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INTERVENTION STUDY

Elaborations in Expository Text Impose a Substantial Time Cost but Do Not Enhance Learning

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Abstract
Textbook passages commonly include elaborations (details supporting main ideas) with the assumption that elaborations will improve learning of the main ideas. However, elaborations increase text length, which subsequently increases the reading time of that text. These observations lead to the two focal questions of interest in the current study: What is the time cost imposed by including elaborations within textbooks? Does the benefit of elaborations for enhancing memory for main ideas outweigh this time cost? In three experiments, students studied elaborated versus unelaborated versions of psychology textbook passages. Two days later, students completed final tests, including cued recall for main ideas and comprehension tests. In all experiments, we found a substantial cost in terms of increased reading time for the elaborated text but no evidence of increased memory for main ideas to offset this cost. To facilitate further interpretation of the similar test performance observed for elaborated versus unelaborated texts, experiment 2 ruled out functional floor or ceiling effects and established that both text versions enhanced learning (but did so to a similar extent). These results indicate that elaborations embedded within textbook passages may not facilitate learning and that unelaborated texts may be more efficient than elaborated texts.

Keywords Elaborations · Expository text · Memory · Student learning · Main ideas

> A typical college text contains about 400 pages of text and about 150,000 words. No educator seriously believes that a student will commit all 150,000 words to memory verbatim (Reder and Anderson 1980, p. 121)

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What do instructors want students to gain from reading textbooks? Given that students cannot memorize every word in the text, a plausible answer is that instructors want students to retain the main ideas. Although main ideas are the targets of learning, they make up only a minority of the information that textbooks contain. Much of the remainder of the text content consists of elaborations (i.e., details that further describe, illustrate, or explain main ideas). Including elaborations in text necessarily increases text length, which likely requires students to spend more time reading that text. This cost in additional time is justified if elaborations lead to a corresponding increase in memory for main ideas. These observations lead to the two focal questions of interest in the current study: What is the time cost imposed by including elaborations within textbooks? And does the benefit of elaborations for enhancing memory for main ideas outweigh this time cost?

Below, we first discuss prior research that has directly investigated the effects of elaborations in expository texts (i.e., the genre of text included in most textbooks) on learning of main ideas. Given the limitations of the extant research, we then discuss findings from related research and theory. Because prior research does not adequately answer our focal questions, we then report three experiments that directly investigated the time costs and learning benefits of including elaborations in expository texts.

Research on the Effects of Elaborations in Expository Text

Given the prevalence of elaborations in textbook passages, surprisingly few studies have investigated the effects of elaborated versus unelaborated expository texts (see Table 1).[1] Concerning our first focal question about time costs, no prior study provides an estimate of how much additional time students allocate to reading elaborated versus unelaborated texts because all previous studies have used an experimenter-paced learning procedure. With an experimenter-paced procedure, elaborated and unelaborated texts are presented for the same amount of time. In contrast, the current experiments used a self-paced learning procedure to provide estimates of time cost. Estimating time cost is important because students have a finite amount of time they can invest in learning, and they have a large amount of material to learn. More time spent studying one set of to-be-learned material necessarily means less time to spend learning other material. If two techniques facilitate a similar level of learning, students can preserve more of their finite time resources by choosing the technique that imposes a smaller time cost. Therefore, to competitively evaluate the effectiveness of elaborated versus unelaborated texts, it is important not only to investigate the possible memory benefits afforded by elaborations but also to estimate the time cost imposed (for similar discussion, see Howe and Singer 1975; Rawson and Dunlosky 2011; Zamary and Rawson 2018).

Concerning our second focal question, all seven prior studies investigated whether including elaborations in expository texts benefits memory for main ideas. Two of these studies demonstrated lower memory for main ideas after reading elaborated versus unelaborated text (Allwood et al. 1982; Reder and Anderson 1980). However, the results of these studies (and also Phifer et al. 1983, experiment 4) are difficult to interpret because these studies did not hold

[1] We limit our discussion to studies comparing elaborated versus unelaborated texts. Other studies have manipulated text length by including more versus less information at the same level (e.g., Hidi and Baird 1988; Mayer and Jackson 2005; Rothkopf and Billington 1983; Van Dam & Brinkerink-Carlier, 1984; Van Dam et al. 1986), which do not directly inform the focal questions of interest here.

Table 1 Relevant studies examining the effect of elaboration in expository text

Paper	Equivalent core	Delay	Self-paced
Reder and Anderson (1980)	No	Yes	No
Allwood et al. (1982)	No	No	No
Phifer et al. (1983, Exp. 4)	No	No	No
Palmere et al. (1983)	Yes	No	No
Dal Martello (1984)	Yes	No	No
Mohr et al. (1984)	Yes	No	No
Freeman (1985)	Yes	Yes	No

Note. Equivalent core = main ideas were the exact same in the elaborated and unelaborated texts; delay = retention interval of a day or more; self-paced = participant was given as much reading time as needed and controlled the presentation rate of the material

the wording of the main ideas constant in the elaborated and unelaborated versions of the text. Differences in wording involve differences in the lexical and syntactic characteristics of the main ideas. Given that these characteristics can affect retention, any difference in retention cannot clearly be attributed to the difference in elaborations.

The four studies that held the wording of main ideas constant provide tentative support that elaborations can enhance memory for main ideas (Dal Martello 1984; Freeman 1985; Mohr et al. 1984; Palmere et al. 1983). However, the outcomes of these studies have limited applicability because aspects of the methods are arguably not representative of conditions in which students read textbooks. For instance, three of these studies involved only one session in which students read the text and then took a final test. In contrast, more time typically elapses between when students complete assigned textbook reading and are tested on the material (e.g., reading the textbook 1 or 2 days before an in-class quiz). Additionally, all of these studies used experimenter pacing. In practice, students determine how long they spend reading the textbook. Given that retention interval and study time both affect retention, the benefits to memory for main ideas found in these studies may not generalize to more representative conditions.

In sum, few studies have directly investigated the effects of elaborations in expository texts. These studies provide no estimate of the time cost imposed by including elaborations and only limited evidence for the benefit of elaborations for enhancing retention of main ideas.

Indirectly Relevant Research and Theory

In contrast to the few studies that have directly investigated the effects of elaborations in expository texts, most studies investigating elaboration effects have used fact lists. Outcomes of these studies have been somewhat mixed, pointing to different plausible predictions for the effects of elaborations in expository texts. Several studies found that elaborations enhance memory for target information. For example, embedding target words (e.g., "short") in elaborated sentences versus unelaborated sentences (e.g., "The child was comforted by the short man *who looked the child in the eye*" versus "The child was comforted by the short man") improves performance on subsequent tests of memory for the target word ("The child was comforted by the ____ man"; e.g., Di Vesta and Finke 1985; Pressley et al. 1987; Stein et al. 1984; Stein et al. 1978). In contrast, other studies suggest elaborations do not enhance memory for target information. For example, recall of target sentences is often similar for target sentences alone versus target sentences studied with causal elaborations (e.g., Kim and Van Dusen 1988; McDaniel et al. 1988; Wood et al. 1993).

Just as empirical outcomes in these related literatures point to different, plausible predictions, theories of text comprehension also provide a basis for making different, plausible predictions. One prominent theory of text comprehension is *construction-integration* (CI) *theory* (Kintsch 1988, 1998). In brief, CI theory proposes that people process texts in cycles, each involving the processing of approximately one sentence. During the construction phase of each cycle, each idea unit explicitly stated in the sentence is represented as a node. These nodes activate associated information from long-term memory. Activation of information is assumed to be a "dumb" process, in that activation is a function of associative strength but not relevance. Activation may include nodes from previously processed segments of the same text and from prior knowledge. The construction phase also involves forming links between nodes based on content overlap. During the integration phase of each cycle, activation spreads through the network. Highly interconnected nodes accrue activation, whereas less well-connected nodes lose activation and may be pruned from the network. At the end of each processing cycle, the resulting network is encoded into the accumulating representation of the text in long-term memory. To maintain coherence across segments, the most highly activated nodes remain in working memory to participate in the next processing cycle. After a text has been processed, the likelihood of retrieving a particular node is a function of the activation that node accumulated across all of the processing cycles in which it participated. Once retrieved, a node can cue recall of any content linked to it. The likelihood that a retrieved node will successfully cue recall of a related node is a function of the strength of the link between those nodes.

Based on these theoretical assumptions, how might elaborations in text enhance memory for main ideas? One plausible expectation is that nodes representing main ideas would participate in a greater number of processing cycles in elaborated texts versus unelaborated texts. In an unelaborated text, each main idea is processed in 1 cycle and then likely supplanted by the next main idea during the subsequent processing cycle. In an elaborated text, main idea nodes may be carried forward in working memory during several subsequent cycles involving processing of the elaborations related to that main idea. Moreover, main ideas that are not carried forward may be re-activated from long-term memory during subsequent cycles based on content overlap with associated elaborations. Main ideas that participate in additional cycles will accrue more activation, form a greater number of connections with other nodes, and strengthen existing connections. Increased node strength increases the likelihood of subsequently retrieving the main idea nodes. Furthermore, more connections with other nodes would provide additional retrieval cues, and stronger connections would further increase the likelihood of retrieving main idea nodes.

With that said, the theoretical analysis above is based on idealized processing of elaborated texts (i.e., nodes representing main ideas are maintained or reactivated and then form additional connections and strengthen existing connections in all subsequent processing cycles involving associated elaborations). A crucial aspect of this idealized model is that main ideas participate in a greater number of processing cycles in elaborated versus unelaborated texts because they are carried forward in working memory during subsequent cycles involving processing of elaborations. An alternative possibility is that main ideas do not participate in additional processing cycles because the elaborations are instead carried forward in subsequent processing cycles. Elaborations are typically more concrete and familiar than main ideas. Therefore, they may activate a greater amount of information from long-term memory and thus accrue enough activation during the integration phase to emerge as the most highly activated nodes to be carried forward. If main ideas do not participate in additional processing cycles, they would not gain the retrieval advantages described in the preceding paragraph. If so, memory for main ideas would be similar following study of elaborated versus unelaborated texts.

The remaining possibility is that elaborations may undermine memory for main ideas. As described above, main ideas may not emerge as the most connected and activated nodes. If main ideas and elaborations are not connected in a coherent representation, they will function as independent pieces of information. In this case, elaborations may compete with the retrieval of the main ideas instead of facilitating retrieval. A prediction that follows from theories of interference is that this competition will decrease the probability of recalling the main ideas (Anderson and Neely 1996). This prediction also follows from the principle of cue overload (Earhard 1967). Given that the probability of recalling any particular piece of information decreases as the amount of information linked to a retrieval cue increases, recall for the main ideas would be lower for an elaborated versus unelaborated text (Nairne 2002). Allwood et al. (1982) similarly note that elaborations may lead to more cluttered representations of facts, making it difficult to distinguish between the main points and related details.

Overview of Current Research

Given the scarcity of prior research, the goal of the current research was to systematically investigate the effects of elaborations in expository text. The applied relevance of this question motivated the use of an educationally representative methodology. In three experiments, participants read excerpts from psychology textbooks. Participants read a text either in the fully elaborated version or in a shortened, unelaborated version containing just main ideas.[2] Reading was self-paced to afford estimation of the time cost imposed by elaborations. Two days later, participants completed tests of their memory of the main ideas (and also comprehension tests).

To review, the current study addresses two main questions: What is the time cost imposed by including elaborations within expository texts? And does the benefit of elaborations for enhancing memory for main ideas outweigh this time cost?

Experiment 1

Method

Participants Participants included 128 undergraduate students at Kent State University (78% female 77% white, 14% black, 8% Asian, 3% first nations, 4% Hispanic or Latino); 47% were first-year college students (*M* years in college = 2.2, *SE* = 0.1) and 22% were psychology majors. Participants were 19.9 years old on average (*SE* = .3, range = 18–38). We recruited all

[2] Given that this study was the first to investigate the effect of elaborations on the learning of main ideas with an educationally representative methodology, we implemented a strong manipulation (full elaboration vs. no elaboration). As Shadish et al. (2002) recommend, "full-dose treatment versus no treatment … is especially valuable early in a research program when it is important to test whether large effects can be found under circumstances most favorable to its emergence" (p. 50).

participants from the Psychology Department participant pool, and they received course credit. Data from 21 participants were excluded from analysis due to lost Session 1 data ($n = 3$), failure to return for session 2 ($n = 7$), or evidence of non-compliance (i.e., if they spent less than 1 s on one or more text pages; $n = 11$). The final sample included 107 participants. Based on sensitivity analyses using G*Power (Faul et al. 2009) with alpha of .05 and .80 power, this sample size afforded sufficient power to detect moderate effects for independent samples t tests ($d \geq .49$ for one-tailed tests, $d \geq .55$ for two-tailed tests).

Materials We used two texts taken directly from undergraduate psychology textbooks. The topic of one text was memory (excerpted from OpenStax 2014), and the topic of the other text was language (excerpted from Goldstein 2005). We edited both texts to remove all seductive details (i.e., details added to text that are intended to increase interest but are unrelated to target material; for a recent review see Clark and Mayer 2012). Given that texts with seductive details decrease memory in comparison to texts without seductive details (e.g., Garner et al. 1989), we removed seductive details to avoid starting the elaborated texts with a known disadvantage. For the language text, we also removed two figures, the references to those figures, and several citations. In the memory text, we removed two figures, the references to those figures, one image, the explanation of that image, and several citations. We also removed all references to other parts of the book or chapter outside of each text. Apart from these edits, given our interest in examining the effectiveness of authentic textbook elaborations, we retained all elaborations presented in the original passages. Then, we broke each text down into a list of sentences in serial order and asked five graduate students and professors to judge whether each sentence conveyed a main idea. We used the 12 sentences with the highest agreement among raters ($M = 4.3$ out of 5 raters on average for the language text and 5 out of 5 for the memory text) to create the unelaborated version of each text. Finally, we made minor edits to the texts by adding transitions and paragraph breaks. The elaborated version of the memory text was 1078 words, and the unelaborated version was 185 words. The elaborated version of the language text was 1119 words, and the unelaborated version was 200 words. The appendix includes both versions of the open-access memory text for reference (the language text is copyrighted material and thus is not included here, but all material can be obtained from the first author upon request).

Procedure and Design A computer program presented all tasks and instructions to participants who worked at individual stations. First, general instructions told participants that they would be learning information from two texts and that they would be tested on this information in the next session. After the general instructions, each participant read the elaborated version of one text and the unelaborated version of the other text. We counterbalanced both the order of the two conditions and the assignment of text topic to conditions across participants. Each text was presented on multiple pages. The elaborated version of the text was presented on six different pages, and the unelaborated version of the text was presented on three different pages. Each page displayed about a paragraph of information. Reading on each page was self-paced. At any point, participants could click buttons to go back to previous pages or to move forward to the subsequent pages. On the last page of each text, participants clicked a button when they finished reading. A textbox required participants to verify that they were completely done reading the text before moving on to the next task.

After reading the first text, participants completed several ratings. First, participants rated, "How difficult did you find this text on a scale of 1–100? (0 = very easy and 100 = very difficult).” Then, participants rated, “If this text was assigned reading for a class you were taking, how likely is it that you would actually read the text? (0 = very unlikely and 100 = very likely).” Finally, participants rated, “How interesting did you find this text on a scale of 1–100? (0 = very uninteresting and 100 = very interesting).” After completing these ratings, participants made topic learning judgments for the five main topics covered in the text they had just finished reading. For each main topic, participants indicated, “How much of the information about this topic will you remember on a test two days from now? (0 = none and 100 = all).” After reading and making ratings for the first text, the procedure repeated for the second text.

Two days later, participants completed a series of final tests.[3] All participants completed the tests in the same order. The questions for each test were presented in a fixed, random order to all participants. Within each test, participants answered questions covering the first text they read in Session 1 and then answered questions covering the second text they read in session 1. Participants had unlimited time to complete each test. First, on the topic recall test, participants saw the five main topics from each text one at a time, and the instructions prompted them to type in everything they remembered about the topic. This measure yielded floor-level performance across both versions of each text (elaborated memory text, $M = 5.7\%$, $SE = .5$; unelaborated memory text, $M = 4.7\%$, $SE = .4$; elaborated language text, $M = 3.8\%$, $SE = .5$; unelaborated language text, $M = 3.4\%$, $SE = .4$). Consequently, we dropped topic recall from experiments 2–3 and do not discuss this measure further. Next, participants completed a cued recall test that included 12 questions for each text, one for each of the 12 main ideas (questions for the memory text are included in Appendix). Participants saw questions one at a time, and the instructions prompted them to type in an answer. Then, participants completed a comprehension test that included five multiple choice questions and three short answer questions for each text (questions for the memory text are included in Appendix). Each multiple choice question included four alternatives. Participants saw comprehension test questions one at a time. After completing the final tests, participants saw the five main topics from each text and indicated if they had learned about any of the topics in a psychology course. Participants selected yes or no for each topic. Finally, participants completed demographic information.

Scoring

For cued recall scoring, we identified all of the information relevant to each question within the unelaborated version of the text and then parsed this information into idea units. Each question had between one and four idea units (the 12 questions for the memory text contained a total of 23 idea units, and the 12 questions for the language text contained a total of 22 idea units). For each question, trained raters scored the percentage of idea units recalled by each participant. Raters scored both verbatim recall and close paraphrases as correct. We used a similar scoring procedure for the short answer portion of the comprehension test. For the multiple choice portion of the comprehension test, trials in which a participant responded in less than 1 s were excluded from analysis (based on the length of the questions, participants could not reasonably read the question and select a response in less than 1 s). Overall, exclusion rates were quite low (0.6% of trials across experiments 1–3). Further, on the short answer portion of the

[3] Given the literature on the testing effect, we chose to use a delayed test only because administering an immediate test prior to the delayed test would influence performance on the delayed test (e.g., Roediger III and Karpicke 2006).

comprehension test and on the cued recall test, we did not exclude any trials (i.e., 0% of trials had responses less than 1 s).

Two raters scored sets of responses from 20 to 40 participants for each of the tests to check reliability. In general, interrater reliability was acceptable (*r*s > .80) except for the short answer questions for the language text (*r* = .68; to foreshadow, this text was not used in experiments 2–3). Given the acceptable interrater reliability, one rater scored the rest of the responses for each test.

We report internal reliability for all measures in Table 2. In all experiments, reliability was acceptable for cued recall, which is the primary outcome of interest. Reliability on the comprehension test was somewhat low. Due to low reliability and given that the comprehension test was always completed after the memory test, some caution is warranted in interpreting the comprehension results.

Results and Discussion

We report one-tailed *p* values for tests of a priori directional predictions (Judd and McClelland 1989; Maner 2014). For all *t* tests, we report Cohen's *d* using pooled standard deviations. Note that the design affords both within- and between-participant analysis to investigate the effect of elaborations. We report outcomes for both the between-participants and within-participant analyses below. The between-participants analysis involves comparison of the elaborated versus unelaborated text for each topic (i.e., in which the main ideas are equated) and permits examination of the extent to which the results generalize across the two topics (embedded replication). We first examined if the order in which participants read the two texts influenced the results. Unsurprisingly, participants spent more time reading the first versus the second text, and final test performance was generally greater for the first versus second text. The only significant interaction between text version and order was for the cued recall memory test, but in follow up *t* tests, the effect of version was not significant for either order. Thus, these order effects do not qualify interpretation of the effects of elaborations reported below. Further, the same qualitative patterns emerged in within-participant comparisons using a z-transformation of the final scores (we used a *z* transformation because of non-equivalent material sets), which are also reported below.

Table 2 Cronbach's alpha for all measures

	Cued recall	Comprehension
Experiment 1		
Language text	.68	.42
Memory text	.62	.61
Experiment 2		
Memory text	.88	.64
Experiment 3		
Memory text	.75	.56

Note. The cued recall test for each text included 12 items. The comprehension test for each text included eight items in experiment 1 and 10 items in experiments 2–3

Question 1: What Is the Time Cost Imposed by Including Elaborations Within Expository Texts? To estimate time cost, we recorded the number of minutes each participant spent reading each text. As shown in Fig. 1, reading time was longer for the elaborated version versus the unelaborated version of each text (memory text, $t(105) = 5.93$, $p < .001$, $d =$ 1.16; language text, $t(105) = 6.00$, $p < .001$, $d = 1.17$; within-participant $t(106) = 9.25$, $p < .001$). Reading time increased 263% for the elaborated version versus the unelaborated version of the memory text, and reading time increased 233% for the elaborated version versus the unelaborated version of the language text. To foreshadow, we report exploratory analyses to further decompose these reading time differences after experiment 3.

Question 2: Does the Benefit of Elaborations for Enhancing Memory for Main Ideas Outweigh This Time Cost? Whereas elaborations imposed a large time cost, they did not yield a concomitant benefit: Figs. 2 and 3 show no evidence that elaborations enhanced memory for main ideas. Instead, cued recall performance was similar for the elaborated and unelaborated versions of each text (memory text, $t(105) = .10$, $p = .921$, $d = .02$; language text, $t(105) = .43$, $p = .668$, $d = .08$; within-participant, $t(106) = .49$, $p = .628$).

Although memory for main ideas was the learning outcome of primary interest for present purposes, we also report outcomes for the comprehension test. Because the comprehension test always followed the memory tests, some caution in interpreting outcomes is warranted. With that said, the pattern of comprehension performance closely parallels that of memory performance. Comprehension performance was similar for the elaborated and unelaborated versions of each text (memory text, $t(105) = .14$, $p = .886$, $d = .03$; language text, $t(105) = .38$, $p = .703$, $d = .07$; within-participant, $t(106) = .49$, $p = .628$).

In sum, these results indicate that including elaborations imposes a considerable time cost that is not outweighed by a correspondingly large increase in memory of main ideas.

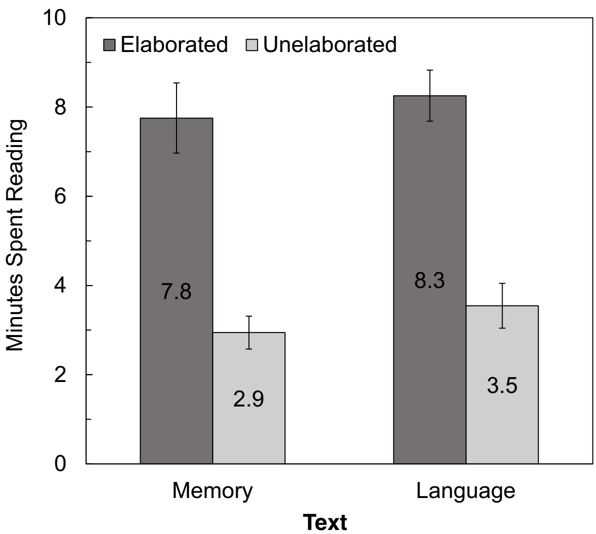

Fig. 1 Experiment 1. Time cost as indicated by the number of minutes spent reading each version of each text. Elaborated = the version with both main ideas and elaborations. Unelaborated = the version with just the main ideas. Error bars reflect standard errors of the means

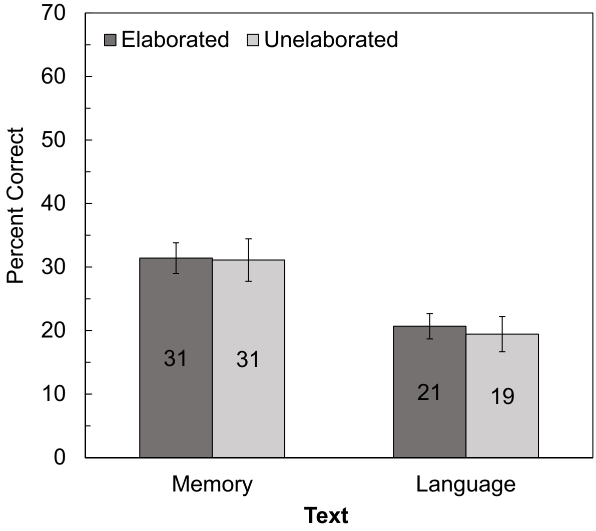

Fig. 2 Experiment 1. Performance on the cued recall posttest. Elaborated = the version with both main ideas and elaborations. Unelaborated = the version with just the main ideas. Error bars reflect standard errors

Experiment 2

Experiment 1 provided initial evidence that the memory benefits of including elaborations in expository texts do not outweigh the time cost they impose. Given the recent emphasis in the field on the importance of direct replication of novel findings (e.g., Pashler and Harris 2012; Schmidt 2009; Simons 2014), the primary purpose of experiment 2 was to replicate the key outcomes of experiment 1. Experiment 2 was a close replication of the first experiment, with an important methodological change. Given that differences in the normative difficulty of the memory and language texts complicates within-participant analyses and given that the pattern of results was the same for the between-participants and within-participant analyses,

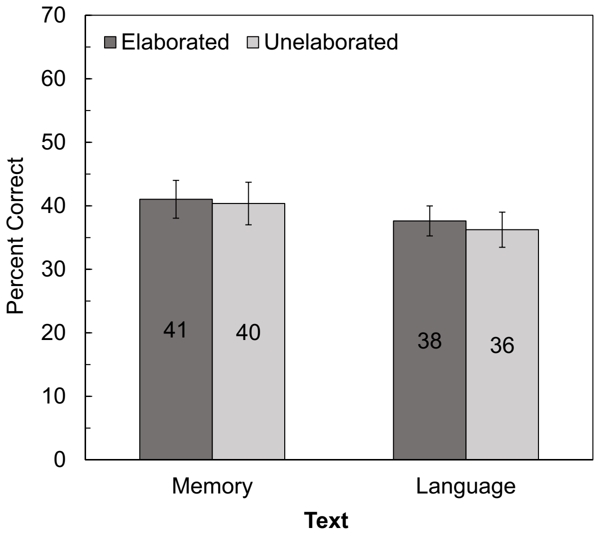

Fig. 3 Experiment 1. Performance on the comprehension posttest. Elaborated = the version with both main ideas and elaborations. Unelaborated = the version with just the main ideas. Error bars reflect standard errors

experiment 2 involved only one text and a between-participants design. Another minor change involved the addition of two questions to the multiple-choice component of the comprehension test in an attempt to increase the reliability of that measure.

Experiment 2 also included an extension group to facilitate further interpretation of the similar memory performance observed for elaborated versus unelaborated texts in experiment 1. One interpretation of this outcome is that the elaborated and the unelaborated versions of the texts facilitated learning to a similar degree. An alternative explanation for this outcome is that neither version of the text facilitated learning. Although performance in both groups was off the nominal floor of 0%, the possibility remains that performance was at a functional floor (i.e., the level of performance that might still be achieved in the absence of experimentally-induced learning due to factors such as prior knowledge). To investigate this possibility, experiment 2 included a control group who completed the final tests without first reading the text. We predicted greater final test performance for the groups who read either the elaborated or unelaborated text versus the control group. This outcome would rule out the possibility that neither text facilitated learning.

Another alternative explanation for the similar memory performance observed for elaborated versus unelaborated texts in experiment 1 is that the two versions yielded different levels of memory, but we were unable to detect these differences because performance on the memory test was near a functional ceiling. Although performance in both groups was off the nominal ceiling of 100%, the possibility remains that performance was at a functional ceiling (i.e., the highest level of performance that might be demonstrated in the absence of memory constraints, which may be lower than 100% due to factors such as difficulty in identifying main ideas). To investigate this possibility, the control group completed the final tests a second time but with the text available (i.e., an open-book test), which provides an estimate of the functional ceiling for these materials. We predicted that open-book test performance in the control group would be greater than final test performance in the experimental groups, which would rule out the functional ceiling interpretation.

Method

Participants Undergraduate students ($N = 108$) at Kent State University who did not participate in Experiment 1 participated in experiment 2 (82% female, 84% white, 12% black, 6% Asian, 0% first nations, 6% Hispanic or Latino); 40% were first-year college students (M years = 2.2, $SE = 0.1$) and 24% were psychology majors. Participants were 20.5 years old on average ($SE = .5$, range = 18–58). We recruited all participants from the Psychology Department participant pool, and they received course credit. Data from 8 participants were excluded from analysis due to lost session 1 data ($n = 2$) or failure to return for session 2 ($n = 6$). The final sample included 100 participants (ns = 34 in the control group, 33 in the unelaborated group, and 33 in the elaborated group). For the comparisons of performance between the experimental groups and control group, this sample afforded sufficient power to detect moderate effects ($d \geq .53$), based on a sensitivity analysis using G*Power (Faul et al. 2009) for a one-tailed, independent samples t test with an alpha level of .05 and .80 power. For the comparison of time cost between the two experimental groups, this sample size afforded power > .99 to detect the large effect of time cost found in the first experiment ($d = 1.16$ for the memory text).

Materials, Design, and Procedure We used the memory text and the memory tests from experiment 1, except for the topic recall test. We also added two multiple-choice questions to the comprehension test.

We randomly assigned participants to one of three groups: elaborated text, unelaborated text, or control. The procedure in the elaborated and unelaborated text groups was similar to Experiment 1, except that participants only read one text in session 1 and did not take the topic cued recall test in session 2. In the control group, participants completed the final tests in session 1 without reading the material. In session 2, 2 days later, participants in the control group had access to a paper copy of the text while they completed the final tests again. We randomly assigned participants in the control group to receive one of the two versions of the text, either the elaborated version ($n = 16$) or the unelaborated version ($n = 17$).

Results and Discussion

We report the planned comparisons that address our research questions below (for recommendations for conducting only the statistical analyses necessary for answering one's research questions instead of an omnibus ANOVA, see Judd and McClelland 1989; Rosenthal and Rosnow 1985; Tabachnick and Fidell 2001; Wilkinson and Task Force on Statistical Inference 1999).

Question 1: What Is the Time Cost Imposed by Including Elaborations within Expository Texts? Replicating a key outcome of experiment 1, reading time in experiment 2 was longer for the elaborated version ($M = 7.6$ min, $SE = 0.8$) versus the unelaborated version($M = 3.5$ min, $SE = 0.6$), $t(64) = 4.09$, $p < .001$, $d = 1.01$. Reading time was 216% greater for the elaborated versus the unelaborated version of the text.

Question 2: Does the Benefit of Elaborations for Enhancing Memory for Main Ideas Outweigh This Time Cost? As Fig. 4 shows, the answer to this question is no. Memory for main ideas was not greater in the elaborated group than in the unelaborated group, $t(64) = -1.55$, $p = .126$, $d = -.38$. Performance on the comprehension test was not significantly different for the elaborated versus unelaborated groups, $t(64) = .60$, $p = .550$, $d = .15$.

Across both experiments, the results provide no evidence of greater memory for main ideas following an elaborated versus an unelaborated version of a text. The finding that performance on the final memory test was less similar in experiment 2 than in experiment 1 partly mitigates concerns about functional floor or ceiling effects. Nevertheless, we still compared performance in the experimental groups to the control group to rule out these two alternative explanations. To investigate the possibility that neither version of the text facilitated learning and performance on the final test was thus near the functional floor, we compared final test performance for the experimental groups (those who took the final tests after reading) versus the control group in session 1 (who took the final tests before reading). Memory for main ideas was greater in the experimental groups ($M = 32\%$, $SE = 2$) versus the control group ($M = 18\%$, $SE = 3$), $t(98) = 3.56$, $p < .001$, $d = .75$, indicating that performance in the experimental groups was not at the functional floor. Additionally, comprehension was greater for the experimental groups ($M = 53\%$, $SE = 3$) versus the control group ($M = 44\%$, $SE = 3$), $t(98) = 1.86$, $p = .033$, $d = .39$. These results provide support that both versions of the text facilitated learning.

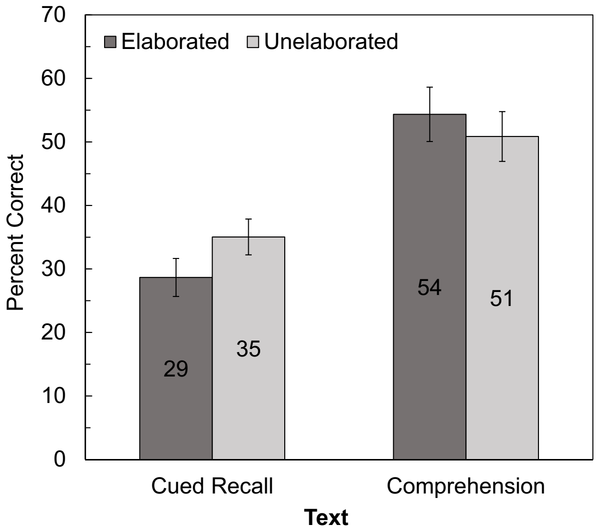

Fig. 4 Experiment 2. Performance on the memory and comprehension posttests. Elaborated = the version with both main ideas and elaborations. Unelaborated = the version with just the main ideas. Error bars reflect standard errors

The second possibility is that differences in memory did exist, but these differences were not detectable because performance was near the functional ceiling. To investigate this possibility, we compared final test performance for the experimental groups versus the control group in session 2 (under open-book conditions). Memory for main ideas was greater in the control group ($M = 78\%$, $SE = 4$) versus the experimental groups ($M = 32\%$, $SE = 2$), $t(98) = 11.95$, $p < .001$, $d = 2.52$, indicating that performance in the experimental groups was not at the functional ceiling. Additionally, comprehension was greater for the control group ($M = 66\%$, $SE = 3$) versus the experimental groups ($M = 53\%$, $SE = 3$), $t(98) = 2.91$, $p < .001$, $d = .61$.

Interestingly, performance on the open-book memory test in the control group was somewhat lower for those who were given the elaborated version ($M = 73\%$, $SE = 5$) versus the unelaborated version ($M = 86\%$, $SE = 2$), $t(31) = -2.22$, $p = 0.033$, $d = -.77$. These results suggest that main ideas may be less identifiable in the elaborated text versus the unelaborated text, a possibility that we consider further in the "General Discussion." Performance on the open-book comprehension test was similar for the elaborated version ($M = 62\%$, $SE = 5$) versus the unelaborated version ($M = 71\%$, $SE = 4$), $t(31) = -1.33$, $p = .193$, $d = -.46$.

Experiment 3

Although we designed experiments 1 and 2 to parallel the conditions under which students use textbooks in several important ways (e.g., self-paced reading, delayed test), other aspects of the procedure did not reflect typical conditions under which students read textbooks. For instance, whereas the texts were presented via computer (for precise measurement of reading times), students often read print versions of their textbooks. Furthermore, computer presentation prevented students from highlighting. In experiments 1 and 2, we also did not permit students to take notes while reading, whereas students are typically able to engage in these activities. To assess the extent to which our results generalize to these more typical conditions, participants in experiment 3 read a paper copy of their assigned text and could highlight and take notes while reading.

Method

Participants Undergraduate students ($N = 83$) at the Kent State University participated in experiment 3 (79% female, 73% White, 11% Black, 13% Asian, 1.4% first nations, 6% Hispanic or Latino); 23% were first-year college students (M years = 2.5, $SE = 0.1$) and 42% were psychology majors. Participants were 20.6 years old on average ($SE = .3$, range = 18–34). We recruited all participants from the Psychology Department participant pool, and they received course credit. Data from 12 participants were excluded from analysis due to lost session 1 data ($n = 1$) or failure to return for session 2 ($n = 11$). The final sample included 71 participants ($n = 38$ in the unelaborated group, $n = 33$ in the elaborated group). For the comparison of time cost between the two experimental groups, this sample size afforded power > .99 to detect the smaller of the two effect sizes observed in experiments 1–2 for the memory text ($d = 1.01$).

Materials, Design, and Procedure We used the memory text and the memory tests from experiment 2.

We randomly assigned participants to one of two groups: elaborated text or unelaborated text. The procedure for both groups was similar to experiment 2, except that participants read a paper copy of their assigned text and had the option to take notes and highlight while reading. The experimenter placed a sheet of notebook paper for notes, a highlighter, and a pen next to the participant's computer. The computer instructed participants to highlight, underline, and take notes as they normally would when reading a textbook. After reading task instructions on the computer, participants were instructed to ask the experimenter for a copy of the text. The experimenter handed the participant their assigned text. The experimenter then clicked a hidden button on the computer screen to being recording reading time. When participants finished reading, they clicked a visible button on the computer screen, which stopped the timer. The experimenter then collected all materials from the participant.

Results and Discussion

Question 1: What Is the Time Cost Imposed by Including Elaborations Within Expository Texts? Two participants were excluded from this analysis due to an experimenter error (i.e., experimenter did not start the timer for reading time) and computer malfunction. Replicating a key outcome of the first two experiments, reading time in experiment 3 was longer for the elaborated version ($M = 10.9$ min, $SE = 1.1$) versus the unelaborated version of the text ($M = 6.3$ min, $SE = 0.9$), $t(67) = 3.27$, $p < .002$, $d = 0.79$. Reading time was 173% greater for the elaborated version versus the unelaborated version of the text.

Question 2: Does the Benefit of Elaborations for Enhancing Memory for Main Ideas Outweigh This Time Cost? As Fig. 5 shows, the answer to this question again is no. Memory for main ideas was similar for the elaborated and unelaborated groups, $t(69) = -0.13$, $p = .893$, $d = -.03$. For the comprehension test, performance was greater for the elaborated versus unelaborated group, $t(69) = 2.24$, $p = .029$, $d = .53$.

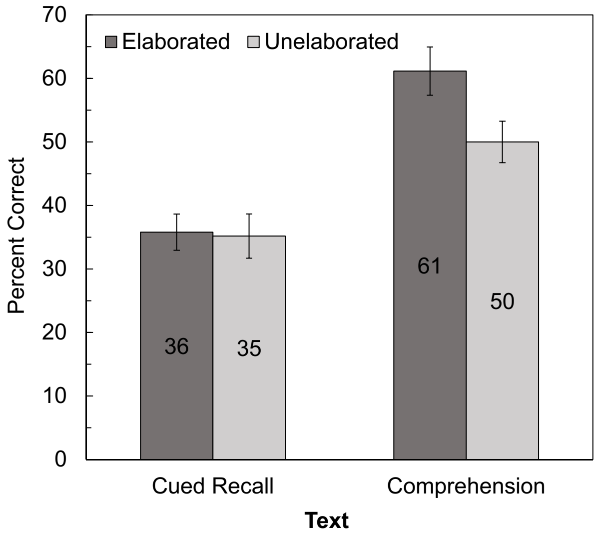

Fig. 5 Experiment 3. Performance on the memory and comprehension posttests. Elaborated = the version with both main ideas and elaborations. Unelaborated = the version with just the main ideas. Error bars reflect standard errors

Secondary Outcomes in Experiments 1–3

To supplement analyses relevant to our primary questions, we report outcomes from exploratory analyses and other outcomes of secondary interest below.

Decomposing Time Cost To examine how students spent their time reading each version of the text, we report various indicators of reading behaviors in Table 3. The table does not include Experiment 3 because we only had a measure of total reading time in that experiment.

On the first time participants read each page of the text, more time was spent by those reading the elaborated version versus those reading the unelaborated version (experiment 1: memory text, $t(105) = 4.61$, $p < .001$, $d = .87$; language text, $t(105) = 4.57$, $p < .001$, $d = .90$; experiment 2: $t(64) = 2.62$, $p = .01$, $d = .64$). Additionally, participants reread a greater percentage of the text when given the unelaborated version versus the elaborated version, although this result was only significant in experiment 1 (memory text, $t(105) = 2.46$, $p = .016$, $d = .60$; language text, $t(105) = 3.08$, $p = .003$, $d = .48$). For pages that were reread, the average time spent rereading per page was similar for the elaborated and unelaborated versions (ts < 1.1). Finally, reading speed (computed as words per minute overall, including initial reading and rereading) was slower for the unelaborated version versus the elaborated version, but this difference was only significant in experiment 1 (memory text, $t(105) = 2.21$, $p = .029$, $d = .43$; language text, $t(105) = 4.07$ $p < .001$, $d = .79$).

Another indicator of time cost is the amount of time required to complete the final test (see Table 4). Across all experiments, participants spent a similar amount of time on each test regardless of the version of the text they read (ts < 1.3).

Self-Report Measures For completeness, we report outcomes for several self-report measures in Table 5. The only significant differences included the ratings of difficulty and likelihood of reading for the memory text in experiment 1 ($t(105) = 3.08$, $p = .003$, $d = .60$, and $t(105) = -2.27$, $p = .027$, $d = -.44$, respectively) and judgments of learning in experiment 3 ($t(66) = 2.35$, $p = .02$, $d = .57$).

Table 3 Reading behavior

	Seconds per page first	% of pages restudied at least once	Seconds per page reread	WPM
Experiment 1				
Elaborated—language	60.0 (4.9)	45.3 (5.6)	36.1 (6.8)	193.7 (19.8)
Unelaborated—language	33.2 (2.8)	70.9 (6.1)	27.8 (4.8)	96.3 (9.7)
Elaborated—memory	60.6 (6.0)	37.2 (6.5)	26.0 (3.8)	238.1 (45.2)
Unelaborated—memory	31.5 (3.1)	58.9 (5.9)	21.9 (2.2)	138.2 (18.5)
Experiment 2				
Elaborated	56.5 (6.0)	55.6 (7.8)	25.1 (4.6)	187.5 (18.0)
Unelaborated	35.4 (5.4)	64.7 (8.1)	21.4 (2.6)	124.9 (32.6)

Note. Trials with reading times less than 1 s were excluded from analysis. Seconds per page first = the average number of seconds participants spent the first time they read each page of the text. % of pages restudied at least once = the percentage of pages in a text that were revisited at least once. Seconds per page reread = the average number of seconds participants spent on each page they reread. WPM = the average number of words read per minute spent reading the entire passage, including both initial reading and rereading. Standard errors are reported in parentheses

For interested readers, Table 6 reports correlations between reading time, final test outcomes, and each of the self-report measures. To increase sample size for these analyses, we combined data from the first two experiments for the memory text. Most correlations were small and non-significant. Caution is warranted in interpreting significant correlations, given the likelihood of capitalizing on chance when examining multiple correlations in the absence of strong a priori predictions and without a sufficiently large sample size (e.g., see Maxwell 2004).

General Discussion

Elaborations are a common feature of textbook passages, yet few studies have investigated the effects of elaborations in expository text. None of these prior studies provided estimates of the

Table 4 Test time in seconds per question

	MC	SA	Cued recall
Experiment 1			
Elaborated—language	8.4 (.5)	38.4 (2.6)	23.7 (1.5)
Unelaborated—language	9.3 (.5)	40.6 (2.9)	22.8 (1.6)
Elaborated—memory	15.4 (.7)	15.5 (1.1)	26.3 (1.8)
Unelaborated—memory	14.8 (.6)	15.2 (1.3)	25.4 (1.8)
Experiment 2			
Elaborated	16.0 (1.0)	15.5(1.1)	36.0 (5.0)
Unelaborated	16.6 (.8)	14.4 (1.0)	30.7 (2.6)
Control—S1	15.7 (.8)	15.7 (1.0)	23.0 (1.8)
Control—S2	19.4 (1.4)	20.1 (1.6)	29.3 (1.4)
Experiment 3			
Elaborated	16.2 (0.9)	14.6 (0.9)	29.1 (2.0)
Unelaborated	17.2 (1.5)	14.6 (1.3)	27.9 (2.2)

Note. MC = the average number of seconds spent on each multiple-choice question on the comprehension test. SA = the average number of seconds spent on each short-answer question on comprehension test. Cued recall = the average number of seconds spent on each cued recall question. Standard errors are reported in parentheses

Table 5 Outcomes for secondary measures

	Self-reported concepts learned (out of 5)	Topic learning judgment magnitude	Difficulty	Interest	Likelihood of reading
Experiment 1					
Unelaborated—language	1 (.2)	62 (3)	42 (3)	53 (3)	57 (4)
Elaborated—language	1 (.2)	58 (2)	49 (3)	54 (4)	60 (4)
Unelaborated—memory	3 (.3)	70 (2)	29 (3)	65 (2)	73 (3)
Elaborated—memory	4 (.3)	69 (2)	43 (4)	61 (3)	62 (4)
Experiment 2					
Unelaborated	4 (.3)	69 (4)	24 (3)	60 (3)	69 (5)
Elaborated	4 (.3)	61 (3)	32 (3)	55 (4)	60 (5)
Experiment 3					
Unelaborated	5 (.2)	67 (3)	21 (3)	68 (4)	64 (4)
Elaborated	5 (.2)	76 (2)	17 (3)	76 (4)	66 (4)

Note. Self-reported concepts learned = the number of main topics students reported learning in a previous class. Topic learning judgment values are mean values across all concepts. Difficulty = self-reported difficulty of the text. Interest = self-reported interest in the text. Likelihood of reading = self-reported likelihood of reading the text if it was assigned for a class. Topic judgments and all ratings were made on a scale of 0 to 100. Standard errors are reported in parentheses

time cost that elaborations impose on students, and the evidence regarding the effect of elaborations on memory for main ideas is mixed and limited for practical purposes. Both of these effects of elaborations (time costs and memory benefits) are important for drawing conclusions about the overall effectiveness of elaborations in expository text. Thus, we investigated these effects across three experiments. To provide the most stable estimates of these effect sizes, we combined results across experiments using the continuously cumulating meta-analysis (CCMA) approach recommended by Braver et al. (2014). We present these analyses in Table 7 for the outcomes that inform our two focal questions, reading time and cued recall, and we also report comprehension performance.

Question 1: What Is the Time Cost Imposed by Including Elaborations Within Expository Texts? The combined estimate compares the average time spent reading the elaborated version versus the unelaborated version of the memory text used in all three experiments. According to the combined estimate, the elaborated version of the text imposes a large time cost on students (pooled $d = 1.00$, 95% CI = .73, 1.27).

Table 6 Correlations between all measures

Measure	1	2	3	4	5	6	7
1. Comprehension	–						
2. Cued recall	.55**	–					
3. Read time	− .06	− .24**	–				
4. Prior knowledge	.19**	.11	− .08	–			
5. Difficulty	− .11	− .10	.00	− .21**	–		
6. Likelihood	− .08	.01	.03	.01	− .11	–	
7. Interest	− .03	.02	.07	− .02	− .05	.44**	–
8. Topic judgment	.25**	.38**	.10	.33**	− .28**	.33**	.31**

Note. ** $p < .01$. Data are from the memory text for participants from experiments 1–2 (combined *n*s range from 168 to 207)

Table 7 Continuously cumulating meta-analysis (CCMA) outcomes for minutes spent reading, cued recall performance, and comprehension performance

	Mean diff.	S_{pooled}	t	p (two-tail)	Cohen's d	z
Elaborated vs. unelaborated minutes spent reading						
Experiment 1	4.8	4	5.93	< .001	1.16	5.50
Experiment 2	4.1	4	4.09	< .001	1.01	3.84
Experiment 3	4.6	6	3.27	.002	.79	3.14
CCMA results				< .001	1.00	
Elaborated vs. unelaborated cued recall						
Experiment 1	0.3	16	0.10	.921	0.02	0.10
Experiment 2	− 6	17	− 1.55	.126	− 0.38	1.53
Experiment 3	0.6	19	− 0.13	.893	0.03	0.13
CCMA results				.513	− 0.08	
Elaborated vs. unelaborated comprehension						
Experiment 1	1	24	0.14	.886	0.03	0.14
Experiment 2	3	24	0.60	.550	0.15	0.60
Experiment 3	11	21	2.24	.029	0.53	2.19
CCMA results				.114	0.20	

Note. Mean diff = mean value for elaborated group minus mean value for unelaborated group for each outcome measure. Effect size homogeneity tests were non-significant for all CCMAs (minutes spent reading: $Q(2) = 1.25$, $p = .535$; cued recall: $Q(2) = 1.96$, $p = .375$; comprehension: $Q(2) = 2.72$, $p = .257$)

Question 2: Does the Memory Benefits for Main Ideas Afforded by Elaborations Outweigh This Time Cost? The combined estimate compares performance for the elaborated version versus the unelaborated version of the memory text. Concerning the main outcome of interest, cued recall performance was similar for the elaborated and unelaborated versions of each text (pooled $d = -.08$, 95% CI = − .34, 17). Of secondary interest, the combined estimate for comprehension suggests that any effect of elaboration on main idea comprehension is small at best (pooled $d = .20$, 95% CI = − .05, .46).

Overall, these results support the conclusion that the substantial time costs imposed by elaborated texts are not outweighed by concomitant benefits to learning of main ideas. The results of these three experiments are the first to indicate, under more representative conditions than have been examined previously, that elaborations in expository text do not increase retention of main ideas. Experiment 2 further established that both the elaborated and unelaborated versions of the text enhanced retention to a similar extent (relative to a no-reading control group). With that said, the level of memory for main ideas afforded by each version of the text was somewhat modest after a delay of 2 days. When evaluating any learning technique, it is important to consider not just relative gains but also the absolute levels of learning achieved (for discussion, see Rawson et al. 2018). Although the absolute levels of retention observed in the current study were relatively modest, they may be a sufficient starting point if the purpose of reading is to acquire foundational knowledge on which to build in subsequent learning activities. For example, students may use textbook reading to acquire information that will support additional learning during a subsequent lecture or during later rereading of the textbook. The first time reading a textbook passage is unlikely to be the terminal point in learning a topic. An interesting direction for future research is to examine if elaborated versus unelaborated versions of a text differ in the preparation they provide for learning additional material related to the same topic (e.g., Bransford and Schwartz 1999; Schwartz and Martin 2004).

The current experiments are also the first to estimate the extent to which elaborated texts are less efficient than unelaborated texts. Whereas the large time cost imposed by elaborations is not surprising, many readers may find the lack of any benefit for learning main ideas surprising. Presumably, the prevalence of elaborations in textbooks is based (at least in part) on the intuitive assumption that elaborations are robust learning tools. In contrast, empirical support for the efficacy of elaborations is lacking, and our results indicate elaborations are not as robust as one might expect.

Practical Implications

One important practical implication of the current work is that omitting elaborations from textbooks may save students time that they can then spend on learning other material. Thus, unelaborated texts could have indirect benefits to the overall amount of learning that student achieve across various sets of to-be-learned material. Another intriguing possibility is that removing elaborations would also increase student compliance in completing assigned reading. As many instructors know, students often fail to complete assigned readings (e.g., Clump et al. 2004). The modal reason students report for not completing an assigned reading is lack of time (Starcher and Proffitt 2011). It follows that students may be more likely to complete short versus long reading assignments. Some empirical support for this possibility stems from a recent survey in which we asked 311 Kent State undergraduates various questions about their study habits, including their likelihood of reading texts of different length for class. Students were asked, "How likely are you to complete a long reading assignment? (more than 20 pages)" and "How likely are you to complete a short reading assignment? (less than 10 pages)." Students answered each question using a 1–7 Likert scale (1 = extremely likely, 7 = extremely unlikely). They reported being more likely to read a short reading assignment ($M = 2.2$, $SE = .1$) than a long reading assignment ($M = 3.8$, SE = .1), $t(310) = 19.34$, $p < .001$, $d = .92$. An online survey with 238 participants from Amazon Mechanical Turk replicated these results. Participants reported being more likely to read a short reading assignment ($M = 2.0$, $SE = .1$) than a long reading assignment ($M = 3.6$, $SE = .1$), $t(237) = 16.82$, $p < .001$, $d = .97$. Given that students are more likely to complete reading assignments that involve shorter versus longer texts, they are more likely to read unelaborated texts that are necessarily shorter than elaborated texts.

Theoretical Implications: Why Might Elaborations Not Enhance Learning?

Despite these intriguing possibilities, it would be premature at this point to make strong prescriptive conclusions about when to omit elaborations from expository texts. Among other things, these prescriptive conclusions await a clear understanding of why elaborations can be ineffective and the conditions under which elaborations are more versus less effective. Our data speak to one plausible reason why the elaborated versions of the texts did not enhance learning of main ideas in the current study. Specifically, students may have more difficulty identifying main ideas in elaborated versus the unelaborated texts. In support of this possibility, on the open-book test for the control group in experiment 2, cued recall for main ideas was lower for those given the elaborated versus the unelaborated version of the text to refer to during this test. Because this test tapped the information explicitly stated about each main idea in the text, these results provide some tentative evidence that students had more difficulty identifying the main ideas in the elaborated versus the unelaborated version of the text.

To examine this possibility further, we conducted a small norming study in which we asked 29 undergraduate participants to identify the main ideas in the elaborated version of the text. All participants were given a printed copy of the text and had as much time as they needed to read and highlight the main ideas. The hit rate (i.e., the average percentage of main ideas identified as main ideas) was 57.2% ($SE = 3.2$). The false alarm rate (i.e., the average percentage of elaborations identified as a main idea) was 12.9% ($SE = 1.4$). To estimate discrimination between main ideas and details, we computed d-prime using the log-linear approach (Hautus 1995). Discrimination was 1.34 ($SE = .07$) and significantly greater than 0, based on a one-sample t test $t(28) = 18.29$, $p < .001$. Although discrimination was above chance, the hit rate indicates that participants only identified about half of the main ideas. Given that students have trouble identifying main ideas in the elaborated version of the text, they may spend less time processing the main ideas in an elaborated text versus an unelaborated text or otherwise devote less attention and resources to these main ideas. This result points to an interesting direction for future research examining the extent to which signaling devices, such as underlining and bolding main ideas, may enhance learning from the elaborated text.

Along with understanding why elaborations may be ineffective, an important next step is to investigate the conditions under which elaborations are more versus less effective. One plausible moderator is background knowledge, given empirical evidence from related literatures suggesting that the effect of elaborations may depend on background knowledge. For instance, one study investigating elaborations using fact lists found greater memory for elaborated target facts versus unelaborated target facts, but only when the target facts described an unknown versus well-known name (Kim and Van Dusen 1988). Although these results are suggestive, they do not provide direct evidence concerning the extent to which the effect of elaborations on memory for main ideas in expository text depends on background knowledge. Although the current study was not designed to investigate individual differences in knowledge, the two texts used in experiment 1 serendipitously yielded different levels of normative prior exposure to the topics included in each text (i.e., self-reported exposure was greater for the memory text versus the language text; see Table 5). Despite the reported exposure differences, the pattern of performance was consistent across both sets of materials, providing no evidence of an advantage with the less familiar language material.[4]

Our data also do not speak to the effects of other possible moderators, such as reading comprehension skill, and the complexity or structure of the materials. An important next step for future work is to examine these and other possible moderators to investigate the conditions under which elaborations may be more effective. Furthermore, students in the current experiments had access to the text on only one occasion. Thus, an interesting direction for future research is examining if these results generalize to conditions under which students can access the text on additional occasions.

[4] We also examined correlations between self-reported prior exposure and performance and the interactions between prior exposure and text version. However, variability in the levels of normative prior exposure reported was low in both studies, and given the lack of a consistent pattern of associations, we did not include these analyses here.

Conclusions

Virtually every class uses a textbook, and these textbooks are often over 100,000 words in length. However, the targets of learning—the main ideas—account for only a small portion of this content. The additional content largely consists of elaborations that are presumably included to enhance learning of these main ideas, but elaborations necessarily increase text length and thus reading time. In the current research involving authentic textbook materials, elaborations more than doubled students' reading time. This cost in additional time would be justified if elaborations led to a corresponding increase in memory for main ideas. However, our results indicate they do not. Given the prevalent use of elaborations in textbooks, we would expect them to have a robust effect on learning. Our results sharply contrast these expectations, signaling the need for future work aimed at understanding why elaborations are ineffective under certain conditions and pinpointing the conditions under which they are effective.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Appendix

Memory Texts and Tests Used in Experiment 1 and Experiment 2

Elaborated Text

Short-term memory (STM) is a temporary storage system that processes incoming sensory memory; sometimes, it is called working memory. Short-term memory takes information from sensory memory and sometimes connects that memory to something already in long-term memory. Short-term memory storage lasts about 20 s. George Miller, in his research on the capacity of memory, found that most people can retain about seven items in STM. Some remember 5, some 9, so he called the capacity of STM 7 plus or minus 2. Think of short-term memory as the information you have displayed on your computer screen a document, a spreadsheet, or a web page. Then, information in short-term memory goes to long-term memory (you save it to your hard drive), or it is discarded (you delete a document or close a web browser).

Through rehearsal, or the conscious repetition of to be remembered information, memories in STM move into long-term memory. This process is called memory consolidation. Long-term memory (LTM) is the continuous storage of information. Unlike short-term memory, the storage capacity of LTM has no limits. It encompasses all the things you can remember that happened more than just a few minutes ago to all of the things that you can remember that happened days, weeks, and years ago. In keeping with the computer analogy, the information in your LTM would be like the information you have saved on the hard drive. It is not there on your desktop (your short-term memory), but you can pull up this information when you want it, at least most of the time. Not all long-term memories are strong memories. Some memories can only be recalled through prompts. For example, you might easily recall a fact ("What is the capital of the United States?") or a procedure ("How do you ride a bike?"), but you might struggle to recall the name of the restaurant you had dinner when you were on vacation in France last summer. A prompt, such as that the restaurant was named after its owner, who spoke to you about your shared interest in soccer, may help you recall the name of the restaurant.

Long-term memory is divided into two types: implicit and explicit. Understanding the different types is important because a person's age or particular types of brain trauma or disorders can leave certain types of LTM intact while having disastrous consequences for other types. Implicit memories are memories that are not part of our consciousness. They are memories formed from behaviors. Procedural memory is a type of implicit memory: it stores information about how to do things. It is the memory for skilled actions, such as how to brush your teeth, how to drive a car, how to swim the crawl (freestyle) stroke. If you are learning how to swim freestyle, you practice the stroke: how to move your arms, how to turn your head to alternate breathing from side to side, and how to kick your legs. You would practice this many times until you become good at it. Once you learn how to swim freestyle and your body knows how to move through the water, you will never forget how to swim freestyle, even if you do not swim for a couple of decades. Similarly, if you present an accomplished guitarist with a guitar, even if he has not played in a long time, he will still be able to play quite well.

Explicit memories are those we consciously try to remember and recall. For example, if you are studying for your chemistry exam, the material you are learning will be part of your explicit memory. Explicit memory has to do with the storage of facts and events we personally experienced. Explicit memory has two parts: semantic memory and episodic memory. Semantic means having to do with language and knowledge about language. An example would be the question "what does *argumentative* mean?" Stored in our semantic memory is knowledge about words, concepts, language-based knowledge, and facts. For example, answers to the following questions are stored in your semantic memory: Who was the first President of the USA? What is democracy? What is the longest river in the world? Episodic memory is information about events we have personally experienced. Currently, scientists believe that episodic memory is memory about happenings in particular places at particular times, the what, where, and when of an event. It involves recollection of visual imagery as well as the feeling of familiarity.

The act of getting information out of memory storage and back into conscious awareness is known as retrieval. This would be similar to finding and opening a paper you had previously saved on your computer's hard drive. Now it's back on your desktop, and you can work with it again. Our ability to retrieve information from long-term memory is vital to our everyday functioning. You must be able to retrieve information from memory in order to do everything from knowing how to brush your hair and teeth, to driving to work, to knowing how to perform your job once you get there.

There are three ways you can retrieve information out of your long-term memory storage system: recall, recognition, and relearning. Recall is what we most often think about when we talk about memory retrieval: it means you can access information without cues. For example, you would use recall for an essay test. Recognition happens when you identify information that you have previously learned after encountering it again. It involves a process of comparison. When you take a multiple-choice test, you are relying on recognition to help you choose the correct answer. Here is another example. Let us say you graduated from high school 10 years ago, and you have returned to your hometown for your 10-year reunion. You may not be able to recall all of your classmates, but you recognize many of them based on their yearbook photos. The third form of retrieval is relearning, and it is just what it sounds like. It involves learning information that you previously learned. Whitney took Spanish in high school, but after high school she did not have the opportunity to speak Spanish. Whitney is now 31, and her company has offered her an opportunity to work in their Mexico City office. In order to prepare herself, she enrolls in a Spanish course at the local community center. She's surprised at how quickly she's able to pick up the language after not speaking it for 13 years; this is an example of relearning.

Unelaborated Text

Short-term memory (STM) is a temporary storage system that processes incoming sensory memory; sometimes it is called working memory. Short-term memory storage lasts about 20 s. Through rehearsal, or the conscious repetition of to be remembered information, memories in STM move into long-term memory. This process is called memory consolidation. Long-term memory (LTM) is the continuous storage of information. Unlike short-term memory, the storage capacity of LTM has no limits.

Long-term memory is divided into two types: implicit and explicit. Implicit memories are memories that are not part of our consciousness. Procedural memory is a type of implicit memory: it stores information about how to do things.

Explicit memories are those we consciously try to remember and recall. Explicit memory has to do with the storage of facts and events we personally experienced. Explicit memory has two parts: semantic memory and episodic memory. Stored in our semantic memory is knowledge about words, concepts, language-based knowledge, and facts. Episodic memory is information about events we have personally experienced. The act of getting information out of memory storage and back into conscious awareness is known as retrieval.

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Cued Recall Memory Test

1. What is short-term memory?
2. How long does short-term memory last?
3. What is rehearsal?
4. What is long-term memory?
5. What is the storage capacity of long-term memory?
6. What are implicit memories?
7. What is procedural memory?
8. What are explicit memories?
9. Explicit memory has to do with what?
10. What is stored in semantic memory?
11. What is episodic memory?
12. What is retrieval?

Multiple choice comprehension test (correct answers are marked with an asterisk; questions marked with ** were only included in experiment 2):

1. If you are shown a list of names and then the next day you are asked to recall them, you would need to retrieve them from:

a. Sensory memory
b. Short-term memory
c. *Long-term memory
d. Encoding memory

2. All of the following would be considered declarative memories EXCEPT:

a. The low-level clouds that look like sheets floating in the air are called stratus clouds
b. *Knowing how to drive a car with a standard transmission
c. Four inches of snow contains the same amount of water as .4 inches of rain
d. Knowing that your boyfriend got you an iPod for your last birthday

3. Right after a friend introduces you to a group of people at a party, the name of the last couple people would like still be in:

a. Sensory memory
b. *Short-term memory
c. Long-term memory
d. Procedural memory

4. By analogy, which of the following is most similar to retrieval?

a. Trying to decide what to wear to a party later that evening
b. Writing down information that you instructor says during her lecture
c. Reading an interesting newspaper article
d. *Looking up the phone number for a restaurant in the phone book

5. When you consciously try to recall the information from the text you saw last week, you are relying on?

a. Implicit
b. *Explicit
c. Sensory
d. Procedural

** 6. Which of the following does NOT involve memory, as defined in the text?

a. recognizing an old friend from elementary school
b. deciding what to buy your brother for his birthday
c. mowing the lawn
d. *all of the above involve memory in some form

** 7. By analogy, which of the following is most similar to encoding?

a. Trying to decide what to wear to a party later that evening
b. Listening carefully for the sound of the doorbell while waiting for a friend to arrive
c. *Writing down information that your instructor says during her lecture
d. Reading an interesting newspaper article

Short Answer Comprehension Test

1. When you recall the meaning of the word college, you are relying on what kind of memory?
2. When you rollerblade, you are relying on what kind of memory?
3. When you recall your first day of college, you are relying on what kind of memory?

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