Using prequestions to enhance learning from reading passages: the roles of question type and structure building ability

Kyle J. St. Hilaire, Shana K. Carpenter & Janine M. Jennings

To cite this article: Kyle J. St. Hilaire, Shana K. Carpenter & Janine M. Jennings (2019) Using prequestions to enhance learning from reading passages: the roles of question type and structure building ability, Memory, 27:9, 1204-1213, DOI: 10.1080/09658211.2019.1641209

To link to this article: https://doi.org/10.1080/09658211.2019.1641209

Published online: 15 Jul 2019.

Article views: 143

Submit your article to this journal

View related articles

View Crossmark data
Using prequestions to enhance learning from reading passages: the roles of question type and structure building ability

Kyle J. St. Hilaire\textsuperscript{a}, Shana K. Carpenter\textsuperscript{a} and Janine M. Jennings\textsuperscript{b}

\textsuperscript{a}Department of Psychology, Iowa State University, Ames, IA, USA; \textsuperscript{b}Department of Psychology, Wake Forest University, Winston-Salem, NC, USA

\textbf{ABSTRACT}

Answering questions before learning something ("prequestions") enhances learning. However, these benefits usually occur for information that was asked in the prequestions (i.e., prequestioned material), and not for non-prequestioned material. We reasoned that this narrow benefit may be due to the fact that studies typically use fairly simple prequestions that have a clear answer within one part of the learning material – isolative prequestions. We explored the effects of integrative prequestions that required participants to make connections across different parts of a reading passage. Experiment 1 showed the usual benefit of isolative prequestions on prequestioned but not on non-prequestioned material, but no benefit of integrative prequestions. However, in Experiment 2 when participants were given instructions to seek the answers while reading, integrative prequestions benefited learning of both prequestioned and non-prequestioned material. Individual differences in structure building positively predicted performance, but did not interact with the effects of prequestions.

An important goal of education is to employ strategies that best facilitate student learning. One well-known strategy is retrieval practice, the finding that answering test questions after studying enhances retention to a greater degree than repeated study (e.g., Carpenter, 2012; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Karpicke, 2017; Rowland, 2014). However, less is known about whether answering test questions before studying (i.e., "prequestions") also enhances learning. Instructors may include pretest assessments in their classrooms to establish how much students know before engaging in a lesson, but whether pretests might also enhance learning remains an open question.

The effects of prequestions on learning were examined by Richland, Kornell, and Kao (2009), who had participants read and try to remember a short prose passage. The Prequestion Group began by answering a series of questions before studying the passage, whereas the Control Group did not answer any prequestions. The posttest assessing memory for the passage was comprised of both repeated questions that were originally asked of the Prequestion Group (i.e., prequestioned material) and other questions from the passage that were never asked (i.e., non-prequestioned material). Therefore, for the Prequestion Group, half of the posttest questions assessed prequestioned material and the other half assessed non-prequestioned material, whereas for the Control Group all of the posttest questions assessed non-prequestioned material. Results showed that answering prequestions boosted performance on the posttest, but only for prequestioned material. For non-prequestioned material, there was neither a benefit nor decrement of answering prequestions relative to the Control Group.

The specific benefit of prequestions – in which prequestions only benefit learning of prequestioned material, relative to a control group – has been shown in other studies that have used similar types of prose passages (Frase, 1968; Hausman & Rhodes, 2018; Pressley, Tanenbaum, McDaniel, & Wood, 1990; Rickards, 1976). These results show that when participants answer prequestions before learning some material – even though they do not receive feedback of the correct answers at the time – they are better able to answer those same questions again on a later test.

These results suggest that prequestions can significantly benefit learning. However, given that these benefits tend to be narrow and highly specific to the prequestioned material, the educational utility of prequestions seems limited. In particular, for students to benefit from prequestions it would seem that an instructor would need to include prequestions about everything they want students to learn, which can become time- and labor-intensive. A prequestioning technique that can produce broad benefits on learning – stimulating learning for both the information in the prequestions, as well as additional information contained in the lesson – would be a more beneficial pedagogical tool.
Thus, an important question is whether prequestions can promote general learning, that is, enhanced posttest performance for both the prequestioned and non-prequestioned material. Recent work by Hausman and Rhodes (2018) has begun to explore this question. Based on the fact that studies on prequestions typically use fairly simple, factual-style questions that assess content explicitly stated in the reading passage (e.g., “How much of the earth is covered by glaciers during an ice age?”), Hausman and Rhodes reasoned that conceptual-style prequestions may be more likely to produce general learning benefits because the answer to a conceptual-style question is not explicitly stated in the passage and must be inferred from multiple pieces of information (e.g., “What is a consequence of higher levels of carbon dioxide in the atmosphere [on sea levels]?”). The authors reasoned that, in order to successfully answer a conceptual prequestion, a learner must actively process information across multiple parts of the text to integrate and extract the information needed to draw the appropriate inference. For example, the answer to their conceptual question was not directly stated in the passage, but had to be inferred from other presented information, namely, that higher levels of carbon dioxide warm the atmosphere thereby melting glaciers which, in turn, will raise the sea level. By contrast, the answer to their factual question was stated explicitly within the prose passage and could be gleaned upon passive reading.

Conceptual prequestions, therefore, should be more likely than factual prequestions to enhance learning of both prequestioned and non-prequestioned material. Replicating previous research, Hausman and Rhodes (2018) found that their factual prequestions only enhanced posttest performance for the prequestioned material. Surprisingly, however, conceptual prequestions did not enhance learning for either prequestioned or non-prequestioned material. What might explain this null effect of prequestions? One possibility is that active, integrative processing does not benefit learning in the hypothesised way. Another possibility, however, is that conceptual prequestions did not sufficiently engage this type of processing. Studies have shown that it can be quite difficult to answer higher-order questions that require the formation of inferences beyond what was directly stated in a text, and this is true even when those questions must be answered after learning the material (Tran, Rohrer, & Pashler, 2015). If participants have a difficult time with such questions after learning has occurred, it may be even more difficult to try to construct these inferences based on questions they receive before learning has occurred. Although conceptual prequestions would seem to require integration of information from the passage, integrating information that was not directly stated in the passage to form new inferences may have been too difficult. As such, these results do not rule out the possibility that prequestions requiring integration can still produce general learning benefits, if the integration is successful.

Successful integration depends upon recognition. If learners do not recognise information in the passage as relevant (or not relevant) to the information they are seeking, they are not likely to notice and integrate it effectively. Because inference-based conceptual prequestions cannot be directly answered using the information in the passage, these questions may not foster the recognition of relevant information to a sufficient degree that promotes integration. Thus, increasing the chances of successful recognition of the relevant information should enhance the effectiveness of prequestions that require integration, ultimately leading to enhanced learning of prequestioned and non-prequestioned material.

The current study explored this hypothesis using a new approach. In particular, prequestions were designed to promote integration while encouraging successful recognition of the relevant information in the reading passage. To encourage successful recognition, the prequestions always referred to information that was directly stated in the passage and did not require the formation of non-stated inferences. Rather, the information needed to answer the prequestion was distributed throughout the passage, requiring participants to integrate concepts from different places within the passage. We refer to these as integrative prequestions.

Along with integrative prequestions, we included simpler prequestions that have often been explored in the literature on this topic, consisting of one discrete piece of information directly stated in the passage. We refer to these as isolative prequestions. Consistent with previous research, isolative prequestions were expected to enhance only learning of the prequestioned material. On the other hand, to the extent that they foster successful integration, integrative prequestions were expected to encourage general processing of the passage, ultimately leading to enhanced learning of both prequestioned and non-prequestioned material.

A final goal of the present study was to explore the effectiveness of prequestions as a function of individual learner characteristics. In particular, learning from prequestions may depend on individual learners’ structure building – the ability to “build a cohesive mental representation or ‘structure’” of complex text material (Gernsbacher, Varner, & Faust, 1990, p. 431). Structure building correlates with reading comprehension (Maki, Jonas, & Kallod, 1994) and academic performance (Arnold, Daniel, Jensen, McDaniel, & Marsh, 2016), and has been shown to predict the learning benefits of using external learning aids such as embedded questions (Callender & McDaniel, 2007), diagrams and text outlines (Bui & McDaniel, 2015), and flashcards (Lin, McDaniel, & Miyatsu, 2018). High-ability structure builders perform well whether or not they use a learning aid; however, low-ability structure builders perform better when they use a learning aid, presumably because they are less inclined than high-ability structure builders to engage by default in the processing facilitated by that learning aid. To the extent that prequestions function as
a type of learning aid, prequestions might be expected to benefit low-ability structure builders more than high-ability structure builders, though we had no specific predictions about the relationship between structure building and question type.

**Experiment 1**

**Method**

**Participants**

One-hundred and fifty-three students (105 were female) at Iowa State University participated in exchange for $10. Participants were recruited via an email sent to all currently-enrolled students at Iowa State University inviting them to participate if they were at least 18 years old and native English speakers. The target sample sizes for both experiments were based on previous work with reading passages showing that thirty participants per group is sufficient to detect reliable prequestion effects (Richland et al., 2009).

**Materials**

The study material included a 675-word reading passage about brakes (Mayer & Gallini, 1990). The passage included information about three different types of vehicular braking systems and the mechanical structure and function of each. Based on the reading passage we developed two factual types of questions, isolative and integrative. *Isolative* questions were designed so that the answer could be found by itself in a single location within the passage. For *integrative* questions, the answer was found by connecting and integrating information across different locations within the passage. Although the answers to the integrative questions were never explicitly stated in the passage, the information needed to answer these questions was always explicitly stated. Thus, the integrative questions simply required participants to combine these multiple pieces of information together and did not require participants to generate new inferences from the material.

A total of 10 isolative questions (e.g. “What type of machine relies on caliper brakes?”) and four integrative questions (e.g. “What is the primary difference between mechanical brakes and hydraulic brakes?”) were created (see Appendix). The questions were designed so that both question types assessed the same material from the passage. For example, information that was assessed using one integrative question was assessed across two or three isolative questions. Each of the 10 isolative questions was worth 1 point. Two of the integrative questions were worth 2 points, and the other two were worth 3 points.

The Multi-Media Comprehension Battery (MMCB; Gernsbacher & Varner, 1988) was used to measure individuals’ structure building ability. The MMCB consists of three modalities: written, auditory, and pictorial; however, because the three modalities correlate highly with one another (Gernsbacher et al., 1990), only the written modality (split-half reliability = .77; see Callender & McDaniel, 2007) was used as has been done in previous research (Arnold et al., 2016; Bui & McDaniel, 2015; Callender & McDaniel, 2007; Lin et al., 2018). This component of the MMCB consists of four short stories, each with 12 corresponding multiple-choice questions (e.g. “What was Ike’s last name?” (A) Halberdin; (B) Hamberlin; (C) Hambelton; (D) Harrigan; (E) Handlin). Written structure building scores range between 0 and 48, with higher scores indicating greater structure building ability.

**Design and procedure**

Participants were randomly assigned to one of four groups. In the Prequestion Isolative Group \((n = 38)\), participants received five of the isolative questions prior to reading the passage, and all 10 isolative questions during the posttest. In the Control Isolative Group \((n = 38)\), participants answered the same 10 isolative questions only at posttest, without answering any prequestions. In the Prequestion Integrative Group \((n = 38)\), participants received two of the integrative questions prior to reading the passage (one 2-point question and one 3-point question), and all four integrative questions during the posttest. Finally, in the Control Integrative Group \((n = 39)\), participants answered the same four integrative questions at posttest, without answering any prequestions.

Although the design comprised two different question types (i.e. Isolative vs. Integrative), the two question types were not directly comparable due to differences in the number of questions and the scoring system for each. As such, the comparisons of prequestion vs. control groups were carried out separately for each question type. In both Prequestion Groups, the set of questions that appeared as prequestions was counterbalanced so that each question appeared equally often as prequestioned material and non-prequestioned material. After reading the passage and finishing the posttest, all participants completed the MMCB.

Participants completed the experiment in groups of 3–12 individuals in a classroom during a single session. All participants within a given session were assigned to the same experimental condition (e.g. Control Isolative Group) to maintain procedural consistency within that session (i.e. same amount of time spent reading the prose passage, etc.), and the order of administration for each experimental condition was randomised across sessions. Each participant sat at his or her own desk to complete the study individually, and there was no interaction between participants during the study. All of the study materials were administered using paper and pencil format, and all instructions were presented orally by the experimenter.

Participants were told at the start of the experiment that they would read a prose passage and that their memory for the passage would later be tested. Participants assigned to one of the Prequestion Groups spent 2 min answering the
prequestions. These questions were printed on a single sheet of paper, and participants were instructed to attempt a response for each prequestion regardless of whether they knew the answer. Thus, guessing was encouraged; however, feedback and correct answers to the prequestions were not provided.

After completing the prequestions, the sheets were collected, and participants were then given 8 min to study the passage. Participants assigned to the Control Groups spent the same amount of time with the materials as the Prequestion Groups, but did so by studying the passage for the entire 10 min. All participants were encouraged to take notes on the passage document if they thought that would help them as they studied.

After participants finished studying the passage, these were collected, and all participants were given a 5 min distractor task in which they listed U.S. states. At the end of 5 min, participants then completed the posttest, consisting of either all the isolative or integrative questions from the passage, depending on the experimental condition to which they were assigned. The posttest was untimed, but took approximately 5 min to complete. Following the posttest, all participants completed the MCB at their own pace. Altogether, the entire procedure lasted approximately 50 min.

Results

Scoring

The pretests and posttests were scored out of 5 and 10 points, respectively, and partial credit was awarded. Two independent raters scored 25% of participants’ responses for overall posttest performance and, for participants assigned to the Prequestion Groups, performance on prequestioned and non-prequestioned material. Inter-rater agreement was high ($rs > .94$, $ps < .001$), so the remaining responses were scored by a single rater. Data from three participants were excluded from further analyses for having posttest scores more than 2.5 standard deviations below the group mean. The final sample included 37 participants in the Prequestion Isolative Group, 38 participants in the Control Isolative Group, 36 participants in the Prequestion Integrative Group, and 39 participants in the Control Integrative Group.

Pretest performance

Participants’ performance on the prequestions was quite low, only 15% accurate ($SD = 17\%$), on average, for the isolative questions and 14% accurate ($SD = 12\%$), on average, for the integrative questions. This result suggests that most prequestion responses were incorrect and that participants had very little prior knowledge of the material.

Posttest performance

Figure 1 shows participants’ posttest performance across all conditions. For both the Isolative and Integrative Groups, we compared posttest performance separately for prequestioned and non-prequestioned material relative to the respective Control Group’s overall performance. As described above, prequestioned material referred to questions that were originally asked during the pretest, and non-prequestioned material referred to questions that only appeared on the posttest (having not been previously asked during the pretest). The distinction between prequestioned vs. non-prequestioned material (i.e. the two left-most bars) therefore only applied to the Prequestion Groups, as the Control Groups never answered any prequestions. Thus, the key comparisons of interest were (1) the Prequestion Group’s performance on prequestioned material compared to the Control Group’s overall performance (i.e. a measure of the specific benefits of prequestions on prequestioned material), and (2) the Prequestion Group’s performance on non-prequestioned material compared to the Control Group’s overall performance (i.e. a measure of the general benefits of prequestions on non-prequestioned material). These two analyses were carried out separately for the isolative and integrative question groups.

Participants who answered isolative prequestions performed marginally better than their respective control group on prequestioned material, $t(73) = 1.71$, $p = .091$, $d = 0.40$, 95% CI [−0.06, 0.85]. However, they did not perform significantly better than the control group on non-prequestioned material, $t(73) = 0.30$, $p = .765$, $d = 0.07$, 95% CI [−0.38, 0.52]. Participants who answered integrative prequestions did not perform any better than their respective control group on either prequestioned material, $t(73) = 0.49$, $p = .626$, $d = 0.11$, 95% CI [−0.34, 0.57], or on non-prequestioned material, $t(73) = 0.25$, $p = .801$, $d = 0.06$, 95% CI [−0.39, 0.51].

Structure building

To examine the effects of prequestions as a function of structure building, posttest performance on both prequestioned and non-prequestioned material was examined separately as a function of MCB scores for participants who received isolative vs. integrative questions. Regression analyses were conducted with prequestion group (dummy coded: $1 =$ prequestion, $0 =$ control) and structure building ability (MCB; centred by subtracting the group mean from each participant’s MCB score) as predictors, along with the interaction term between prequestion group and MCB.

As shown in Table 1, the beneficial effects of isolative prequestions were significant after controlling for structure building ability. However, these benefits were specific to prequestioned material, and did not occur for non-prequestioned material. Beyond this finding, MCB score was the only significant predictor of posttest performance, such that higher structure building scores positively predicted performance on the posttest.
Discussion

As expected, results from Experiment 1 showed a benefit of isolative prequestions for memory of prequestioned material, but not for memory of non-prequestioned material. This result is consistent with other studies showing specific (but not general) benefits of prequestions when those questions target discrete factual information directly stated in the reading passage (Frase, 1968; Hausman & Rhodes, 2018; Pressley et al., 1990; Rickards, 1976). What was unexpected, however, was that answering integrative prequestions failed to show any learning benefits at posttest. We expected that answering integrative prequestions might facilitate connections across various parts of the passage, ultimately enhancing learning of both prequestioned and non-prequestioned material. However, integrative prequestions failed to enhance memory even for the specific information from the prequestions, suggesting that integrative prequestions were ineffective.

Before concluding that integrative processing fails to enhance learning, however, it is important to address whether participants did in fact integrate the information in the way we expected. Because integrative questions assess multiple concepts at the same time (e.g. compare and contrast relationships), it may be difficult for participants to remember the prequestions or to glean the answers to these somewhat complex questions upon passive reading. Learning from integrative prequestions (compared to the simpler isolative questions) may thus require more concerted efforts to remember the prequestions and notice the relevant information in the passage while reading.

Figure 1. Posttest performance on the prequestioned and non-prequestioned material for participants answering isolative questions (top) or integrative questions (bottom) in the Prequestion Groups and in the Control Groups in Experiment 1. Error bars represent standard errors.
In Experiment 1, all participants were aware from the outset that their later memory for the passage would be tested. However, we did not explicitly instruct participants in the Prequestion Groups to remember the prequestions while reading, or to actively look for the information needed to answer these questions. Providing explicit instructions may encourage participants to process the prequestions more fully, and in the case of integrative prequestions, produce the expected benefits on both prequestioned and non-prequestioned material. Experiment 2 was designed to address this possibility.

### Experiment 2

The design of Experiment 2 was identical to Experiment 1, with three primary changes. First, given the novelty of integrative prequestions and the need for further experimental work on their potential effects, Experiment 2 involved only the integrative prequestions. Second, instructions were modified to encourage participants to find the answers to the integrative prequestions while reading. Finally, to verify that participants were able to successfully remember the questions, after finishing the reading participants were asked to reproduce the two prequestions from memory. These design modifications made it possible to measure the effects of integrative prequestions on learning under conditions in which participants are more likely to remember and utilise the prequestions.

### Method

**Participants**

Sixty-five new students (41 were female) at Iowa State University participated in exchange for $10.

### Design, materials, and procedure

The experimental materials were the same as those from Experiment 1, except only the integrative questions were used. Thus, participants were randomly assigned to either the Prequestion Integrative Group or the Control Integrative Group. The procedure was also the same as in Experiment 1; however, after the 2 min prequestion phase, participants assigned to the Prequestion Integrative Group were provided with additional instructions to find the answers to the two prequestions while reading, as later they would receive the same two questions again on the posttest. They were informed that the answers to the questions were located in the prose passage but they would have to construct the answers across multiple paragraphs.

Immediately following the 8 min study phase, participants in the Integrative Prequestion Group were instructed to write down the two prequestions they had previously received. This instruction served as a manipulation check to determine whether participants were able to remember the prequestions while reading the passage. All participants then completed the integrative questions posttest, followed by the MMCB.

### Results

**Scoring**

As in Experiment 1, two independent raters scored 25% of participants’ responses for overall posttest performance, and posttest performance for prequestioned and non-prequestioned material in the Prequestion Group. Inter-rater agreement was high ($r > .96, p < .001$), so the remaining responses were scored by a single rater. Data were excluded from participants who did not complete all experimental tasks (1 participant), had posttest scores more than 2.5 standard deviations below the group mean (2 participants), and failed the manipulation check by being unable to remember one or both prequestions (3 participants). The final sample included 29 participants in the Prequestion Integrative Group and 30 participants in the Control Integrative Group.

**Prequestion performance**

As in Experiment 1, accuracy on the prequestions was quite low ($M = 13\%, SD = 10\%$), reflecting little prior knowledge of the material.

**Posttest performance**

Figure 2 shows participants’ performance on the posttest. Participants who answered prequestions performed significantly better on prequestioned material compared to the control group, $t(57) = 4.61, p < .001, d = 1.20, 95% CI [0.65, 1.76]$. Answering prequestions also significantly enhanced performance for the non-prequestioned material relative to the control group, $t(57) = 2.31, p = .024, d = 0.60, 95% CI [0.08, 1.12]$. Thus, answering integrative prequestions

### Table 1. Regression results predicting posttest performance for isolative and integrative questions as a function of condition and structure building ability (MMCB).

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>R²</th>
<th>β</th>
<th>Experiment 1</th>
<th>R²</th>
<th>β</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolative Questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prequestioned Material</td>
<td>.39***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>0.23*</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMCB</td>
<td>0.64***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>−0.09</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-prequestioned Material</td>
<td>.45***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>0.07</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMCB</td>
<td>0.70***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>−0.05</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrative Questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prequestioned Material</td>
<td>.12*</td>
<td>.38***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>0.04</td>
<td>–</td>
<td>0.44***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMCB</td>
<td>0.42**</td>
<td>–</td>
<td>0.44**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>−0.12</td>
<td>–</td>
<td>−0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-prequestioned Material</td>
<td>.19**</td>
<td>.21**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>−0.07</td>
<td>–</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMCB</td>
<td>0.41**</td>
<td>–</td>
<td>0.49**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>0.04</td>
<td>−0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: *p < .05, **p < .01, ***p < .001.
enhanced posttest performance for both prequestioned and non-prequestioned material.

**Structure building**
To examine the effects of prequestions as a function of structure building ability, posttest performance on both prequestioned and non-prequestioned material was examined separately. Regression analyses were conducted with prequestion group (dummy coded: 1 = prequestion, 0 = control) and structure building ability (MMCB; centred by subtracting the group mean from each participant’s MMCB score) as predictors, along with the interaction term between prequestion group and MMCB.

As shown in Table 1, the beneficial effects of integrative prequestions were still present after controlling for structure building ability. These analyses revealed sizeable benefits of integrative prequestions on prequestioned material ($\beta = .44$, $p < .001$), although the effect was reduced for non-prequestioned material ($\beta = .21$, $p = .105$). As in Experiment 1, structure building ability significantly predicted performance for both prequestioned and non-prequestioned material, but did not interact with the effects of prequestions ($ps > .155$) (see note 2).

**Discussion**
Results from Experiment 2 suggest that integrative prequestions might indeed produce general learning benefits under the conditions examined here. Unlike isolative prequestions which tend to produce specific benefits only on prequestioned material, integrative prequestions appeared to produce more general benefits, at least when combined with the instructions to actively seek the answers to the prequestions while reading the passage.

**General discussion**
The current study examined whether answering prequestions before studying enhances learning, and more specifically, if this learning benefit differs as a function of question type. When answering isolative prequestions (e.g., fill-in-the-blank-style questions where the answer was located in one discrete part of the text), only a specific learning benefit of prequestions occurred, benefiting prequestioned but not non-prequestioned material.

The specific learning benefits of isolative prequestions observed in Experiment 1 support a growing body of research showing that answering these kinds of prequestions enhances learning, but that the learning benefits are specific to the prequestioned material (Carpenter, Rahman, & Perkins, 2018; Hausman & Rhodes, 2018; Pressley et al., 1990; Richland et al., 2009; Rickards, 1976). Indeed, research on prequestions has typically used discrete, factual types of questions that can be answered from a single phrase or sentence within the learning material. It makes sense that answering these isolative prequestions would not show general learning benefits for non-prequestioned material because such questions are only answerable from a few discrete phrases or keywords; by design, isolative questions would thus not draw attention to the non-prequestioned material. These results emphasize how robust the prequestion effect is for isolative prequestions, but demonstrate consistently that the effect is limited to material that was initially prequestioned.

Although Experiment 1 failed to show any learning benefits of answering integrative prequestions, this result may have been due to insufficient processing of the prequestions and their connection with the subsequent reading passage. In Experiment 2, when participants were provided with explicit instructions to seek the answers to
the integrative prequestions during reading, not only did the prequestions produce specific benefits for the prequestioned material, but also general benefits for the non-prequestioned material. This finding might suggest that integrative prequestions enhance general learning under conditions that increase participants’ processing of the material, possibly due to the compare-and-contrast nature of the questions which may encourage more systematic or comprehensive processing (e.g. Gentner & Markman, 1997). Importantly, however, it is also possible that the instructions themselves influenced learning of the material in Experiment 2, perhaps by enhancing how much effort or active processing participants engaged in while reading. As different types of instructions have not been systematically explored in the research on prequestions, this presents an interesting question for future research.

Previous work by Hausman and Rhodes (2018) also manipulated question type to determine whether some kinds of prequestions were more likely to show general learning benefits; however, they were unable to find such general benefits. This inability to find a prequestion effect may be because they used inference-based conceptual questions. Although conceptual questions require integration, namely, by piecing together multiple pieces of text to come to a logical inference, it can also be difficult to answer these questions because the answers are never explicitly provided in the learning material. Failure of the conceptual prequestions to enhance learning, therefore, could be due to the difficulty associated with recognizing and integrating the information in the text that is needed to infer the answers.

By contrast, the present study used questions that required integrative processing of information that was explicitly stated in the text. Unlike conceptual questions requiring inference-based processing of information not directly stated, the integrative questions we used were more likely to rely on information that could be recognized from the text, possibly making it easier for participants to integrate the key portions of the passage needed to answer these questions. Consistent with Hausman and Rhodes (2018), however, we found that participants did not automatically engage in this processing (Experiment 1), and that some extra encouragement to process the integrative information was required in order to produce these benefits (Experiment 2). Thus, compared to isolative prequestions which typically show consistent and specific benefits on prequestioned material (Frase, 1968; Carpenter et al., 2018; Pressley et al., 1990; Richland et al., 2009), integrative prequestions may require some extra effort to engage in the processing needed to produce these benefits.

Other studies have shown general benefits of prequestions under conditions in which the prequestions encourage processing of multiple parts of the learning material. In a study by Little and Bjork (2016), multiple-choice prequestions for various facts from a prose passage produced learning benefits for both prequestioned and non-prequestioned material. However, rather than display one correct answer option in an array with three blatantly incorrect answer options, the incorrect answer options were designed to be “competitive alternatives” to the correct answer, designed to activate non-prequestioned material before reading the passage. For example, if a participant answered a multiple-choice prequestion (“What is the tallest Geyser in Yellowstone National Park?”) with answer options Old Faithful, Steamboat Geyser, Castle Geyser, and Daisy Geyser, it was proposed that they would actively process and consider each of the four answer options before selecting one as their prequestion guess. Even though the correct answer to the prequestion might be Steamboat Geyser, a novel question at posttest might be written so that Castle Geyser (which was activated during the prequestion phase) is the correct answer. Little and Bjork believed that if an individual actively considers each of the four answer options before selecting one as the “right” answer, then details related to each option would be attended to when that material is encountered during the subsequent reading of the passage. In other words, not only would the participant search for the correct answer to the prequestion, but they would also search for details related to the competitive alternatives. This learning enhancement is indeed what the researchers found, showing general learning benefits for non-prequestioned material when that material was activated during the prequestion phase as a competitive alternative.

Along similar lines, Carpenter and Toftness (2017) found benefits of factual prequestions for non-prequestioned material when utilising video materials rather than reading passages. Unlike self-paced reading passages in which participants can selectively focus on prequestioned material, video materials are experimenter-paced and presented continuously, requiring participants to carefully process all of the material as it is impossible to predict when the answers to the prequestions will be presented. Consistent with this reasoning, Carpenter and Toftness observed both specific and general learning benefits for the prequestioned and the non-prequestioned material for video-based learning.

Across Experiments 1 and 2, structure building ability was highly related to posttest performance, in that higher MMCB scores were positively associated with higher posttest scores. However, the results of the current study did not show reliable interactive effects between structure building ability and prequestions. Although answering prequestions tended to benefit low-ability structure builders more than high-ability structure builders (see Table 1), the interactions were weaker than what has been observed in previous research showing that study aids such as embedded questions (Callender & McDaniel, 2007), text outlines and illustrative diagrams (Bui & McDaniel, 2015), and flashcards (Lin et al., 2018) benefit low-ability structure builders to a significantly greater degree than high-ability structure builders. One plausible difference between the current study and the
extant structure building literature, however, might be that the study aids employed in the extant literature are directly available during learning (e.g. answering embedded questions while reading), whereas in the current study, prequestions primarily function as a pre-learning activity as the questions are not physically provided during the learning episode. Thus, compared to an external learning aid that is directly provided to participants while learning, prequestions may serve as more of an internal learning aid (i.e. only available in memory) that is less effective and less likely to interact with individual differences in structure building ability for low-ability structure builders. Additional research is encouraged that can shed further light on the role of individual learner characteristics in learning from prequestions, as this is the first known study to explore such effects.

Toward educational application, laboratory-based research showing promising effects of prequestions (Carpenter & Toftness, 2017; Hausman & Rhodes, 2018; Little & Bjork, 2016; Pressley et al., 1990; Richland et al., 2009) has led researchers to explore prequestion effects in the classroom. In both a university lab course (Carpenter et al., 2018) and a fifth-grade classroom (McDaniel, Aganwal, Huelser, McDermott, & Roediger, 2011) isolative prequestions have been shown to produce positive effects on learning course material. However, in light of the current results, a fruitful avenue for future research may be to conduct classroom studies with integrative prequestions to determine whether their general benefits apply to classroom learning. It remains unclear whether this general learning benefit may occur for more complex classroom learning tasks, across different age groups, in different educational domains, or when transferring knowledge to new situations.

Notes

1. A student reading about oceans, for example, would create a general knowledge structure for oceans and “build” relevant information onto that structure. This structure would likely include information about fish, the names of the four oceans, and details about islands, among other things. High- and low-ability structure builders differ in how they build information that is not directly related to the concept of oceans (dolphins and whales for example, are mammals, and mammals primarily live on land), with high-ability structure builders more likely to build these thematically-unrelated details onto their structure of oceans, and subsequently access them during retrieval of the “oceans” structure.

2. Statistical assumptions underlying the analyses were evaluated for both experiments. Visual inspection revealed that the distribution of scores across all conditions was approximately normal (although these tests have been shown to be robust to violations of normality; e.g., see Boneau, 1960; Box, 1953). Visual inspection of the scatterplots for all conditions revealed a linear relationship between MMCB scores and posttest scores, and no systematic variation in residual posttest scores along the range of MMCB scores. Levine’s test revealed non-significant departures from equal variance for all but two comparisons across the two experiments combined, and the significant effects were identical whether or not equal variances were assumed.

Acknowledgement

Portions of this work were presented at the annual meeting of the Psychonomic Society, New Orleans, Louisiana, November, 2018. We thank Payten Fenimore for her help with data scoring and coding.

Disclosure statement

The authors declare no conflict of interest.

Funding

This material is based upon work supported by the James S. McDonnell Foundation Twenty-First Century Science Initiative in Understanding Human Cognition, collaborative grant number 220020483.

References


Appendix

Full List of Isolative and Integrative Test Questions

Isolative Test Questions

1. Mechanical brakes have levers or __________ that force one or two pads against the wheel.
2. __________ and brake lines are filled with brake fluid.
3. For hydraulic brakes, what kind of wheel cylinder is on the front wheel?
4. For drum brakes, when the brake is applied, the shoes press in what direction against the drum?
5. A piston slides back and forth in the __________.
6. Air brakes use __________ to apply brake pressure to the pads or shoes.
7. What type of machine relies on caliper brakes?
8. Brake pads press against a turning wheel to produce friction that converts the wheel’s energy of motion to __________.
9. On which of a car’s wheels does the emergency brake exert its force?
10. How many different kinds of brakes are vehicles equipped with?

Integrative Test Questions

1. What is the primary difference between mechanical brakes and hydraulic brakes? (2 pts)
2. There are two key types of mounts in hydraulic brakes. What are the two types? Next, name two ways in which they differ from one another. (3 pts)
3. Are air brakes more similar to mechanical brakes or hydraulic brakes? Why? (2 pts)
4. Train brakes and bicycle brakes rely on different systems to function. In what way are the two systems fundamentally different, and in what way are they similar? (3 pts)