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The Effects of Inserted Questions and Mandatory Review in Computer-Mediated Texts

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The Effects of Inserted Questions and Mandatory Review in Computer-Mediated Texts

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Abstract. *The authors investigated the effects of inserting questions in a computer-mediated text that required readers to review relevant portions of the text when a question was answered incorrectly. College students served as their own controls while reading a scientific text under three treatment conditions that varied as to the consequences of an incorrect response to a question. Participants spent proportionately more time reviewing target paragraphs directly relevant to inserted questions when mandatory review was linked to answering the same as opposed to a different question after a review cycle. A statistically significant interaction ($p < .001$) between treatment and question type on a posttest indicated that participants' scores were higher on repeated inferential questions and lower on new literal questions when review cycles were followed by a different question. The authors conclude that varying the contingencies associated with responses to questions inserted in computer-mediated texts may affect readers' strategies and consequently the information recalled.*

The research literature investigating the effects of questions inserted in texts spans more than 20 years and comprises dozens of published studies as summarized in major reviews by Anderson and Biddle (1975) and Hamilton (1985). The computer has played a role in this research. For example, in two frequently cited studies (Reynolds & Anderson, 1982; Reynolds, Standiford, & Anderson, 1979), texts displayed on a computer screen (computer-mediated texts) enabled the researchers to determine how inserted questions affected readers' attention to specific portions of the text. However, the purpose of these experiments was to test competing hypotheses about the effects of questions inserted in printed texts. As has been the case in much of the previous research, inserting questions in printed texts has been viewed as an adjunct aid to learning designed to stimulate cognitive activity and focus attention.

In other studies employing computer-mediated texts researchers have employed inserted questions for different purposes. A common function of a question in computer-mediated texts is a comprehension check. An incorrect response to the question triggers some remedial action directed by the computer.

For example, in an early study Alessi, Anderson, and Goetz (1979) inserted questions to determine participants' understanding of prerequisite and related target information in the text. The computer required some participants to look back at the prerequisite information when their response to an inserted question indicated that they needed such information to understand the target text. Nonetheless, the researchers were interested primarily in addressing the importance of lookbacks as a study technique for printed texts and in highlighting the need for developing lookback strategies.

More recently, researchers have begun to consider the unique characteristics of computer-mediated texts and to investigate intra-media rather than inter-media differences (Reinking, in press; Reinking & Bridwell-Bowles, 1991). In other words, rather than using computer-mediated texts as a research tool to make generalizations about reading printed texts or to compare reading performance to printed texts, researchers have become interested in the unique effects of various computer-mediated texts.

The present study falls into that category of research because it addresses the following general question: What are the effects of inserted questions in computer-mediated texts employing some of the unique characteristics of reading with the aid of a computer? Specifically, we were interested in the effects of inserted questions when they were coupled with mandatory review of previously-read text; that is, when readers answer a question incorrectly, they are required to review text related to that question until they are able to answer it correctly.

A consistently robust finding from the research literature on questions inserted in printed texts is that questions increase recall and comprehension of textual information directly related to the content of the questions; a less robust finding reflected by the mixed results across studies is that inserted questions may also have an indirect effect on incidental information not addressed by the questions (Anderson & Biddle, 1975; Hamilton, 1985). Apparently, under some conditions, inserted questions inhibit the learning of incidental but important information not addressed by the questions.

Previous research suggests that computer-mediated texts linking an incorrect response on an inserted question to mandatory review of relevant text may lead readers to search for the answer to the question at the expense of other information. Tobias (1987, 1988), for example, compared participants reading computer-mediated texts with or without mandatory review after an incorrect response to an inserted question. He found higher post-test scores among participants in the mandatory review condition; however, their scores were lower on items covering incidental information not addressed directly by the inserted questions. He speculated that participants "required to review skimmed preceding text for content relevant to the adjunct questions rather than carefully rereading the preceding text" (Tobias, 1987, p. 159).

Little is known about what effect computer-mediated texts employing inserted questions and mandatory review may have on readers' strategies. Do readers use a "search-and-destroy" strategy when required to review text in order

to respond correctly to a question, especially when continued reading is contingent on a correct response? We hypothesized that under these conditions readers are likely to adopt such a strategy and that such a strategy would result in less incidental learning of content not addressed in the inserted questions. Furthermore, we hypothesized that we would alter readers' use of such a strategy by using the computer's capability to provide a different question after each mandatory review. That is, would readers be more likely to review uniformly the content of the text when they knew that after their review they would be required to answer a different, as opposed to the same, question? Would the level of the inserted questions (i.e., literal vs. inferential) affect readers' performance? Our study was designed to address these questions and to test these hypotheses.

Method

Participants

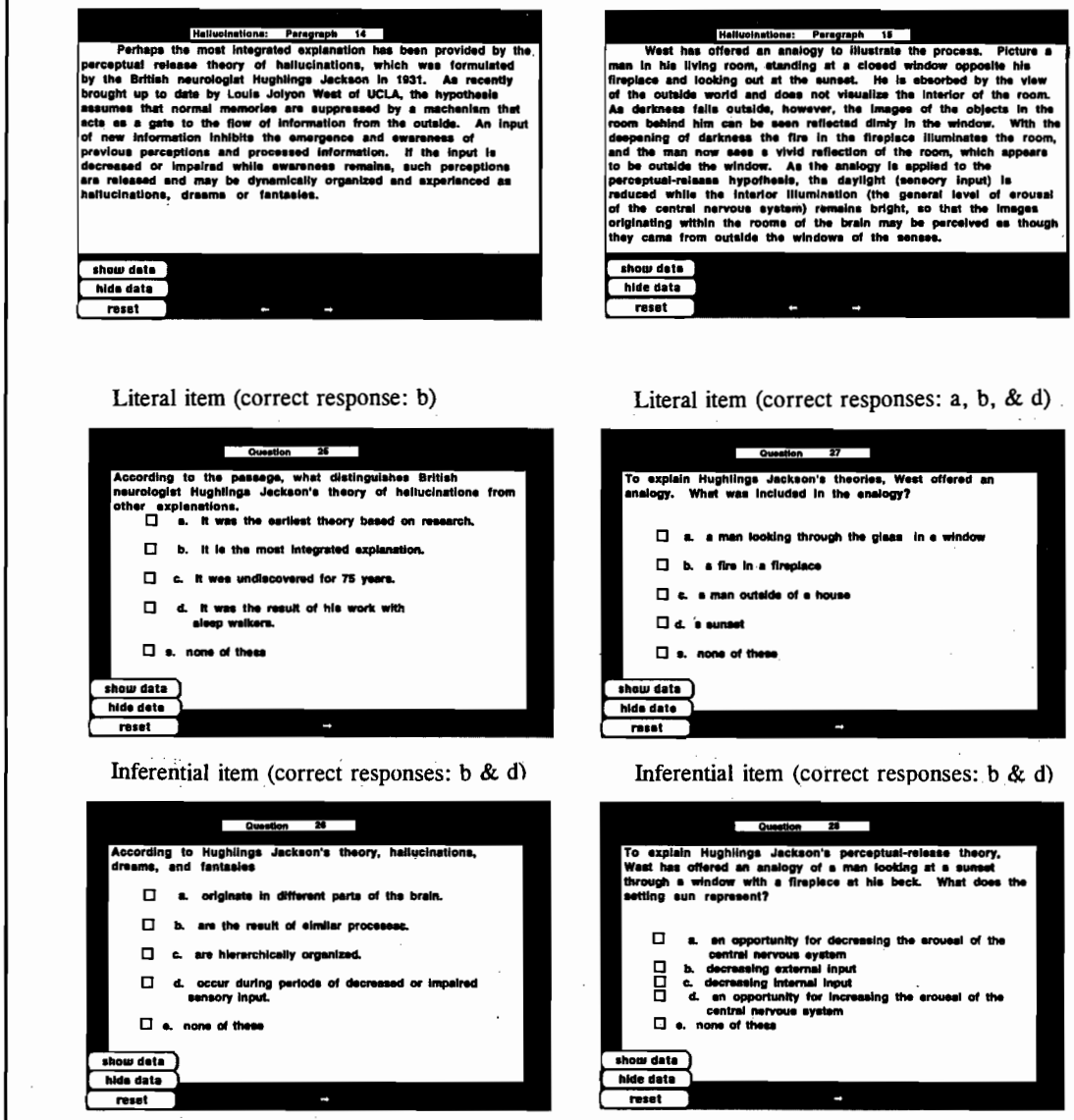
Participants were 36 undergraduate education majors enrolled in one of several methods courses related to the teaching of reading. Participants volunteered for participation in the experiment. In most instances, the participants' instructors gave them extra credit for participating in the experiment. Only a few participants volunteered without such an incentive. Most of the participants had taken a required media course during which they had been introduced to the use of several computers, including a Macintosh computer similar to the one used in the present experiment.

Materials

The stimulus materials consisted of a practice passage and an experimental passage. The practice passage discussed misconceptions about dyslexia. It consisted of seven paragraphs adapted from a published reading text. The experimental passage was an adaptation of an article about hallucinations published in *Scientific American*. The adapted article consisted of 27 paragraphs and discussed the similarities of drug-induced hallucinations, how hallucinations progressed through distinct stages, and the various theories that account for these phenomena. A readability estimate computed using the Fry formula resulted in a placement of the experimental passage at the 14th grade.

Both passages were presented to participants one paragraph at a time on a standard Macintosh II computer. Participants used a mouse to click on one of two arrows to move either forward or backward through the text, one paragraph at a time. A two-paragraph section of the passage and the corresponding questions are shown in Figure 1. The screen displays were created using *Hypercard*. In addition to displaying the text of the passages, the *Hypercard* program recorded the time that each paragraph was displayed and the sequence and number of lookbacks readers made while reading the passages.

Two multiple-choice questions, one literal and one inferential, were generated for each paragraph in the passages. For the purposes of the experiment, the practice passage and the experimental passage were divided into 2–3 paragraph sections. A question from one of the



Note. The computer program randomly selected a multiple-choice item from the pool after participants signaled they had completed reading the section. The paragraph containing information relevant to the item selected was identified as the target paragraph.

Figure 1. Sample section of experimental passage comprised of two paragraphs (consecutive screens) and a pool of two literal and two inferential multiple-choice items.

paragraphs in each section was randomly selected by the computer and inserted at the end of each section. The paragraph containing the information relevant to answering the question was designated the target paragraph and the other paragraphs in a section were designated as the nontarget paragraphs. Questions not selected for insertion into the text of the passage formed a pool of unseen items that were available for use on a posttest following the passage. The posttest consisted of 24 randomly ordered items, 12 of which were identical to those questions selected for insertion into the passage; the remaining 12 were drawn from the pool of unseen items. Whenever possible, depending on a particular participants' performance, there was an equal number of literal and inferential items in each of these question categories for the posttest. The computer program tracked participants' performance on inserted questions and posttest questions.

An important characteristic of the multiple-choice questions was that more than one of the choices for each question could be correct. Thus, as participants were told, a correct response to a question entailed choosing *all* of the correct choices and none of the incorrect choices. The stem of each question was followed by five choices, one of which was "none of these." Thus, as participants were told, a correct response could be one of the choices or as many as four of the choices. Questions were so constructed in order to increase the difficulty of the items. This format for multiple-choice items is also ecologically valid for computer-mediated texts, given the capability of the computer to generate and score such items. Additionally, we believe that this format would improve the items' reliability and validity (e.g., it is less likely that participants would get a correct answer by guessing).

The 2–3 paragraph sections of the experimental passage, each of which was followed by a question, were divided sequentially into three parts according to the following scheme:

Part I
- Section 1 (Paragraphs 1 & 2)
- Section 2 (Paragraphs 3 & 4)
- Section 3 (Paragraphs 5,6, & 7)
- Section 4 (Paragraphs 8 & 9)

Part II
- Section 1 (Paragraphs 10 & 11)
- Section 2 (Paragraphs 12 & 13)
- Section 3 (Paragraphs 14 & 15)
- Section 4 (Paragraphs 16, 17, & 18)

Part III
- Section 1 (Paragraphs 19 & 20)
- Section 2 (Paragraphs 21, 22, & 23)
- Section 3 (Paragraphs 24 & 25)
- Section 4 (Paragraphs 26 & 27)

The three major parts in this scheme corresponded to the counterbalanced order of treatments in the repeated measures design used in this study. In each part there are 9 paragraphs embedded in 3 sections of 2 paragraphs and 1 section of 3 paragraphs. A section with 3 paragraphs was included in each part to discourage participants from expecting a question after every occurrence of 2 paragraphs. Data from the 2 nontarget paragraphs in each of these three sections were averaged in analyses.

Procedures

To recruit participants, the experimenters visited several undergraduate classes providing general information about participating in the experiment and about the Macintosh computer. The presentation took place in a computer lab equipped with 10 Macintosh II computers. Following the presentation, students in the class were encouraged to create pictures on the Macintosh screen with the computer's mouse. Students had little difficulty with this task because most of them had previously taken a course in which they had used a Macintosh computer. During this time, students were also encouraged to sign up for a time to participate in the experiment.

Those who volunteered, returned at a specified time during the following 3 weeks to carry out the experimental activities. When participants reported to the computer lab to participate in the experiment, they were seated at one of the computers where they completed the practice passage, which was specifically designed to insure that participants clearly understood the experimental task and that they were well-practiced in using the computer to carry it out. Specifically, the practice passage emphasized the atypical format of the multiple-choice questions and it clearly illustrated the varying contingencies of the three treatment conditions (described in the next section on design). After completing the practice passage, participants responded to several questions about the experimental task in order to insure they fully understood what they were to do. In addition, one of the experimenters interviewed participants individually about their understanding prior to directing the computer to display the experimental passage. When the experimenter was convinced that a subject understood the experimental task, the experimental passage was displayed and the subject began reading. Before the text of each of the 3 parts was displayed, a screen informed participants as to the conditions under which that part would be read. After reading the experimental passage with inserted questions, participants completed a posttest covering the content of the passage, which was also displayed by the computer. Typically, participants spent 15–30 min completing the practice passage and 60–75 min completing the experimental passage and posttest.

Design

Three treatments comprised the independent variable of interest in the experiment. In each of the three treatments, participants had the option of looking back to any previously displayed text, except while they were answering questions. Treatment conditions varied as to the computer's response when a subject answered an inserted question incorrectly. Treatment conditions varied as follows.

Feedback-only condition. After participants answered an inserted question after a section of the text, they were informed as to whether their response was correct or incorrect. This information was followed by a display of the first paragraph in the subsequent section.

Review/same condition. When an answer was incorrect, the computer required participants to review the previous section from which the question was drawn. A mandatory

review cycle began when a subject was automatically branched from the question back to the first paragraph in that section. After freely reviewing the paragraphs in that section, participants would be given the same question again. This cycle was repeated until the subject responded correctly to the question or missed the question three times, after which the computer would display the first paragraph in the subsequent section.

Review/different condition. This condition replicated the second condition except that each review cycle was followed by a different question. That is, the mandatory review after an incorrect response to a question was always followed by a different question.

A dependent variable was attention to target and nontarget information as measured by the time spent viewing individual paragraphs. Another dependent variable was comprehension of literal and inferential information in the experimental passage as measured by performance on inserted questions and the posttest questions.

Participants served as their own controls in a repeated measures design. Each subject received all three treatments in a counterbalanced order across participants. Data analyses were conducted using analysis of variance (ANOVA) procedures for within-subject designs and *t*-tests for correlated samples.

Results

Questions Missed

Before proceeding with subsequent analyses, we compared the number of questions missed by treatment condition. The means and standard deviations for the treatment conditions were as follows: *feedback only*, $M = 1.78$, $SD = 1.12$; *review/same*, $M = 1.78$, $SD = 1.07$; and *review/different*, $M = 2.31$, $SD = 1.09$. A one-way ANOVA computed on these means indicated that there was a statistically significant difference between the mean number of errors across treatments, $F(2,70) = 4.56$, $p = 01$.

Lookbacks

The computer recorded the number of times participants looked back in the text. Mandatory review by the computer was not counted as a lookback, although participants' decisions to lookback within a mandatory review cycle was counted. The number of participants looking back in the text on their own was 9, 8, and 8 respectively by treatment condition. Sixteen of the 36 participants never looked back under any of the treatment conditions. Because so few participants looked back on their own and those who did look back did so infrequently, lookbacks were not analyzed further.

Reading Time

The computer recorded the time each subject spent viewing individual paragraphs. The purpose for including this measure was to investigate our hypothesis that participants would be more likely to review paragraphs containing target information in the *review/same* condition than in the *review/different* condition. The Hypercard program records

Table 1. Means and Standard Differences in Rate Between Target and Nontarget Paragraphs

	Treatment	
	Review/Same	Review/Different
1st Error		
M	930*	451.31
SD	2727.35	1703.91
	(*n* = 32)	(*n* = 32)
2nd Error		
M	2074.36	756.09
SD	4933.81	2157.53
	(*n* = 24)	(*n* = 24)
3rd Error		
M	1196.46	1041.15
SD	4933.81	1975.42
	(*n* = 10)	(*n* = 10)

**Note.* Values represent words per minute (rate) as computed by the following formula RATE = (3600/no. of "ticks" per paragraph) × (no. of words in paragraph)

time in a unit referred to as a *tick*, which is equivalent to 1/60th of a second. To control for paragraph length, time in ticks was converted to rate (in words per minute) using the following formula:

$$\text{Rate} = (3600/\text{no. of ticks per paragraph}) \times (\text{no. of words in paragraph})$$

Using these values, we computed the difference between reading rate on target and nontarget paragraphs by subtracting the nontarget rate from the target rate. Thus, a positive number indicated that a subject spent proportionately more time reading the paragraph containing information related to the previously missed question. The values for rate were large relative to normal reading rate because after missing a question, participants were likely to engage in reading that has been defined operationally as skimming and scanning (see Carver, 1990). Large values would also be obtained when participants skipped over a paragraph, perhaps to focus on information in another paragraph.

The means and standard deviations for reading rate by treatment condition and error cycle are shown in Table 1. Means were compared using *t*-tests for correlated samples. These analyses revealed a statistically significant difference between the treatment conditions on the 2nd error cycle, $t(23) = 2.77, p < .05$. It

Table 2. Means and Standard Deviations for Percentage Correct on the Posttest Scores

	Treatment					
	Feedback Only		Mandatory Review (same)		Mandatory Review (different)	
Questions Level	Repeated	New	Repeated	New	Repeated	New
Literal						
M	51.86	47.86	75.19	35.36	75.11	29.44
SD	34.93	34.90	31.41	36.45	34.23	36.97
Inferential						
M	46.64	32.50	59.28	24.14	73.39	24.00
SD	35.58	31.51	40.91	29.75	27.22	27.74

should be noted that the *n* decreases in each cycle due to the fact that, after each cycle, some participants responded correctly to the missed item.

Posttest

After participants had completed reading and answering questions inserted in the experimental passage, they completed a 24-question, multiple-choice posttest presented by the computer. Participants were not permitted to lookback at the passage to answer these questions. The posttest consisted of 12 items identical to the inserted questions that a subject had answered while reading (repeated items) and 12 items that had not been answered (new items). These items were selected randomly by the computer from the respective item pools with the stipulation that half of the items in each 12-item set be literal-level questions and half be inferential questions. Because literal and inferential questions were inserted randomly in the passage and because the number of different questions answered varied by treatment condition, it was not possible in every instance for the computer to select an equal number of literal and inferential items within each 12-item set. Thus, raw scores of items answered correctly were converted to percentages.

Participants' means for the percent of questions answered correctly by treatment, question level (literal vs. inferential), and question type (repeated vs. new) are shown in Table 2. A three-way (Treatment × Level × Type) ANOVA for a repeated measures design indicated statistically significant main effects for Level, $F(1, 35) = 15.29$, $p < .001$, and for Type, $F(1,35) = 70.84$, $p < .001$, but not for Treatment, $F(2,70) = 1.08$, $p = .34$.

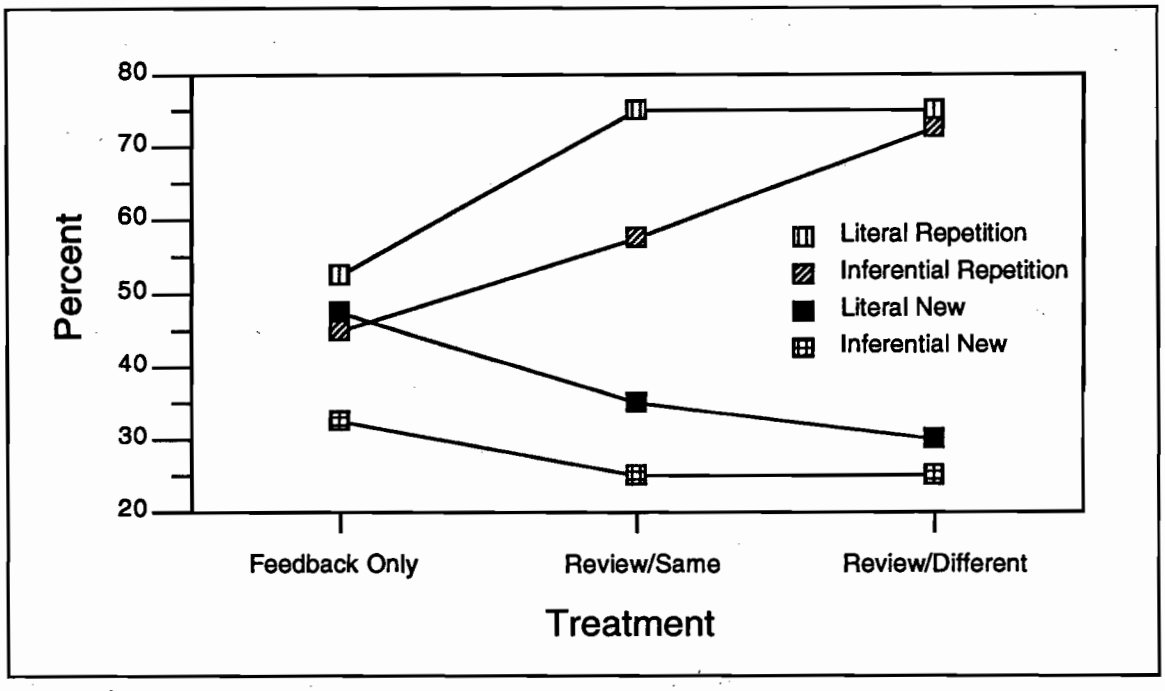


Figure 2. Posttest Means by Treatment, Question Level, and Question Type

However the Treatment by Type interaction was statistically significant, $F(2,70) = 11.969$, $p < .001$. The interaction is shown in Figure 2.

Because the interaction was significant, we conducted post hoc comparisons of treatment means by Level and Type. The Newman-Keuls procedure was used for these analyses. These analyses revealed statistically significant differences as follows.

Repeated literal items. The mean of the *feedback-only* condition (M = 51.86) was statistically different from the *review/same* (M = 75.19) and the *review/different* (M = 75.11) conditions.

New literal items. The mean of the *feedback-only* condition (M = 47.86) was statistically different from the *review/same* (M = 35.36) and the *review/different* (M = 29.44) conditions.

New inferential items. The differences across the three conditions were not statistically significant.

Discussion

The present study investigated the effects of inserted questions in computer-mediated texts that require mandatory review after an incorrect response to a question. We hypothesized that readers who are required to review the text after a missed question are likely to attend more to portions of the text directly

relevant to the question and less to other portions of the text. Furthermore, we hypothesized that a condition in which mandatory review was followed by a different rather than the same question would alter readers' attention to portions of the text. We were also interested in how mandatory review under two question conditions would affect comprehension as measured by literal and inferential posttest questions that were either new or repeated.

Our results support previous research suggesting that mandatory review linked to answering correctly an inserted question increases comprehension as measured by questions directly related to those inserted in the passage. That is, when answering repeated questions on the posttest, participants performed better on questions from the sections of the text in which review was mandatory. However, for new items, participants tended to score less when they were reading in one of the mandatory review conditions as opposed to the *feedback-only* condition. Nonetheless, the only statistically significant difference was between the *feedback-only* and the *review/different* conditions for the new literal items. These findings are consistent with previous studies, which found that mandatory review produces greater learning of information related to the questions, but less learning of information not specifically addressed by the questions (see Tobias, 1987, 1988). In the present study, however, this finding held only for the information tapped by the literal-level questions when answered by participants faced with a different question after reviewing the text.

The posttest scores provide additional evidence that a different question inserted after mandatory review affected comprehension. Participants answered more repeated inferential questions correctly when they received a different question after a mandatory review. When participants knew that a different question would follow their review, they may have processed the information more holistically rather than attending to specific facts in their attempts to answer an individual question. This interpretation is supported by the fact that participants performed more poorly on new literal questions drawn from the sections of the text in which an error was followed by a different question.

These results might be explained further by Battig's (1979) theoretical position that individuals use different learning strategies when "materials are particularly difficult or presented under conditions of high inference" (p. 24) and that the strategy invoked will have a distinct affect on delayed retention (see also Kintsch, 1986). The *review/different* condition in the present experiment may have induced participants to adopt a strategy consistent with difficult texts requiring high inference. The higher scores on repeated inferential questions are consistent with this explanation. Similarly, previous studies have found that readers tend to recall more inferential or applied information and sometimes less literal information under conditions that require more cognitive effort during reading (Bromage & Mayer, 1981; Mannes & Kintsch, 1987; Perrig & Kintsch, 1985). The lower scores on new literal questions in the *review/different* condition when compared to the *feedback-only* condition are consistent with these findings.

There was some support for our hypothesis that participants would attend more to target paragraphs when they knew that the same question would follow their review. As shown in Table 1, the discrepancies between the time spent reviewing the target and nontarget paragraphs in the two review conditions was in the predicted direction after each error. However, the relatively large variance in these times militated against finding statistically significant differences between these conditions except after the second error. Interestingly, the standard deviations are considerably larger in the *review/same* condition than in the *review/different* condition.

There are several possible explanations for these results. It is possible that after a first error in both conditions, participants reread carefully the entire section, albeit with a different orientation as indicated by the differences on the posttest between repeated literal and repeated inferential questions. Or, if participants were looking for specific information in the *review/same* condition, they were not as efficient in locating it after the first error. After a second error, however, participants were either inclined to scan quickly for information that would enable them to answer the same question or perhaps they were more efficient in locating the relevant information. The lack of a strong difference after the third error may be a function of participants' frustration or perhaps the fact that the number of participants who missed questions a third time was relatively small. The smaller standard deviations in the *review/different* condition suggest that participants used a more consistent review strategy in that condition.

Several limitations must be taken into account in interpreting the results of the present study. First, the questions were designed to be difficult in order to insure that errors would be made. Additionally, the format of the multiple-choice questions was not typical of paper-and-pencil tests, although participants were given ample opportunity to practice answering the questions before data were gathered. The difficulty of the experimental task may have led some participants not to make an honest attempt to answer the questions correctly. For example, in checking the time data we discovered that 8 of 32 participants spent less than 3 seconds per paragraph during their review after the first error. When these participants were removed from the analysis, the mean differences in the discrepancy between the target and nontarget paragraphs for the *review/same* and *review/different* conditions was statistically significant after the first error, $t(23) = 2.10$, $p < .05$. Another limitation, perhaps related to the same phenomenon, is that participants missed more questions in the *review/different* condition. They may have been frustrated by the added difficulty of that condition and may have been more likely to give up. We also believe that participants' low number of spontaneous lookbacks regardless of treatment condition may reflect the difficulty of the experimental task.

Additional research is needed to address these limitations and to investigate the alternative explanations of the results reported here. Nonetheless, the present study adds to a growing body of research suggesting that the computer's capability to alter the normal contingencies of reading associated with printed texts

may affect readers' processing strategies. Specifically, the present study suggests that varying the contingencies associated with responses to questions inserted in computer-mediated texts may affect readers' strategies and consequently the information they recall from the text.

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