correctly. For instance, they could have answered Questions 1 to 8 correctly for text sequencing but Questions 9 to 15 correctly for MC. In other words, it is possible to obtain a statistically reliable correlation with no overlap in the questions answered correctly.

To rule out this nonoverlap scenario, difference scores were analyzed for text-sequence and place-on-the-page questions.

Difference scores were defined as the number of text-sequence or place-on-the-page questions answered correctly when the corresponding MC questions were also answered correctly, minus the number of correctly answered text-sequence questions or place-on-the-page questions when the corresponding MC questions were answered incorrectly. The difference scores were compared to zero using one-sample *t* tests to determine whether performance was greater when MC questions were answered correctly.

Collapsed across texts, analysis of the difference scores indicated that participants answered 1.4 more text-sequence questions correctly when they knew the answer to the corresponding MC questions ($M = 3.5$) than when they did not know the answer ($M = 2.1$). This difference was statistically significant, $t(119) = 5.704$, $p < .01$. Further analysis indicated that this was true for the Gould text (*M* difference score = 1.9), $t(59) = 5.0$, $p < .001$, and the Boring text (*M* difference score = .9), $t(59) = 2.99$, $p < .01$. This suggests that the nonoverlap scenario is not driving the correlation between text sequencing and comprehension.

For place-on-the-page questions, participants answered 0.4 more questions correctly when they knew the answers to the corresponding MC questions ($M = 2.2$) than when they did not ($M = 1.8$). Although the difference score is small, it is statistically significant, $t(119) = 2.341$, $p < .05$. When the texts were examined individually, difference scores were significant for the Gould text (*M* difference score = .7), $t(59) = 2.15$, $p < .05$, but not for the Boring text (*M* difference score = .3), $t(59) = 1.14$, $p > .25$.

To further examine the difference scores, a 2 × 2 ANOVA was conducted using memory test (text sequencing and place on the page) and text type (Gould or Boring) as factors. Difference scores were significantly larger for text-sequence questions ($M = 1.4$) than for place-on-the-page questions ($M = 0.49$), $F(1, 118) = 18.45$, $p < .001$ ($MSE = 45.93$). This indicates that performance on text-sequencing questions varies, based on comprehension, to a greater degree than performance on place-on-the-page questions. There was not a main effect of text type, $F(1, 118) = 2.88$, $p > .09$ ($MSE = 9.5$), but this is theoretically misleading because the main effect collapses across text-sequence and place-on-the-page questions. More interesting is the mild interaction between text type and memory test, $F(1, 118) = 3.09$, $p < .081$ ($MSE = 7.07$). To evaluate this interaction, *t* tests were conducted to compare difference scores for each passage. Results indicated that text-sequence difference scores were significantly larger for the Gould text ($M = 1.9$) than for the Boring text ($M = 0.9$), $t(59) = 2.19$, $p < .05$. This demonstrates that when the reader's knowledge of the text (in this case the Gould text) increases, there is a stronger relation between comprehension and text-sequence memory. In contrast, there was no significant difference between place-on-the-page difference scores for the Gould ($M = 0.7$) and

Boring ($M = 0.3$) texts, $t(59) = .752$, $p > .45$. Unlike text sequencing, comprehension difficulty has little impact on place-on-the-page memory.

Confidence Ratings

Confidence ratings were measured for each MC, text-sequence, and place-on-the-page question. Responses were almost identical for both texts, so we provide confidence rating collapsed across passages. Mean confidence ratings for correctly answered questions were 3.1 for MC, 2.7 for text sequence, and 2.3 for place on the page. For incorrect answers, mean confidence ratings were 2.4 for MC, 2.5 for text sequencing, and 2.1 for place on the page. Not surprisingly, participants were more confident about correct responses.

GENERAL DISCUSSION

Our experiment provides several pieces of evidence that text-sequence memory is related to comprehension, whereas place-on-the-page memory is not. First, as expected, performance on MC and text-sequence questions was poorer for the more difficult Boring text than for the easier Gould text, but text type did not influence performance on place-on-the-page questions. Second, performance on text-sequence and MC questions was correlated, but performance on place-on-the-page and MC questions was not correlated. Third, analyses of the difference scores showed that the relation between comprehension and text-sequence memory was stronger for the Gould text than the Boring text. This makes sense because the Gould text was easier to understand. Difference scores for place-on-the-page questions did not vary as a function of text type, which further indicates no reliable relation between text difficulty and memory for place-on-the-page material. Support for these conclusions is discussed next.

Our findings show that memory for text-sequence information increases as comprehension increases, whereas memory for place-on-the-page information does not. This leads us to conclude that place-on-the-page memory is a form of surface memory and text-sequence memory is part of the textbase or situation model. The importance of storing text-sequence information is consistent with Zwaan and Radvansky's (1998) claim that a critical dimension of the situation model is time or sequence. Their conclusion is based on evidence that readers assume that the narrated order of events will match the chronological events in a text, and deviations from this order result in comprehension difficulty (i.e., the iconicity principle).

We manipulated comprehension by varying text difficulty. Analyses of raw scores indicated that the Gould text was easier to read than the Boring text. This led readers to acquire and maintain more text-sequence information from the Gould text than from the Boring text. This supports our prediction that text-sequence memory should be poorer for the Boring text. This strengthens our case for a link between comprehension and text-sequence memory. Recall that the Boring text is a biography and is more linearly organized. Therefore, one would expect better text-sequence performance for the Boring passage. However, performance on text-sequence questions was better for the more easily comprehendible Gould text. If text type strongly interacted with text-sequence performance, then participants should have performed better on the Boring passage (the reverse of what we found).

The correlations and difference score analyses both demonstrated that memory for text sequence was strongly related to comprehension. Text-sequence memory increased when readers knew the answer to the corresponding MC questions, and text-sequence memory was superior for the Gould text, which was easier to comprehend. Because comprehension is tied to a textbase or situation-level representation, it is logical to infer that text sequencing is linked to the textbase or situation model.

The outcome of the analyses for place-on-the-page memory is less clear. There were no correlations between performance on place-on-the-page and MC questions, yet accuracy on place-on-the-page questions increased slightly (by 0.5 questions) when the corresponding MC question was also answered correctly. This is interesting given that past research has found a strong relation between performance on place-on-the-page memory and comprehension when comprehension was tested using fill-in-the-blank questions (Rothkopf, 1971; Zechmeister et al., 1975). In our study, there is much more evidence that place-on-the-page memory is not related to comprehension than evidence that it is related to comprehension.

The relation between comprehension and memory can be used to explain why Rothkopf (1971) found no link between performance on text-sequencing and comprehension questions. A sample page of a text he used scored 12.0 on the Flesch–Kincaid Grade Level. This is similar to the difficult Boring passage in our experiment, which had a Flesch–Kincaid score of 11.3. Thus, Rothkopf's text was probably too difficult for readers to form strong text-sequence representations.

Our findings also indicate that text-sequence and place-on-the-page memories are distinct. In addition to the differences just mentioned, there was no correlation between performance on text-sequencing questions and place-on-the-page questions. Although both types of memory could be used to find the location of information in a text, they appear to tap different representations. This distinction has not been made in prior research and helps to explain why significant text-sequence memory can be found in the absence of place-on-the-page memory.

Whereas text difficulty and question type dramatically influenced memory performance, reading a normal or scrambled text had virtually no impact on memory. Scrambling was expected to reduce readers' abilities to form higher-order text representations, but we found no evidence that scrambling reduced comprehension.

There are several explanations for this outcome. One likely reason is that readers were able to overcome the difficulty associated with reading scrambled text by employing their understanding of story-schemas or story grammars (Kintsch, Mandel, & Kozminksy, 1977). Levy et al. (1995) found that scrambling does impair higher-order text representations, but scrambling must occur at the sentence level or word level to substantially reduce a reader's ability to understand a text. Because the Boring text follows a well-established story-schema (i.e., a narrative biography), our paragraph-level scrambling probably was not strong enough to impair comprehension. For the Gould text (i.e., an expository science text), the exact order of information might not be as essential to comprehension because the text can be understood well simply as an unordered collection of facts.

We also found that cueing did not impact text-sequence or place-on-the-page memory. Although no strong conclusions can be drawn from a null effect, several possibilities can be evaluated. One possibility is that readers do not store place-on-the-page or text-sequencing information, so cueing will have no effect. This is not true for text-sequencing information, but it remains a possibility for place-on-the-page information. A second possibility is that readers do store this information, but they are not aware of it (i.e., it is an automatic component of reading). A third possibility is that our participants focused on comprehension at the expense of remembering location and sequence information. Recall that all participants expected a comprehension test. Comprehension tests are the norm; therefore, participants might be more adept at focusing on the type of information needed to answer MC questions.

Resolving Inconsistencies With Past Research

In contrast to text-sequence memory, memory for place-on-the-page information was very weak. Our findings are consistent with Rothkopf's (1971) conclusion that memory for text sequence is stronger than memory for place on the page. Our results are inconsistent with previous reports of reliable but small amounts of memory for place-on-the-page information (Rothkopf, 1971; Zechmeister & McKillip, 1972; Zechmeister et al., 1975). Recall that Zechmeister et al. (1975) suggested that spatial memory is a "fundamental attribute when text material is encoded" (p. 43).

We propose three reasons why prior research found more evidence for memory of purely spatial, place-on-the-page information. First, fill-in-the-blank questions were used in the prior research. Zechmeister et al. (1975) pointed out that knowledge of the text serves as a recall cue. Because fill-in-the-blank questions provide the exact structure of the sentences (short of a word or two) as well as part of the content to be recalled, they may aid retrieval of place-on-the-page location more than our MC questions. In essence, fill-in-the-blank questions provide stronger recall cues.

Second, in Zechmeister and McKillip's (1972) and Zechmeister et al.'s (1975) experiments, the texts were presented in four quadrants on a page (similar to a newspaper). It is possible that added spatial cues provided by separating text into quadrants contributed to superior performance on place-on-the-page questions.

Third, this discrepancy could be attributed to how chance performance was defined. Rothkopf (1971) and Zechmeister et al. (1975) used statistical chance as a baseline. For example, chance was set at 25% if there were four options. This is a valid baseline if the reader's prior knowledge about the topic or the text genre does not influence performance. This is likely to be a false assumption in many cases. We pretested all three of our question types to ensure that students who had not read the texts did not perform significantly above statistical chance levels, and we compared performance to our slightly higher, estimated chance levels. If, in past studies, statistical chance was substantially less than what we called estimated chance, then prior research might overestimate the amount of information remembered purely from reading the text.

Memory for place on the page was not reliable in our experiment, but it is still valuable to ask whether surface features could facilitate memory. Using more salient surface-level cues such as italics, bold print, headers, or separating the text into sections (e.g., quadrants) might elicit different results. In fact, Weiten, Guadagno, and Beck (1996) described research showing that strategically placed typology cues (e.g., bold print) aid comprehension. It seems reasonable to expect these types of cues to facilitate memory as well. Cues such as bold print provide emphasis and headers provide transitions, and consequently, these surface cues might encapsulate meaning into a surface-level representation. Our study shows that in the absence of special surface cues, memory for spatial location is not reliably greater than chance.

CONCLUSIONS

To summarize, our results support the conclusion that readers store a substantial amount of text- sequencing information when the passage is well understood and that memory for sequence is enhanced when the material to be remembered is correctly understood (i.e., the corresponding MC questions are answered correctly). Our study also supports an important distinction between place-on-the-page and text-sequence memories. Memory for text sequencing was robust, was related to comprehension, and can be described as a textbase or situation-level representation that codes temporal information. Memory for place on the page was weak, was largely unrelated to comprehension, and can be described as a surface-level representation that is spatial in nature. This distinction has not been identified in prior research and helps to clarify the nature of the representation of place-on-the-page and text-sequence memories, as well as to further specify the type of information stored in a text memory.

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