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The Benefits of Embedded Question Adjuncts for Low and High Structure Builders

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The effectiveness of two types of adjunct questions, standard embedded questions and "why" questions (elaborative interrogation), was investigated for readers differing in structure-building ability (Gernsbacher, 1990). Participants read a textbook chapter either with or without the adjunct questions. Learning was assessed with typical classroom testing methods (multiple choice, short answer). Also, relatedness ratings were used to assess the coherence of learners' representations. High structure builders generally outperformed low structure builders. However, embedded questions but not elaborative interrogation improved the low structure builders' test performances on information targeted by and related to the adjunct questions. Neither study method improved test performance for the high comprehenders. Embedded questions also stimulated more coherent representations. Results indicate that embedded questions are an effective study method for low comprehenders.

Key words: embedded questions, elaborative interrogation, structure building, reading comprehension, individual differences

Comprehending written material is essential in academic settings. Accordingly, the educational psychology literature is replete with research evaluating text adjuncts intended to help students learn (e.g., see Hamaker, 1986; Hamilton, 1985; Mayer, 2003). Less well investigated is the extent to which the benefits of various text adjuncts might vary as a function of students' comprehension abilities. Findings from the basic memory literature suggest that students' comprehension abilities are critical in determining the benefits of certain text presentations. For instance, Waddill and McDaniel (1992) examined embedded pictures depicting either detail or relational information and found that readers classified as less skilled improved their recall of details with the use of pictures depicting details, whereas those classified as moderately or highly skilled were able to use relational pictures to improve recall of both detail and relational information. Likewise, McDaniel, Hines, and Guynn (2002) demonstrated an interaction between text format and learner characteristics. For comprehenders assessed as low structure builders (Gernsbacher, 1990), text presentations that required readers to reorganize incoherently ordered sentences improved recall relative to an intact text presentation, whereas text with letters deleted from words did not improve their recall relative to the intact text. For high structure builders, a somewhat different pattern of text presentation effects emerged.

These interactions between comprehension ability and laboratory-based text manipulations raise the possibility that such interactions may be important for understanding and predicting benefits of text adjuncts that can be applied in educational settings. Indeed, textbook publishers seem to implicitly, if not explicitly, embrace this idea. For example, book editors encourage authors to include study questions (embedded questions) with the chapters for textbooks aimed at junior/community colleges, whereas they do not request that of books aimed at 4-year colleges or upper division classes (H. L. Roediger, August 2005, personal communication). The largely untested assumption (though see Hamilton, 1986; Hollen, 1971) is that students at community colleges may need more help in comprehending the text, whereas those in upper division courses are thought to have the skills necessary to comprehend the text without the use of study questions.

Accordingly, we focused on two text adjuncts that have received attention in educational psychology—embedded questions and elaborative interrogation—but for which interactions with comprehension ability have not been widely investigated. Specifically, the present study investigated the role of individual differences in comprehension in determining the benefits of embedded questions on the learning and retention of content of educational texts. To support generalization to classroom settings, we used criterial tests of learning that are representative of the classroom. Before outlining predictions, we briefly review the extant findings relating to the types of embedded questions investigated herein and then describe the comprehension-ability domain on which we focus.

Embedded Questions and Elaborative Interrogation

Embedded questions have been used widely both in classrooms and in research and have generally been shown to be effective in enhancing memory of prose (Bing, 1982; Dowaliby, 1990; Hamilton, 1985). Hamaker (1986) established that embedded questions have a positive effect on criterial assessments focused on the same

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content as the embedded questions. The general effectiveness of embedded questions placed after the pertinent section of text is well established, but the influence of individual differences in comprehension ability on the effectiveness of this method has been largely overlooked. Two reviews of the literature on the effects of adjunct questions (Hamaker, 1986; Hamilton, 1985) did not include learner characteristics as variables in their analyses. Moreover, the few studies that have addressed this issue have not yielded a clear-cut pattern. Hollen (1971) measured reading ability with associative memory, chunking memory, memory span, and vocabulary and found that embedded questions aided the lower ability readers and eliminated any advantage the higher ability readers had. Shavelson, Berliner, Ravitch, and Loeding (1974) also found an interaction between ability and question, with readers who had poor vocabularies benefiting more from adjunct questions than readers with good vocabularies. By contrast, Hamilton (1986) used a test of prior knowledge, a test of problem-solving ability, and the Reading Efficiency subtest from the Iowa Silent Reading Test to evaluate reading ability. Adjunct questions were ineffective for both groups. Similarly, Bing (1982) found no interaction between ability and adjunct questions.

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In light of Hamilton's (1986) and Bing's (1982) findings and stimulated by more recent work, in the present experiment we also investigated the effectiveness of a newer type of embedded question: elaborative interrogation (EI). EI consists of readers answering "why" questions while learning new material. The process of answering these questions enables students to recall more studied facts presented in lists (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987) and to better answer test items requiring inferences about target concepts presented in short paragraphs (McDaniel & Donnelly, 1996). It is thought that EI works by activating prior knowledge to relate the new ideas to information that is already known (Woloshyn, Pressley, & Schneider, 1992) and to help form connections between the items that are being learned (Seifert, 1993). These findings raise the possibility that EI could be fruitfully applied to longer passages. However, Seifert (1993) argued that the effectiveness of EI might be reduced in extensive texts, because once the facts are embedded in paragraphs, the context potentially augments the meaning.

Two studies have applied EI to standard educational materials. Boudreau, Wood, Willoughby, and Specht (1999) used an eight-page passage from a textbook that discussed early childhood education and found that EI may be beneficial, but students need more support or guidance with the method when they first encounter it. Ozgungor and Guthrie (2004) attempted to determine variables that could influence the effectiveness of EI by using a 1,500 word article from *Scientific American*. The authors found that less knowledgeable and less interested students benefited from the strategy more than did those with more knowledge. This interaction suggests that individual differences may alter the effectiveness of text adjuncts, in this case EI.

Individual Differences in Structure Building

As researchers and educators attempt to find new ways to help students learn, the wide range of comprehension ability among students is often not taken into consideration. An innovative feature of the present study is that we focus on comprehension skills that relate to structure building (Gernsbacher, 1990). The structure-building construct arises from Gernsbacher's (1990) emphasis that comprehension involves building a coherent structure out of the information. This process involves laying a foundation with the initial information that is read and mapping the new information onto the existing structure. When information is encountered that is not conceptually related to the existing structure and cannot be mapped onto it, the reader shifts and builds a new substructure. This is done repeatedly throughout the text resulting in a mental representation, or structure, of the text. According to Gernsbacher, poor structure builders are unable to inhibit irrelevant information. As a result, the reader maintains information that will not fit into an existing structure, so the reader must shift and build a new substructure. As a result, the reader shifts too often and builds too many substructures. Consequently, this type of comprehender loses access to recently encoded information and builds a less coherent structure. As amplified below, we thought it possible that embedded question text adjuncts might link well to these deficient processes and, accordingly, that structure building could be an important individual difference variable in determining the effects of such adjuncts.

Assessment of structure-building ability was carried out through the Multi-Media Comprehension Battery (MMCB; Gernsbacher & Varner, 1988). The MMCB reflects two major changes from speeded reading measures like the Nelson-Denny Reading Test (NDRT; Brown, Fishco, & Hanna, 1993; a common measure of reading comprehension used with high school and college students). First, it allows readers as much time as they need to read through the passages. Second, unlike in the NDRT, in the MMCB the passage is not available to the reader when answering the questions, therefore placing a premium on the mental representation of the text for question answering. Therefore, performance on the MMCB appears to place relatively more emphasis on the quality of the structure that readers can construct from passages they have completed.[1]

Fn1

[1] Certainly the comprehension abilities captured by the MMCB overlap somewhat with abilities captured by more commonly used reading ability measures; previous research has found significant correlations between the MMCB and the NDRT (r = .46; R. H. Maki, Jonas, & Kallod, 1994; see also, Brown, Fishco, & Hanna, 1993) and the verbal portion of the SAT (r = .64; Gernsbacher, 1990). However, the moderate value of these correlations implies that the MMCB is sensitive to aspects of comprehension ability not captured by these measures. Specifically, the MMCB appears to diverge from the NDRT in terms of the degree to which reading efficiency contributes to performance. The NDRT (as well as the verbal SAT), by definition a speeded test (for criteria, see Pomplun, Frey & Becker, 2002), emphasizes in part efficiency of lower level reading skills such as with word-decoding processes (i.e., low scorers on the NDRT appear to be challenged with word decoding; see Mason, 1978; McDaniel et al., 2002; Petros, Bentz, Hammes & Zehr, 1990). The suppressed scores of poor readers are not necessarily because of inadequate mental representations constructed during reading; instead, the poor readers are able to process less text in the allotted time. In line with this idea, when given the extended time version of the reading test, poor readers improve their performance (Baldwin, Murfin, Ross, & Seidel, 1989; Jensen, 1998). Further, when poor NDRT readers are given as much time as they need on passages, their free recall (an index of the coherence of a mental representation of a text) is at the level of the more able NDRT readers (McDaniel et al., 2002). Generalizing beyond the NDRT, factor analyses have revealed that other standardized reading tests (the study included the NDRT as well) measure the efficiency of reading, which is largely influenced by reading rate (Carver, 1992).

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Accordingly, by using the MMCB, the present study focused on an individual difference factor not investigated in previous work on embedded question adjuncts. Specifically, prior studies with embedded questions have either assessed efficiency of reading ability (Hamilton, 1985) or combined reading ability with other measures to obtain an assessment of general ability (Bing, 1982; Hollen, 1971; Shavelson et al., 1974). Studies with EI and individual differences have examined the effects of different amounts and types of prior knowledge (Ozgungor & Guthrie, 2004; Woloshyn, Paivio, & Pressley, 1994), interest in the text (Ozgungor & Guthrie, 2004), age (with reading ability covaried out; Wood et al., 1999), and gifted versus average elementary-grade students (Gaultney, 1998). We expected that the structure-building ability reflected by the MMCB would generally impact learning performance on educational texts, and we were interested in whether EI and embedded questions adjuncts would be differentially effective for readers varying on structure-building ability.

Predictions

To allow understanding of the predictions, we first briefly describe the design. A social psychology chapter was used for the text. Participants either read through the chapter and answered questions (standard embedded questions or EI questions) as they read or read through the chapter without answering questions. Multiple-choice and short-answer items were the criterial measures. The items on the criterial tests were categorized by the type of information that was necessary to answer them. The multiple-choice test consisted of items that targeted information that was used to answer the embedded or EI questions, items related to the embedded or EI questions, and items not at all related (nontarget). The application test was similar but consisted only of target and nontarget items. In addition to these standard criterial tests, we included a more sophisticated measure of learning, relatedness ratings, which assess the integration or coherence of learning that has occurred (Goldsmith, Johnson & Acton, 1991).

We predicted that the effects of traditional embedded questions would vary as a function of individual differences in structure-building ability. Because low structure builders keep unnecessary information activated (Gernsbacher & Faust, 1991), these learners would presumably benefit from identification of anchoring information around which to build a coherent representation. Embedded questions orient the learner to specific information that could act as an anchor (Mayer, 2003). Thus, embedded questions should improve low structure builders' performance on target test items, as the embedded questions require the reader to focus on that material. Further if the questions change the entire structure being built (by providing an anchor), then the benefits could extend to the nontarget and related test items and improve coherence as well (assessed by the relatedness ratings). In contrast, high-ability structure builders may show little benefit of embedded questions because these readers are already able to identify concepts around which to anchor their representations.

Regarding the EI adjunct, one possibility is that the more capable structure builders are more likely than less able structure builders to have the skills and background knowledge (general knowledge is significantly correlated with reading skill; cf. McNamara & McDaniel, 2004) necessary to perform EI. However, according to a recent finding that EI is effective with low-knowledge readers (Ozgungor & Guthrie, 2004), EI could improve performance even for the low-ability readers. Alternatively, given the use of an educational text, EI may not be effective for either low or high structure builders (cf. Boudreau et al., 1999). As discussed above, it is possible that a textbook provides sufficient explanatory elaboration, thus making the explanatory activity stimulated by EI redundant (Seifert, 1993).

One final feature of the present experiment warrants mention. We examined the effects of embedded questions and EI against a control in which the participants read the text twice. One overlooked aspect of embedded questions, EI, and other study methods is that they often require more time than simply reading the text. Many studies that have espoused the benefits of one method or another have not addressed or controlled for the amount of time spent with the text (McDaniel & Donnelly, 1996; McNamara, 2004; Seifert, 1993; Woloshyn, Willoughby, Wood, & Pressley, 1990). Generally, the controls read the text once, and the experimental groups read the text once plus engaged in additional processing required to answer the embedded questions. When positive effects of embedded questions are found, one cannot be sure whether the embedded questions encourage processing that leads to better retention or if differences in study time per se underlie better retention (i.e., no special benefit of embedded questions).

To eliminate less interesting study time explanations of possible effects, in this experiment we used a read-twice control. It is a particularly useful control in this experiment because a previous study using a variation of the text used in this experiment found that rereading provided no benefit over reading once on short-answer and multiple-choice test items (Callender & McDaniel, 2006). Because of students' reports that rereading the text is a common study method (Carrier, 2003; Goetz & Palmer, 1991), for applied reasons it is important to show that embedded question methods are effective above and beyond simply rereading the text. If these study methods can be shown to be more effective than rereading, then educators will be in a stronger position to advocate more potent study methods over those that students spontaneously use.

Method

Participants and Design

The participants who completed the experiment were 84 undergraduate students between the ages of 18 and 25 at the University of New Mexico or Washington University in St. Louis who were enrolled in their university's Introduction to Psychology course. All participants had not yet covered the social psychology chapter in their course at the time of participation. Of the 84 participants in the study, 45% of participants were male, and 55% of participants were female. Six of the participants in the embedded questions and EI groups and 5 of the participants in the control group were from Washington University in St. Louis. Participants were given class credit for participating in the experiment. Participants who scored in the middle comprehension range were excluded from this study. A total of 131 students were tested to yield the 84 who met the comprehension-ability criteria (see below) or who had not taken a social psychology class (the content of the study material).

The experiment was a 2 (reading level) $\times$ 3 (reading condition) between-subjects design. Reading comprehension level was eval-

uated with the MMCB (Gernsbacher & Varner, 1988). A fully text-based version of this test was adapted for the computer, which involved reading four stories and answering 12 questions immediately after each story for a total of 48 possible points. According to preexisting cutoffs determined by a previous study (McDaniel et al., 2002), participants were grouped into low or high comprehenders (below 32 = low, 36 and above = high). Participants were placed in one of three reading conditions: a twice-read control, embedded question group, and EI group. In the control and EI conditions, there were 14 low and high comprehenders in each group, and the embedded questions group had 15 low and 13 high comprehenders.

Materials

The passage used was a chapter on social psychology taken from an introductory psychology textbook (Crooks & Stein, 1988). All pictures and commentary were removed from the chapter, as were some sections, to shorten the text to make it more readable in the allotted time. The text was approximately 16 pages long with extra pages added to allow for placement of the embedded or EI questions.

As noted in the introduction, a pilot study using a version of the same text indicated that rereading the passage provided no benefit as compared with reading once. Reading twice was no more effective than reading once as assessed by both a multiple-choice test (*M*s = .70 and .69, respectively; $F < 1$) and a short-answer test requiring application (*M*s = .83 and .84, respectively; $F < 1$).

The embedded questions and EI questions paralleled each other. For example, one embedded question asked, "What is a scapegoat?" and the parallel EI question asked, "Why do we scapegoat?" Students were provided with a piece of paper on which to write their answer. For purposes of generality, two sets of embedded or EI questions (sets A and B) that targeted different information were used. Questions were placed throughout the text, about every two pages. All participants included in the study answered the questions. Note that for all text questions, students could not use them as advance organizers, as each set of embedded or EI questions referred to material on the one to two previous pages. The data of 1 participant who acknowledged paging ahead to answer the questions were discarded from the study. Answers to the embedded and EI questions were scored on a 3-point scale: A zero indicated the question was not answered or was incoherent or incorrect, a 1 indicated the question was answered satisfactorily (was coherent and correct), and a 2 indicated the answer not only was coherent but also elaborated upon the principle in some way (i.e., application or further explanation).

Criterial tests consisted of a 12-item multiple-choice test and an 8-item application/short-answer test. The multiple-choice test was divided into 4 items that directly targeted the information from the adjunct questions, 4 items that were related to the adjunct questions, and 4 items that were completely unrelated to the adjunct questions (and are labeled *nontarget*). Likewise, the application test was divided into 4 items that targeted the information from the adjunct questions and 4 items that were unrelated to the adjunct questions. Each application item was worth 2 points to allow for more discriminating scoring, for a total of 16 possible points. The questions were scored on a 3-point scale: A 0 indicated the question was not answered or was incoherent or incorrect, a 1 indicated the question was answered satisfactorily (was coherent and correct), and a 2 indicated the answer not only was coherent but also elaborated upon the principle in some way (i.e., application or further explanation). This scoring scheme, used previously in the embedded questions and EI literature (Cordon & Day, 1996; Durgunoglu, Mir, & Arino-Marti, 1993; Kozminsky & Kozminsky, 2001; Seifert, 1993) was adopted because it was apparent that some correct answers were more complete or included further elaboration or application of the concept (see Appendix A). Two raters scored the answers: One rater randomly scored answers for half of the participants, and the other rater scored all of the answers. Scores were correlated, and interrater reliability was high ($r = .90$)

Two versions of the tests for each of the two sets of embedded and EI questions were used; thus there were four versions of the criterial test. For each set of the embedded or EI questions, the first version of the test targeted four of the embedded questions in the multiple-choice and application/short-answer tests. The second version of the test reversed which questions were targeted by the multiple-choice and application tests. These variations in question set and criterial tests were counterbalanced across participants in each reading condition and comprehension-ability level (see Appendix B).

Last, a relatedness rating task was developed to evaluate the structure of the concepts that the participants built out of the text. Two sections of the text (one covering prejudice and stereotypes and the other covering interpersonal attraction) were used in this task. Nine terms were taken from each section. For each section, all possible combinations of terms plus six randomly chosen repeats were presented with a 5-point Likert scale. Participants were told to rate the relatedness of each pair of terms, with 1 meaning *unrelated* and 5 meaning *highly related*. They were told to make their rating quickly and intuitively and to use all of the numbers in the scale.

Through use of Pathfinder (Schvaneveldt, 1990), the relatedness ratings determined the proximity among concepts, and the proximity matrix in turn was reflected in a network structure (with each concept represented by a node; Goldsmith et al., 1991). In this case, we looked specifically at the coherence of the proximity data, which correlates with the degree of learning of a specific subject. Coherence reflects the consistency of the ratings and is obtained by correlating a derived measure of relatedness with the original proximity data. This correlation is the measure of coherence we used in this study.

Previous research has shown the MMCB to be highly reliable ($\alpha = .987$; Gernsbacher, Varner, & Faust, 1990). We calculated split-half reliability on the text version of the MMCB that we used to be .77. We also assessed the reliability of the criterial tests as suggested by a reviewer of this article, though there is little precedence for acceptable levels of reliability for educationally relevant multiple-choice questions used for research purposes. We calculated Cronbach's α to be .63 for the multiple-choice questions and .68 for the application questions. To establish that the content of the test questions used in the experiment were representative of content students might encounter on a classroom test, we consulted test banks prepared for the social psychology chapter of various introductory textbooks. Nearly all of the questions in our tests (100% of the multiple-choice questions and all but two of the application questions) probed content identical to that targeted by

summative assessment questions prepared for educational purposes.

Procedure

Participants were brought into the lab and were provided with an informed consent form to sign. Participants then took Gernsbacher's MMCB. At the end of the test, each participant was assigned to reading condition (read twice control, embedded questions, or EI questions) according to reading ability so that there were equal numbers in each of the conditions. Participants in the control group were instructed to read through the text two times.[2] Participants in the experimental groups were instructed to read through the text and to answer each question as they reached it in the text. All participants were timed, however they were told to take as much time as needed and to not rush through the text. Upon completing the reading, they were distracted with math problems for 2 min. They were then presented with the criterial tests. They were instructed to answer the application items first, then the multiple choice, and last to do the concept ratings. Participants were then debriefed and dismissed. The session lasted for approximately 1.5 hr.

Results

Analyses were performed with the proportion of correct answers as the dependent measure. A set of initial ANOVAs was performed to ensure that there were no concomitant effects of counterbalancing condition or question set. For the application test, there were no significant effects (all Fs < 1) for both main effects of question set and counterbalancing condition and the interaction. The same held for the multiple-choice test, largest $F(3, 80) = 2.57$, $p = .11$.

To determine whether the reading difficulty of the embedded questions differed across type of question (embedded or EI), we calculated the Flesch Reading Ease Index for each question (scores range between 0 and 100, with 100 meaning *easiest* and 0 meaning *most difficult*). There was no significant difference between readability for the embedded questions ($M = 40.13$, $SD = 26.20$) and EI questions ($M = 42.56$, $SD = 24.60$, $F < 1$).

We also performed an ANOVA investigating the effects of study condition on the number of minutes participants spent processing the text. Study time (measured in minutes and seconds) did not differ significantly ($M_{control} = 43$ min, 56 s, $SD = 9$ min, 03 s; $M_{embedded} = 39$ min, 33 s, $SD = 14$ min, 15; $M_{EI} = 48$ min, 33 s, $SD = 17$ min, 13 s), $F(2, 81) = 2.93$, $p = .06$, and, further aiding interpretation of effects reported below, the group that took the least amount of time was the embedded questions group.

Criterial Test Performance

We used a planned comparisons approach to test a priori hypotheses. First, we tested the effects of reading ability on performance on the two criterial tests. We then performed contrasts of each experimental group (EI or embedded) against the control group on each type of question (target, related, or nontarget for multiple choice and target and nontarget for application/short answer) for low- and high-ability readers. This resulted in 13 comparisons for the multiple-choice test and 9 comparisons for the short-answer test. We adopted an experimentwise error rate for the planned comparisons of each criterial measure (multiple choice, short answer) comparable to that had we used an omnibus ANOVA approach for each criterial measure (i.e., an experimentwise error rate of .35, based on the seven effects tested in a three-factor ANOVA, in this case, Study Condition × Reading Ability × Question Type). Accordingly, the rejection level was set at .027 for all contrasts involving multiple-choice questions and .044 for all contrasts involving application questions. We calculated effect size using Cohen's d, and the effect size is reported after each significant contrast.

Reading ability. The first two contrasts evaluated performance on multiple-choice and application questions by the ability of the reader. The multiple-choice questions revealed a significant effect of reading ability, with low-ability readers ($M = .62$, $SD = .20$) performing worse than high-ability readers ($M = .78$, $SD = .16$), $F(1, 82) = 17.60$, $p = .00$, $d = .92$. Analysis of the application questions revealed a similar effect of reading ability, with low-ability readers ($M = .42$, $SD = .17$) performing worse than high-ability readers ($M = .56$, $SD = .19$), $F(1, 82) = 12.69$, $p = .001$, $d = .78$

Multiple-choice test. We further tested each of the study methods against the control group for low- and high-ability readers for each type of multiple-choice question (see Table 1). First, for the low-ability readers, we tested the target multiple-choice questions to see whether the study methods help on the material directly addressed by the embedded and EI questions. A significant effect was found for the embedded questions group, with those answering embedded questions performing better than controls, $F(1, 29) = 7.83$, $p = .009$, $d = .67$. We then tested the related questions to evaluate transfer to information not specifically addressed by the study questions. Again, we found an effect of embedded questions, with those answering the questions performing better than controls, $F(1, 29) = 7.83$, $p = .009$, $d = .92$. We then tested the nontarget questions to evaluate transfer to completely unrelated information, and no significant effects were found. The low-ability readers also improved performance on target questions when answering EI questions, $F = 5.03$, $p = .033$, $d = .57$. Although this contrast just missed the a priori significance level, it is significant by the traditional .05 rejection level. More important, however, is the effect size was medium, bordering on high (Cohen, 1992).

High ability readers showed a different pattern of results with only one significant contrast, revealing that those in the control group performed better than those in the embedded questions group when answering nontarget questions, $F(1, 27) = 6.20$, $p = .001$, $d = .99$. There were no significant effects of EI for high-ability readers.

Application/short-answer test. We performed a similar set of contrasts for application questions, first testing target questions

[2] Participants in the control condition were not directly monitored while they were reading. Consequently, a reviewer of this article was concerned whether participants performed in the control as intended. To provide some assurance that participants generally read the text twice as instructed, we instructed an additional 13 participants from the same subject pool to read the text once. These participants spent significantly less time reading the text once ($M = 31$ min, 36 s) than did the control participants who were instructed to read the text twice ($M = 43$ min, 56 s), $F(1, 39) = 20.24$, $p = .00$. This pattern is consistent with the assumption that control participants read the text twice.

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Table 1
Mean Performance on Multiple Choice Questions by Ability and Question Type

	Low comprehenders			High comprehenders		
Question type	Control	Embedded	EI	Control	Embedded	EI
Target	.54 (.35)	.75 (.24)*	.71 (.24)	.84 (.21)	.83 (.19)	.84 (.25)
Related	.46 (.24)	.68 (.24)*	.54 (.26)	.68 (.25)	.75 (.25)	.75 (.22)
Nontarget	.59 (.29)	.67 (.28)	.61 (.25)	.88 (.16)	.67 (.24)*	.80 (.22)
Mean	.53 (.22)	.70 (.18)	.62 (.16)	.80 (.15)	.75 (.16)	.80 (.18)

Note. All comparisons are against the control group. Standard deviations are in parentheses. EI = elaborative interrogation.
* $p < .027$

T2 and then nontarget questions (see Table 2). For target questions, low comprehenders who answered the embedded questions performed better than controls, $F(1, 29) = 8.60$, $p = .007$, $d = .81$. There was no effect of study method for nontarget questions.

High-ability readers again performed more poorly on nontarget questions when answering embedded questions as compared with controls, $F(1, 27) = 4.46$, $p = .04$, $d = .53$. Again, there was no effect of EI for either target or nontarget questions for high ability readers.

Relatedness Ratings

The relatedness ratings were analyzed with Pathfinder. This resulted in a correlation that depicted the coherence of each individual's set of ratings. The first analysis performed was a reliability check on the measure. In each rating task, six pairs were repeated. Correlations were obtained for each of the pairs that were repeated. The measures were reliable, with five of six of the repeated pairs correlating significantly at a .05 level for each set of ratings.

A separate ANOVA was performed on each of the two sets of correlations, one for attraction and one for prejudice. Study method and structure-building ability were included as variables in both ANOVAs. Data for 2 participants were not included in the prejudice ratings analysis because they did not complete the task correctly. Data for 5 participants were not included in the analysis for attraction ratings for the same reason.

The ANOVA for the ratings for pairs of terms from the section on prejudice did not reveal any significant effects, largest $F(5, 77) = 1.12$, $p = .33$. The results for the attraction ratings did, however, show a significant effect of study method, $F(5, 75) = 4.03$, $p = .02$. Upon examination of the means, it was apparent that embedded questions resulted in more coherent representations of the text ($M = .38$, $SD = .23$) than the methods used in the control ($M = .26$, $SD = .30$) and EI ($M = .18$, $SD = .26$) groups. Individual comparisons (with Bonferroni correction for multiple comparisons) showed a significant difference between the means of embedded questions and EI ($p = .02$, $d = .81$). Structure-building ability, however, did not significantly affect coherence.

Embedded Questions/EI Answers

The means presented are proportions of answers correct (see Table 3). Because a 1 indicated a satisfactory answer, a mean of T3 .50 indicates the questions were answered correctly and satisfactorily, whereas a mean of 1 indicates exceptional answers. An ANOVA was performed on the data, with reading ability and study condition included as variables. There were no significant results (largest $F = 1.68$, $p = .20$). Examination of the means indicates that questions were answered correctly and coherently.

Discussion

This research revealed several novel findings. First, we established the applicability of the MMCB to educational issues, finding that it is a useful measure to evaluate individual differences in expository text comprehension. On the basis of the reading ability findings, we found that low-ability readers benefited from study adjuncts, whereas high-ability readers did not. Embedded questions appear to be useful to improve memory for text for low structure builders but not for high structure builders. EI enables low structure builders to comprehend and remember information directly targeted by the adjunct questions. Again, high structure builders were not helped by the EI study adjunct. Each of these findings is discussed in turn.

Table 2
Mean Performance on Application Questions by Ability and Question Type

	Low comprehenders			High comprehenders		
Question type	Control	Embedded	EI	Control	Embedded	EI
Target	.40 (.21)	.59 (.24)*	.45 (.13)	.57 (.26)	.54 (.20)	.67 (.19)
Nontarget	.40 (.18)	.42 (.25)	.28 (.12)	.60 (.22)	.47 (.29)*	.53 (.23)
Mean	.40 (.19)	.49 (.20)	.37 (.10)	.59 (.20)	.50 (.19)	.60 (.18)

Note. All comparisons are against the control group. Standard deviations are in parentheses. EI = elaborative interrogation.
* $p < .044$

Table 3
Mean Performance on Answers to Embedded and Elaborative Interrogation (EI) Questions by Ability

Condition	Low comprehenders	High comprehenders
Embedded	.54 (.17)	.59 (.18)
EI	.53 (.18)	.49 (.19)

Note. Standard deviations are in parentheses.

For the first time in the literature, we tested whether individual differences in structure-building components of comprehension as assessed by the MMCB would impact learning from text-based classroom type materials (but see W. S. Maki & Maki, 2002, for other classroom applications). We found that, overall, low structure builders performed worse than the high structure builders on tests of learning and memory for textbook content. Until now, considerations of individual differences in structure building as gauged by the MMCB have been limited to the experimental psychology literature. The MMCB and the accompanying structure-building framework have not penetrated to the educational psychology arena, probably because the battery has been based on narrative comprehension, and the accompanying theoretical work has focused on the relation of basic cognitive processes like inhibition to structure building. Nevertheless, a primary ingredient for learning from any text is the ability to build a coherent mental representation of the text (Kintsch, 1988; Rapp & van den Broek, 2005). The present findings confirm the theoretical expectation that structure-building ability is related to learning outcomes on didactic materials.

From an educational perspective, sensitivity to student variation in structure building (e.g., using the MMCB) may help identify students for whom additional learning support. Additional measures with diagnostic capabilities (like the MMCB) are of use only if there is a method in place to aid those who perform poorly. This point leads to the major objective of the current study. Do traditional embedded questions or more recently developed EI techniques or both benefit low structure builders, perhaps differentially from high structure builders? We discuss the embedded question results first, followed by discussion of the EI results.

Embedded Questions

The results supported the predictions outlined at the outset. Embedded questions that focused readers on explicit text content benefited low structure builders. Important for educational implications, with embedded questions, the performance of the low structure builders improved to the level of high structure builders. The benefits for low structure builders were also observed on criterial questions that were related to the concepts addressed by the embedded questions, but not directly targeted by the embedded questions. In contrast, such questions did not produce gains for high structure builders compared with control conditions in which high structure builders spent equivalent time reading the text.

One concern in the literature has been whether the effect of embedded questions, when found, is due to the processing stimulated by the questions or to an increase in the time spent processing the text (Carver, 1992; Peeck, 1970; Rothkopf, 1974). Faw and Waller (1976) suggested that one must look at both the performance on criterial tests as well as time spent with the text. In the present experiment, the positive benefit of embedded questions on learning (for the low structure builders) was clearly not because of increased time spent on the text. Indeed, participants in the embedded question group spent less time processing the text than did the rereading control group (although not significantly so). Thus, embedded questions were efficient at producing the observed levels of learning (relative to reading twice). For low structure builders at least, answering embedded questions can improve performance on criterial tests without requiring more time than rereading the text, a commonly used study strategy (Carrier, 2003; Goetz & Palmer, 1991).

The present study does not conclusively pinpoint the particular processes through which embedded questions improve learning and retention for low structure builders, but one tentative idea is that the questions preclude the activation of irrelevant information during comprehension of the segments of the textbook chapter. According to this explanation, embedded questions would foster fewer competing substructures being built, which would allow the low-ability structure builder to construct a more coherent mental representation of the target material. Specifically, embedded questions provide the reader with anchoring points for constructing a focal mental representation. Consequently low structure builders may not spend as much effort processing provisional mental representations that are off target.

The critical idea is that embedded questions promote a more coherent representation of the text for low structure builders, which these readers cannot accomplish on their own. This finding is corroborated by the relatedness ratings collected for the section on attraction. Embedded questions enabled individuals to create representations of the text that revealed a greater degree of learning, possibly through providing better anchor points for building a more coherent structure. This finding is consistent with the prediction that low structure builders will be helped by embedded questions, whereas high structure builders will not.

The results indicate that embedded questions may be a richer, more potent strategy that leads to more learning and a better mental representation of the text than previously thought, though we offer this interpretation cautiously. The caution arises from two considerations: First, the relatedness ratings showed benefits of embedded questions for one but not the other section of the text. Further, if low comprehenders did improve the coherence of their representation, it might be argued that the effects should have generalized to the nontarget test items (but they did not). Thus, it is possible that the entire structure was not improved but that the improvement was limited to individual substructures.

The improvement seen in low structure builders, whether through improvement at the level of individual substructures or the entire superstructure, indicates that embedded questions may be of use in remedial reading programs to provide additional support to readers. As embedded questions enable low structure builders to focus on the material targeted by the questions, the questions could be used to aid students in identification of specific parts of the text (i.e., main ideas). Main idea identification in a text is not always automatic (Afflerbach, 1990), yet it is important in the construction of a coherent representation of the text. Through learning to identify the main ideas in a text, low structure builders may learn

which information is crucial to include in their representation of the text.

Embedded questions did not improve high structure builders' learning. This finding converges with several previous studies that used more typical reading ability indices. Both Hollen (1971) and Shavelson et al. (1974) found a similar interaction of ability and adjunct question in which low-ability readers improved with the adjuncts, but high-ability readers did not. The present analysis of the answers to the embedded questions showed that high structure builders were, if anything, more able than the low structure builders to answer the embedded questions. Thus, the success at answering embedded questions per se does not ensure a subsequent benefit on a criterial test. Perhaps the high structure builders spontaneously constructed a coherent representation of the material targeted by the questions, so that the processing stimulated by the embedded questions was superfluous for the high structure builders. More negatively, the embedded questions likely interfered with the high structure builders' natural processing of the text. On both multiple-choice and application tests, answering embedded questions significantly diminished learning (relative to the reading control) of information not targeted by the embedded questions. From a pedagogical standpoint, these patterns support the apparent practice mentioned in the introduction of not including embedded questions in texts designed for highly selective college-level institutions.

EI

In contrast to embedded questions' improvement of performance on both target and related questions, EI improved the performance of low structure builders only on multiple-choice questions that targeted explicit text context. This finding corroborates the results obtained by Ozgungor and Guthrie (2004), but is inconsistent in one important aspect. Ozgungor and Guthrie found that EI improved the coherence of the readers' representations (as measured by Pathfinder, the same relatedness rating algorithm used in this study). We, however, did not find an improvement in coherence when EI was used. This reveals an important difference between embedded questions and EI. Embedded questions improved coherence, which corresponded to an improvement on related questions as well as the target questions. EI, however, did not improve the coherence of the representations and did not result in an improvement on related questions. Thus, embedded questions may work through a different mechanism than EI. EI, then, is a less robust study method for low comprehenders but one that does improve performance on target information.

One explanation for the results is that low structure builders do not use their prior knowledge to take full advantage of EI. McNamara and McDaniel (2004) showed that activating domain specific knowledge could compensate for inhibitory deficits. Gernsbacher (1990) asserted that a significant source of difficulty for low structure builders is the inability to inhibit irrelevant information. This information, then, remains active and must be included in the mental representation of the text. McNamara and McDaniel (2004), however, showed that it may not necessarily be an inhibitory deficit, as activating other knowledge can deactivate the irrelevant information. The EI questions may help orient the reader to the most important information in the text and thus may activate the knowledge specific to that information, but it may not improve the coherence of the representation beyond what is targeted because poor readers tend not to automatically activate prior knowledge (Long, Oppy & Seely, 1994). The remainder of the representation, then, may remain unorganized and incoherent.

A second possible explanation is that EI activated prior knowledge, but too much irrelevant knowledge was activated. This would further exacerbate the difficulties that low structure builders face by requiring them to fit additional irrelevant information into their mental structure.

We had anticipated that high structure builders might be helped by EI. That they were not is consistent with Seifert's (1993) concerns that EI may not be effective for educational texts because the processing produced by EI is redundant with the spontaneous processing of high structure builders, which is supported by the text itself. The surrounding text may provide the relevant explanations, thus rendering "why" questions ineffective because the answers are already within the text. One could argue that the lack of effects seen for high structure builders could be due to a ceiling effect; however, in most cases, high-ability readers missed more than 15% of the questions. For the one condition in which high-ability readers missed fewer than 15% of the questions (controls answering nontarget multiple-choice questions at 88% correct), the other two conditions (EI and embedded questions groups) performed much more poorly than the controls, precluding any chance that an improvement in performance was masked by a ceiling effect. There is growing and corroborating evidence that although EI may be effective with lists of facts (Pressley et al., 1987), EI may not be as beneficial with more lengthy, expository prose (Boudreau et al, 1999; Seifert, 1993). AQ: 4

However, it is important to note that our participants were students in college, and our criterial tasks were limited to multiple-choice and short-answer tests. Perhaps in some contexts (certain content, certain student educational levels, certain types of criterial tasks) EI would benefit learning from text. The few experiments that have found benefits of EI with prose have had less text per "why" question, with one question per paragraph (McDaniel & Donnelly, 1996; Seifert, 1993). Possibly when more text (1–2 pages of text) must be processed for each "why" question, the questions become ineffective because there is too much information that must be sifted through in order to answer the question. Possibly, EI is more beneficial with shorter texts, with questions placed more frequently.

Age and/or educational level of the student may also play a role in the effectiveness of EI. Seifert's (1993) study tested middle school students and did find a benefit of EI, whereas the present study and previous studies that did not find a benefit of EI (Boudreau et al. 1999) tested undergraduate college students. The learner's background knowledge may be an important factor also, as Ozgungor and Guthrie (2004) found that EI was more beneficial for students who had less prior knowledge. Younger students, or students with less prior knowledge, may need the type of additional learning support that EI provides, whereas older or more knowledgeable students may not benefit from EI. However, this is tentative, as we have no measure of participants' prior knowledge for the text.

In conclusion, the finding that embedded questions are not beneficial for high structure builders (and even penalize them for nontargeted information), but produce gains for low structure builders, underscores the importance of considering individual

differences when implementing embedded question adjuncts. The weak or null effects of embedded questions that are often reported in the literature may be because of the common practice to collapse across individual differences. The present results show that when adjunct study methods are evaluated, sensitivity to individual learner differences is warranted and that one important individual difference factor in this regard is comprehension ability as assessed by a structure-building measure.

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Appendix A

Example of Open-Ended Scoring

Question

There are many presidential candidates campaigning to be elected. What is a correspondent inference, and can one be drawn about someone when looking at their behavior on the campaign trail?

Answers

Scored 0 (Incorrect Answers)

"Yes"

"One inference is that he is friendly because he shakes hands and says hello."

"A correspondent inference is when you attribute other qualities to a person when they do not show these qualities, merely because that person shows a specific quality. One can be drawn about someone when looking at their behavior. For instance if a candidate does not show patience, he is likely an intolerant person."

Scored 1 (Correct Answer)

"Behavior of a politician on a campaign trail is not indicative of actual behavior."

"Correspondent inference is all candidates seem warm and caring because they have to put up an act, for example waving and smiling."

Scored 2 (Correct Answer, including additional correct information)

"Since political candidates are *expected* to be friendly and polite, you are not sure if they are acting that way because that's the way they are or because that's the way they are supposed to be. You can't correspond their behavior with their disposition. You can't make a correspondent inference."

"A correspondent inference is something inferred about someone's personality based on their behavior. One would generally not be drawn about their behavior on the campaign trail because they are socially expected to behave a certain way—kissing babies, friendly, etc."

Appendix B

Sample Embedded/Elaborative Interrogation (EI) and Criterial Test Questions

There were 8 parallel embedded/EI questions per chapter. Participants answered test items that targeted, were related to, or did not target the embedded/EI questions.

How do schemas influence how we perceive people we meet? (embedded)

Why do schemas influence how we perceive people we meet? (EI)

What is the relationship between stereotypes and discrimination? (embedded)

Why do stereotypes lead to discrimination? (EI)

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AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES 1

AQ1: Embedded Questions and Elaborative Interrogation section, 2nd to last sent. of 1st para.: Please provide a reference for the Iowa Silent Reading Test.

AQ2: para. preceding *Criterial Test Performance* section, last sent.: For the *M* and *SD* data provided, please indicate whether "9 min, 3 s" or "9 min, 30 s" was intended.

AQ3: *Multiple-choice test* section, 3rd to last sent.: Please provide the degrees of freedom for this *F* value.

AQ4: 5th para. of *EI* section, sent. beginning "For the one condition. . .": Please indicate whether edits to this sentence have retained your meaning.

AQ5: thor note: Please provide the month in which the 2005 Midwestern Psychological Association meeting was held.