

The Critical Importance of Retrieval— and Spacing—for Learning

Nicholas C. Soderstrom, Tyson K. Kerr, and Robert A. Bjork

Department of Psychology, University of California, Los Angeles

Abstract

We examined the impact of repeated testing and repeated studying on long-term learning. In Experiment 1, we replicated Karpicke and Roediger's (2008) influential results showing that once information can be recalled, repeated testing on that information enhances learning, whereas restudying that information does not. We then examined whether the apparent ineffectiveness of restudying might be attributable to the spacing differences between items that were inherent in the between-subjects design employed by Karpicke and Roediger. When we controlled for these spacing differences by manipulating the various learning conditions within subjects in Experiment 2, we found that both repeated testing and restudying improved learning, and that learners' awareness of the relative mnemonic benefits of these strategies was enhanced. These findings contribute to understanding how two important factors in learning—test-induced retrieval processes and spacing—can interact, and they illustrate that such interactions can play out differently in between-subjects and within-subjects experimental designs.

Keywords

learning, memory, testing, retrieval practice, spacing

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Memory tests do not merely assess memory. The retrieval practice promoted by testing acts as a "memory modifier" (Bjork, 1975) by rendering successfully retrieved information more recallable in the future than if that same information had not been tested or had been merely restudied (i.e., *the testing effect*). Testing can also potentiate, or enhance, the effectiveness of subsequent study sessions (for a review of the direct and indirect benefits of testing, see Roediger, Putnam, & Smith, 2011).

In a highly cited article, Karpicke and Roediger (2008) reported a particularly dramatic demonstration of the benefits of retrieval practice. In their experiment, subjects studied Swahili-English vocabulary pairs (e.g., *afrika-science*) according to several different learning schedules that varied in the amount of repeated studying and repeated testing during the acquisition phase. They used four between-subjects conditions, each with four study (S)–test (T) cycles: ST, in which all pairs were studied and then tested in each cycle; $S_N T$, in which pairs recalled on a test were dropped from subsequent study periods but retained in subsequent test periods; C^N refers to "nonrecalled" items, and thus S_N

indicates that only nonrecalled items were restudied); ST_N , in which pairs recalled on a test were dropped from subsequent test periods but retained in subsequent study periods; and $S_N T_N$, in which pairs recalled on a test were dropped from both subsequent study and subsequent test periods. At the end of the acquisition phase, subjects were asked to predict how many pairs they would remember on a test in 1 week. They then returned after 1 week for a final retention test that included all of the pairs.

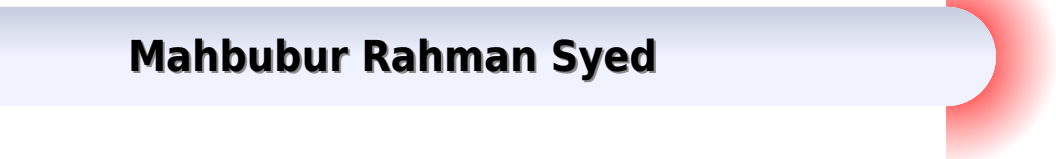
The results of Karpicke and Roediger's (2008) experiment were clear and striking. Although cumulative learning at the end of the acquisition phase was virtually identical across the four conditions—in the sense that each subject, regardless of condition, had recalled almost every pair at least once successfully—and although subjects in the four

Corresponding Author:

Nicholas C. Soderstrom, Department of Psychology, 1205 Franz Hall,
Box 951563, University of California, Los Angeles, Los Angeles, CA
90095-1563
E-mail: nsoderstrom@psych.ucla.edu

The Critical Importance Of Retrieval For Learning

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