

EFFECTS OF TESTING ON LEARNING

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Synonyms

Testing Effect; Retrieval Practice; Test-Enhanced Learning

Definition

Research on the effects of testing on learning has become increasingly popular over the last several years. The *testing effect*, as it is commonly called, refers to the learning advantages that occur as a result of trying to retrieve information from memory (i.e., being tested), in comparison to simply being re-exposed to that information. For example, consider a student who is studying German and trying to learn new vocabulary by pairing a German word (Hund) with its English translation (Dog). The student could construct flashcards containing Hund on one side and Dog on the other. Each time she sees the German word, she must try to recall the correct English translation before turning over the card to check her answer. As an alternative strategy, she could construct cards containing both the German and English words on the same side (Hund – Dog), and try to commit these words to memory by reading them together over and over. According to research on this topic, the student will perform best on the upcoming vocabulary exam if she uses the former strategy rather than the latter.

Theoretical Background

Why is it beneficial to test oneself over information? There are two primary means by which these benefits can occur—through indirect means, and through direct means. Tests can benefit learning through indirect means by revealing to the learner which portions of the material are already well-learned (i.e., the information that was successfully retrieved on the test), and which portions are not yet well-learned (i.e., the information that could not be retrieved on the test). The learner can then use this information to guide subsequent study. For example, a student who is using flashcards to study German-English vocabulary may go through the stack of flashcards and try to recall the English translation to a German word. If the English translation can be readily recalled, the learner may decide to set this card aside and focus more time on the German words for which she cannot readily recall the English translations. Through the process of trying to retrieve an answer and then receiving feedback, therefore, tests may optimize the learning process by identifying which items require further study.

Interestingly, tests are known to benefit learning even when corrective feedback is not provided. This is generally true as long as the information is correctly retrieved on the test. Tests can therefore benefit learning through direct means—that is, through the act of retrieval itself. What is beneficial about the act of retrieval? There have been three general hypotheses to explain this. The first and earliest hypothesis was based on the *total time hypothesis* of learning (Cooper and Pantle, 1967). This view proposes that, all else being equal, the more time a learner devotes to learning information, the better that information will be learned. Early research on the testing effect did not always control for the time that learners spent learning the material. In fact, many studies that reported beneficial effects of testing were based on a comparison of a learning method

that utilized testing (e.g., the flashcard method described above) vs. no method at all. It was therefore unknown whether testing was beneficial because of the act of testing per se, or because it simply afforded the learner more time to spend learning the material.

The most common and straightforward way to test this hypothesis is to compare two learning methods: one that involves testing, and another that provides an equivalent amount of exposure to the material but does not involve testing. Suppose learners are given the following list of words to memorize: Street, Flower, Horse, and Bridge. After seeing the list once, some learners are asked to recall all of the items from the list, whereas others are simply shown the word list again, exactly as they saw it the first time. All learners then complete a final test in which they are asked to recall the entire word list. Studies that have used this general method have falsified the total time hypothesis by demonstrating that, even when the exposure time to the material is equated between the two methods, the testing method leads to better learning than does a simple re-exposure method (e.g., Roediger and Karpicke, 2006).

The second hypothesis to be advanced was based on the notion of *transfer-appropriate processing* (Morris, Bransford, and Franks, 1977). Simply stated, this view proposes that learning will benefit to the extent that the operations required by the final test match those that were required during initial learning. Learning information via testing could be more beneficial than through re-exposure because the testing method provides practice at the same type of operations that will be required on the final test, whereas the re-exposure method does not.

This hypothesis also lends itself to a fairly straightforward test. One could learn material using a testing method that is either similar to, or different from, the way in which that material will eventually be tested on the final test. For example, one could learn information from a textbook chapter by first trying to recall everything they can remember from that chapter (similar to an essay test). Later, the learner can complete a final test over that information that is either an essay test (similar to the initial testing method they used), or a multiple choice test (different from the initial testing method they used). According to this view, information should be learned better if the final test is similar to the initial testing method. Research that has used this basic method has not confirmed this, however. Instead, it appears to suggest that initial testing methods that are more difficult (e.g., essay methods) lead to better learning, regardless of the way that information is tested on the final test (e.g., Kang, McDermott, and Roediger, 2007).

This finding has led to another theoretical perspective that is based on *elaborative processing*. According to this hypothesis, testing is beneficial for learning because it stimulates the learner to think more deeply about the material and activate information that may facilitate its retrieval in the future. It is believed that this level of elaboration does not occur during a simple re-exposure, because here learners are just viewing the material without actively engaging in the elaborative processing that is believed to occur during testing. Research has supported this theory by showing that initial test conditions that encourage elaborative processing by making information harder to retrieve (e.g., by using fewer cues, or by administering the test after a longer, as opposed to a shorter, time interval) can lead to better learning of that information (e.g., Carpenter, 2009).

Important Scientific Research and Open Questions

Tests are widely used in educational settings as assessment devices. There appears to be less awareness among students and educators that tests can also be used as a means of *promoting* learning, however. Recent research has therefore attempted to increase the awareness of testing as a means of benefiting learning (not just assessing it), and to discover ways in which tests can be most effectively used as an educational tool.

Much of the research on the testing effect has been conducted in laboratory settings using relatively discrete stimuli such as lists of words or simple pictures. An important question, therefore, is whether the benefits of testing can apply to more complex learning materials in realistic educational environments. When high school students are studying for their exam on the French Revolution, for example, would they be better off to test

themselves over the material than to review their notes? Recent research has made some progress in this area by demonstrating beneficial effects of testing on the learning of educationally-relevant materials such as textbook chapters, general knowledge facts, foreign language vocabulary, and maps. Some studies have also been conducted in school settings to demonstrate that testing can benefit learning of information being taught in middle schools and high schools.

Another important theme in this research is how best to utilize testing in a way that will optimize learning over meaningful intervals of time. In addition to the flashcard method, how can learners make use of a testing strategy in order to improve their learning? How many times should they test themselves over information before it is fully learned? The widespread use of testing as an educational tool may not be advisable if its benefits are short-lived or limited to a specific set of materials. Therefore, another important question is how long these learning benefits last over time. After learning information through testing, how likely are students to remember that information after one day? One week? One year? Some progress has been made in these areas by demonstrating, for example, that learning benefits more when students retrieve something multiple times on a test, as opposed to just once, and that these benefits appear to persist over time intervals of several months.

Researchers have also begun to explore whether testing can promote the transfer of learning to information that was not directly tested. For example, if learners are able to recall that toucans are related to woodpeckers, does this help them to remember that toucans sleep in tree holes at night, even if the latter fact was never tested? (e.g., see Chan, McDermott, and Roediger, 2006). Other questions that have emerged include whether there is a certain type of testing strategy that works best for promoting long-term retention and transfer, and whether testing benefits learning more than other types of organizational learning activities, such as outlining.

Cross-References

- Elaboration effects on learning
- Elaboration strategies
- Spread of activation theory
- Cued recall
- Recall and effect of repetition on recall

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