

Pretesting with Multiple-choice Questions Facilitates Learning

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Abstract

Taking a test before study can improve subsequent learning of that pretested information. How the pretest affects subsequent learning of other information in the passage is less clear, however. In three experiments, we examined the consequences of taking a multiple-choice (MC) pretest on the later recall of both pretested and non-pretested related information, finding that pretesting improved recall of pretested information without impairing recall of non-pretested information. In addition, we compared a pretest condition to conditions in which subjects were told to memorize the questions and in which subjects studied facts prior to reading. Although taking a pretest was not significantly more effective than memorizing questions or studying facts for the pre-exposed information, it did not impair the learning of related information, whereas studying facts did. Thus, even when an MC pretest takes time away from study, that pretest appears to make subsequent study more effective than other types of activities that pre-expose students to to-be-tested information.

Keywords: pretesting, testing effects, multiple-choice

Introduction

In addition to assessing learning, tests can enhance learning. Testing information after study improves later recall more than additional study (see, e.g., Roediger & Karpicke, 2006). Likewise, testing information before study (i.e., pretesting) has been shown to improve subsequent learning of the pretested information (e.g., Kornell, Hays, & Bjork, 2009; Richland, Kornell, & Kao, 2009; Rothkopf, 1966), although some evidence suggests that pretesting can have negative consequences (e.g., persistence of errors, Fritz, Morris, Bjork, Gelman, & Wickens, 2000). How pretest-taking affects subsequent learning of information not tested—in particular, related information—is less clear, but of concern for both practical and theoretical reasons. In the present work, we examine the effects of pretesting on the later recall of both tested and nontested related information.

The Effect of Pretesting on Pretested Information

Testing information after study may improve its later recall because the act of retrieving information from memory modifies its representation in such a way as to make it more recallable in the future than it would have been otherwise (e.g., Bjork, 1975; Bjork & Bjork, 1992). When given a pretest, however, correct retrieval of answers is unlikely given that students have not yet been exposed to the to-be-

learned material. Thus, the observed improved recall of pretested information should reflect the consequence of processes other than successful retrieval.

Pretesting may be beneficial because it encourages more active involvement in learning, perhaps by increasing general interest in the topic. Additionally, the pretest may help students to discern what information is most important or what type of information the teacher is likely to test later. Thus, a pretest may lead to better recall for the previously tested information because it directs attention to the need to encode that information when encountered again during subsequent study (Hamaker, 1986).

Possible Negative Consequences of Pretesting with Multiple-choice (MC) Tests Answering a question incorrectly may strengthen the erroneous response and decrease one's ability to learn the correct information later (e.g., Fritz et al., 2000). A negative characteristic of MC tests, in particular, is that they expose students to incorrect, but often attractive, alternatives, which can lead students to intrude those incorrect alternatives on later cued-recall tests (e.g., Roediger & Marsh, 2005). Of particular concern when using MC pretests is the finding by Butler and Roediger (2008) that intrusions increase when participants take a test without having studied the relevant information beforehand. On the other hand, Butler and Roediger also found that students were likely to change erroneous responses made on the pretest—to correct answers on a later test—when feedback was given. Therefore, the intrusion of errors on a later test might be reduced or eliminated as a consequence of being able to read the passage after taking the MC pretest.

The Effect of Pretesting on Related Information

The effect of pretesting on the subsequent learning of related information not tested on the pretest has been investigated in a variety of studies (e.g., see Anderson & Biddle, 1975; and Hamaker, 1986 for meta-analyses). Evidence suggests that pretesting directs attention towards the processing of pretested information. Pretesting appears to improve subsequent learning of information that is related to pretested information, but perhaps only when the tested and nontested information are related in certain ways (e.g., the related information aids in searching for the pretested information during subsequent study). To the extent that non-pretested information does not aid in the search task,

however, such non-pretested information may not be better learned during subsequent study, even if the pretested and non-pretested information have a systematic relationship. For example, non-pretested information that has a competitive relationship with the pretested information (e.g., the answer to one question in a pair of related questions would be a plausible, although incorrect answer, to the other question in the pair) might not be useful in the search task. A pretest might thereby impair the learning of competitive related information. To our knowledge, past research has not examined the effect of pretesting on the later learning of competitive non-pretested information.

Benefits for Related Information with Multiple-Choice Tests Little and Bjork (2010) demonstrated that taking an MC test following the study of a text passage improves the later recall of both tested and competitive nontested information—if the answer to a competitive question appears as a incorrect alternative in the initial MC test. They argued that MC alternatives with competitive incorrect alternatives encourage students to recall information that not only confirms why the right answer is correct, but also why the other alternatives are incorrect. In a pretesting situation, students would not have access to information that would allow them to reject incorrect alternatives. The MC pretest, however, would still encourage participants to examine the alternatives thoroughly (perhaps in hope that they have some background information that would enable them to reject one or more alternatives to make a better guess). In this process, students may encode not only the question, but also the alternatives. Consequently, when reading the passage after the pretest, students may direct their attention not only to the processing of information that would answer the pretested questions, but also to the processing of information having to do with the alternatives—information that might otherwise interfere with the search for pretested information. From this perspective, it seems likely that pretest MC questions could be effective in improving learning of information that has a competitive relationship with the pretested information.

The Present Work

In the present research, we aimed to assess whether MC pretests provide benefits for tested information that outweigh the potential costs of errors made on the initial test and whether such tests can improve learning of nontested competitive information. In addition, we explored whether benefits or costs occur simply as a consequence of being exposed to to-be-tested information before study or whether the act of trying to answer questions engages processing that leads to these effects. Specifically, in Experiments 2 and 3, we investigated whether a benefit of test-taking (although mostly unsuccessful) exceeds that of exposure to material, by comparing pretesting to a condition in which questions are memorized, but not answered, before reading the passage (Experiment 2) and a condition in which participants study facts that could have been tested prior to

reading (Experiment 3). Our expectation was that testing would provide benefits (for both tested and related information) not afforded by spending the full time studying, and that these benefits would be larger than those obtained with other pre-exposure activities.

Experiment 1

Method

Participants and design Twenty-five students at the University of California, Los Angeles, participated for partial course credit. Condition of study (pretested vs. extended-study) was manipulated within-subjects. On the final cued-recall test, all participants answered pretested and non-pretested related questions from the passage that was preceded by a pretest and questions from the passage that was not preceded by a pretest (baseline control).

Materials Two passages were constructed, one about Saturn and one about Yellowstone National Park (~800 words), and ten pairs of MC questions were created for each passage. The two questions in each pair tested the same topic (e.g., geysers) and had the same four alternatives (e.g., *Old Faithful*, *Steamboat Geyser*, *Castle Geyser*, and *Daisy Geyser*), but different correct answers (e.g., *What is the tallest geyser in Yellowstone National Park?* Answer: *Steamboat Geyser*; and, *What is the oldest geyser in Yellowstone National Park?* Answer: *Castle Geyser*). The questions from each passage were randomly divided into two 10-item sets (for each pair, one question was in Set A and one question was in Set B), such that one set would be tested on the pretest and the other set would serve as related questions on the final test (counterbalanced). Passage order and condition order were also counterbalanced across participants.

Procedure Each participant read two passages—one that would be preceded by an initial MC test (4 min test; 10 min study) and one that would be studied for the full time (14 min study). For the pretested condition, the ten MC questions (i.e., all the items in one of the question sets for that passage) were presented one at a time on the computer screen for 22 s. Participants were told that although they had not yet read the passage, the experimenters wanted to assess how much they already knew about the topic. In addition, participants were told that they would take a later test on the topic and that the questions on the pretest would provide them with an idea of the type of information that would be tested later. No corrective feedback was given during the test. For the passage that was not tested (control), participants were given the full 14 min to read the passage, and they were told that if they finished reading early, they should spend the remainder of the time studying.

Finally, after a 5-min retention interval during which they played Tetris (a spatial-reasoning puzzle game), participants received a 40-item final cued-recall test, with the questions presented one at a time on the computer screen. For the pretested condition, except for the absence of alternatives,

half of the questions were identical to the MC questions (i.e., pretested) and half were the non-pretested related items (i.e., the 10 questions from the set that had not been tested). Related questions were always tested in the first half of the test, along with half of the control questions, to which their performance would be compared. Similarly, previously tested questions were tested in the second half of the test, along with half of the control questions, to which their performance would be compared.

Results and Discussion

Pretest Performance Performance on the MC pretest ($M = 27\%$, $SD = 12\%$) was not significantly different from chance performance (25%), $t(24) = 0.89$, $p > .05$.

Final-test Performance We found that taking an MC pretest in lieu of additional time spent studying improved recall of that pretested information, but not recall of related information.

Performance in the pretested condition was compared to that in the corresponding extended-study control condition via planned paired-samples t tests. Specifically, these comparisons revealed that pretested questions ($M = 61\%$, $SE = 4\%$) were answered correctly more often than were control questions from the topic that did not receive a pretest ($M = 43\%$, $SE = 4\%$), $t(24) = 5.26$, $p < .05$. No such benefit occurred for questions of non-tested related information ($M = 48\%$, $SE = 4\%$) as compared to control questions ($M = 46\%$, $SE = 5\%$), $t(24) = 0.35$, $p > .05$.

Our results suggest that taking a pretest is beneficial for learning. Previous work, however, has suggested that spending part of one's study time taking a test, for which one is unlikely to know the correct answers might not lead to the pattern of results that we obtained: Rather, that errors would persist (e.g., Fritz et al., 2000).

Indeed, participants did sometimes recall previously incorrect alternatives on the final test. Because all of the alternatives were contained in the text, however, participants intruded these responses in the extended study condition as well. Of interest regarding the costs of MC testing is whether intrusions are greater after taking a pretest than after extended study. Table 1 shows recall (intrusion) rates for incorrect alternatives (or items that could have been incorrect alternatives) on the final test for the experimental and control conditions in Experiments 1, 2, and 3. As shown in Table 1, taking a MC test did not increase intrusion of incorrect information.

Table 1: Intrusion Percentages for Experiments 1, 2, & 3

Exp.	Activity Type	Previously Tested Memorized, or Studied	Extended-study Control
1	Pretest	10%	13%
2	Pretest	11%	13%
	Memorize	14%	13%
3	Pretest	8%	14%
	Fact-Study	7%	14%

Additionally, participants were not—as a consequence of spending some study time taking a test—impaired in their ability to answer correctly related, but initially non-pretested questions. Students were told that the pretest would “give them an idea of the questions to expect,” in order to steer them away from focusing on the pretested information during subsequent study. It was clear from the high performance on pretested items, however, that—purposefully or not—they paid significant attention to pretested information. In fact, it is more likely that participants directed attention towards the processing of pretested information than towards the processing of non-pretested information. For this reason, we believe that a numerical benefit for related information given significantly less study time for that tested passage (10 min compared to 14 min, respectively) is worth consideration.

Experiment 2

In Experiment 1, we found that taking a pretest improved the effectiveness of a subsequent reading session, even though the pretest took time away from reading and participants answered a majority of the questions incorrectly on the pretest. Specifically, recall of pretested information was improved. Moreover, recall of related information was not hurt, suggesting that the 10 min of studying after a test was as effective as studying for the full 14 min without a test.

It is uncertain, however, whether trying to answer questions would increase the effectiveness of study beyond what would occur from simply being exposed to those questions beforehand. Previous work has demonstrated that testing (with cued-recall questions) improves retention more so than does reading those questions before study (Richland, Kornell, & Kao, 2009). In Experiment 2, we explored whether trying to answer an MC question leads to improved performance as compared to memorizing that question and what impact this difference in processing would have on the learning of competitive related information. On the one hand, if trying to answer a question engages a deeper level of processing than memorizing a question, then answering questions should provide a benefit that outweighs that of memorizing questions. On the other hand, perhaps answering questions would increase the encoding of misinformation as compared to memorizing questions.

Method

Participants and design Sixty-four students at the University of California, Los Angeles, participated for partial course credit. Condition of study (question-study vs. extended-study) was manipulated within-subjects. Type of instructions for the question-study condition (pretest vs. memorize) was manipulated between subjects. On the final cued-recall test, all participants answered pretested or memorized questions and non-pretested or non-memorized related questions from the passage that was preceded by questions, in addition to questions from the passage that was not preceded by questions (baseline control).

Materials and procedure The materials and procedure were the same as those used in Experiment 1, with one exception: the addition of a between-subject variable (type of instructions). For half of the participants, instead of answering the questions, they were told to memorize the questions. Specifically, they were told that they would see questions that could be asked about the to-be-read passage, and that they should memorize the questions and the answer choices. They were given this instruction to insure that they processed the questions. The pretesting group was not told anything about a later test, just that the experimenters wanted to assess their knowledge of the to-be-learned topic.

Results and Discussion

Pretest Performance Performance on the MC test ($M = 27\%$, $SD = 18\%$) was not significantly different from chance performance (25%), $t(31) = 0.68$, $p > .05$.

Final-test Performance Correct recall performance on the final test is presented in Figure 1, and, as indicated there, performance on previously exposed questions (in both the pretest and memorize conditions) was improved, as compared to spending the full time studying (i.e., control condition). The recall of related information, however, appears only to have been improved when participants answered questions on an initial MC pretest, not when they simply memorized those questions.

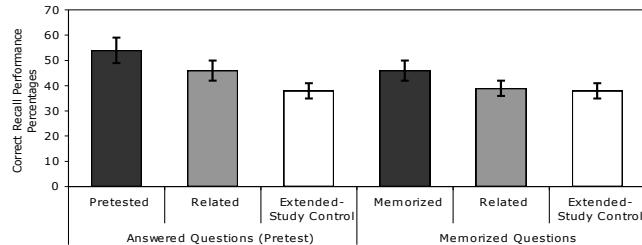


Figure 1: Correct recall performance percentages as a function of instruction type and item type in Experiment 2. The white bars show the average performance for extended study control questions tested in the first half and second half of the test for each condition. Error bars represent ± 1 SE.

Correct performance for the pretested and memorized items was compared to that for the corresponding items in the extended study control condition via planned paired-samples t tests. Benefits were found for both pretested items ($M = 54\%$, $SE = 5\%$) as compared to control ($M = 37\%$, $SE = 4\%$), as well as for memorized items ($M = 46\%$, $SE = 4\%$) as compared to control ($M = 36\%$, $SE = 5\%$), $t(31) = 3.64$, $p < .01$ and $t(31) = 2.54$, $p < .05$, respectively. A 2×2 repeated-measures ANOVA did not reveal a significant interaction between type of instructions (pretested vs. memorized) and condition of study (question-study vs. extended study control), $F(1,62) = 1.55$, $p > .05$. Additionally, a 2×2 repeated-measures ANOVA also did

not reveal a significant interaction between type of instructions (pretested vs. memorized) and condition of study (question-study vs. extended study control) for related information, $F(1,62) = 2.32$, $p > .05$. In both cases, however, the interaction trended towards testing being better than memorizing.

In Experiment 2, we found that although taking a pretest and memorizing information both led to improved recall of correct answers to those pre-exposed questions, the benefit afforded by actually trying to answer questions was numerically greater than that afforded by a comparable pre-exposure activity (i.e., memorizing questions). We found that this trend occurred for related information as well. In neither case, however, was the benefit of taking a test significantly better than the benefit afforded by memorizing the questions, a result that we believe may have occurred as a consequence of participants in the memorize condition spontaneously trying to answer the questions. In Experiment 3, we attempted to control for this possible problem with a modified method that would remove the propensity to endorse an answer, with the expectation that testing would then reveal a greater overall benefit.

Experiment 3

In Experiment 3, our aim was similar to that in Experiment 2: to compare the effects of pretesting with another task that also exposes participants to to-be-tested information before reading. In this case, however, we wanted to ensure that the non-test activity did not encourage the type of processing occurring when answering questions, as might have been the case in Experiment 2. Thus, in Experiment 3, we compared taking a pretest to being exposed to comparable facts that contained the correct answer as well as competitors (e.g., *The oldest geyser in Yellowstone National Park is Castle Geyser, not Old Faithful, Steamboat Geyser, or Daisy Geyser*). Because the facts contained the correct answer to the matched question, we also gave feedback in the pretest condition. In addition, we manipulated all variables within subjects. To do so, we developed a third passage so that all participants would take a pretest before one passage, study facts before another passage, and receive extra time to study a third passage

Method

Participants and design Seventy-two students at the University of California, Los Angeles, participated for partial course credit. Activity type (pretest vs. facts vs. extended-study) was manipulated within subjects. On the final cued-recall test, all participants answered questions pertaining to the pretest or studied facts and questions related to the pretest or studied facts, in addition to questions from the passage that received extended study time (baseline control).

Materials The materials were variations of those used in Experiments 1 and 2. We shortened the passages about

Saturn and Yellowstone (~600 words), without removing any information contained in the questions. In addition, we added a passage about stimulant drugs. For each passage, we used ten pairs of MC questions. Questions for Saturn and Yellowstone were the same as those used in Experiment 1 and 2. Questions for the passage about stimulants were constructed in the same manner.

Finally, Experiment 3 differed from Experiment 2 in that the question-memorization condition from Experiment 2 was replaced with a fact-study condition. For example, in the fact-study condition, participants would see: *The oldest geyser in Yellowstone National Park is Castle Geyser, not Steamboat Geyser, Daisy Geyser, or Old Faithful*. The facts contained all of the information contained in the matched question, including the competitors.

Procedure The procedure for Experiment 3 was the same as that of Experiment 1, with the following exceptions. All participants learned about three topics. For one topic, the reading of the passage (6 min) was preceded by a 10-item MC test (4 min); for a second topic, the reading of the passage (6 min) was preceded by a 10-fact study session (4 min); for a third topic, participants were given the full 10 min to read the passage.

On the pretest, participants were given 20 s to answer each question. After typing in their response, they continued to view the question until the 20 s elapsed. After each question, participants received feedback (i.e., the correct answer presented below the question) for 4 s. For the fact-study condition, participants were presented with 10 facts for 24 s each and were told to think about the fact for the full time that it was presented.

After a 5-min non-verbal distractor task (i.e., playing Tetris), participants received a final cued-recall test with sixty questions, ten questions for each of the following (previously tested, related to tested, previously studied as facts, related to studied facts) and twenty questions from the extended study control condition.

Results and Discussion

Pretest Performance Performance on the MC test ($M = 30\%$, $SD = 15\%$) was higher than chance performance, $t(71) = 2.69$, $p < .01$, and resulted as a consequence of high performance on the pretest for the stimulants topic ($M = 38\%$). Performance for Saturn ($M = 25\%$) and Yellowstone ($M = 26\%$) were comparable to that found in Experiments 1 and 2.

Final-test Performance Correct recall performance on the final test is presented in Figure 2, and, as indicated there, participants' ability to answer questions for information that was exposed during the pretest and fact-study conditions was improved, as compared to spending the full time studying (i.e., control condition). The recall of related information appeared not to be hurt as a consequence of taking an initial pretest, but appeared to be hurt as a consequence of studying facts before reading.

Correct performance for the information pretested or studied as facts was compared to that for the corresponding items in the extended study control condition via planned paired-samples t tests. Benefits were found for both pretested items ($M = 69\%$, $SE = 3\%$) and items studied as facts ($M = 66\%$, $SE = 2\%$) as compared to control ($M = 39\%$, $SE = 3\%$), $t(71) = 10.67$, $p < .01$ and $t(71) = 9.21$, $p < .01$, respectively. Pretested information was not recalled correctly more often than was information studied as facts.

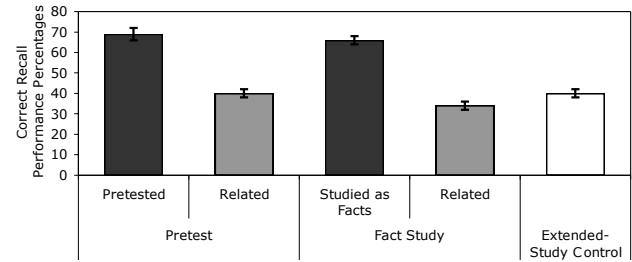


Figure 2: Correct recall performance percentages as a function of activity type and item type in Experiment 3. The white bar shows the average performance for extended study control questions tested in the first half and second half of the test. Error bars represent ± 1 SE.

Correct performance on questions pertaining to information that was related to the pre-exposed information was not better than that for the corresponding information in the extended-study control condition. Interestingly, however, although correct performance on items related to pretested information ($M = 40\%$, $SE = 2\%$) was not significantly different than that for control items ($M = 41\%$, $SE = 3\%$), correct performance on items related to studied facts ($M = 34\%$, $SE = 2\%$) was significantly worse than that for control items, $t(71) = 2.57$, $p < .05$, and, in fact, was significantly worse than that for questions related to pretested information, $t(71) = 2.81$, $p < .01$. Thus, although answering questions before study did not impair one's ability to learn related information, studying comparable facts before study did—even when the facts also provided participants with the answers to the related questions.

When assessing the total effect of taking a pretest (as compared to studying facts beforehand or spending the full time studying) across both tested and related information ($M = 56\%$, $SE = 2\%$), there was a clear benefit for pretesting over studying facts ($M = 50\%$, $SE = 2\%$), $t(71) = 2.67$, $p < .01$ and for pretesting compared to extended study ($M = 40\%$, $SE = 2\%$), $t(71) = 6.91$, $p < .05$.

In Experiment 3, we found that taking a test with feedback prior to the reading of a passage provided a learning benefit that outweighed that of studying facts beforehand or of spending additional time studying.

General Discussion

Although incorrect answers were endorsed for a majority of the questions on the MC pretests, we found that taking a pretest made subsequent study more effective, as demonstrated by improved recall of that pretested

information as compared to spending the full time studying; additionally, the pretest appeared not to lead to misinformation.

This result cannot be the sole consequence of pre-exposure to to-be-tested information. The trend towards a benefit for pretesting over studying facts in Experiment 3 is intriguing because the fact-study condition provided participants with access to the correct answer for each question, in the form of a fact, for 24 s (as opposed to receiving the correct answer for only 4 s after spending 20 s choosing an incorrect answer for the majority of questions). This pattern suggests that testing can serve as an effective learning event before study, even when retrieval fails.

Additionally, although we did not find that related information was learned better in the pretest condition than in the extended-study condition, we never found it to be impaired, even though the extended-study condition actually provides a very conservative control for total time on task. In the pretesting condition, participants received substantially less time to read the passage than they did for the extended-study condition. We would thus contend that comparable recall across the two conditions is likely to be under-representative of relative learning (i.e., correct recall per minute of reading time). Evidence from Experiment 3 would further support this contention because reduced time to read the passage in the fact-study condition led to impaired recall of related information. Finally, compared to this fact-study condition (which also offers a valid control for time-on-task), testing did improve recall of related information.

The present pattern of results speaks to the benefit of pretests as learning events. The present experiments, however, do not reveal what specific mechanisms might lead to testing being more beneficial than studying facts (Experiment 3). The results are consistent with the idea that an MC pretest directs attention broadly, such that students search not only for the correct answer to the pretested question, but also for information pertaining to the other choices. Additionally, it is the act of trying to answer question that leads to enhanced recall of related information—not simply pre-exposure—as facts containing the competitors do not seem to direct attention so broadly. That is, testing might lead to a deeper level of processing than trying to memorize questions (or studying facts), thus making it more likely that students will be reminded of those questions and alternatives when reading the passage during subsequent study. Although the present research provides evidence that MC pretests can serve as effective study events, future research should further investigate the specific underlying processes that lead to such benefits of pretesting.

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