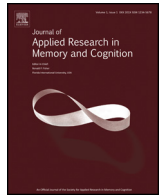


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## Investigating the Replicability and Generalizability of the Negative Testing Effect

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Although tests typically improve long-term retention, recent research suggests that certain types of tests may disrupt memory, referred to as the *negative testing effect*. According to one explanatory framework, this detrimental effect on memory results from tests disrupting organizational processing, which hinders the ability to make associations between items. From an educational perspective, these outcomes are concerning because they suggest contexts in which taking a test may impair subsequent retention. However, no research has explored whether the negative testing effect extends to more educational designs and materials. The goal of the current research was twofold: investigate the replicability of the negative testing effect by examining the original demonstration with a novel participant population and explore whether such organizational disruptions generalize to more ecologically valid materials. Outcomes establish the replicability of the negative testing effect and provide evidence that the detrimental effects of testing may not extend to educational material.

**General Audience Summary**

Research suggests that retrieving information facilitates later retrieval. That is, recalling a memory at Time 1 makes recalling that same memory at Time 2 easier. In an effort to explore why tests typically facilitate memory, a recent study (Peterson & Mulligan, 2013) identified an important boundary condition to this basic effect, such that performance was worse following retrieval versus restudy. This study suggests there may be educational contexts in which students should not be taking tests. In the present experiment, we adapted the basic design of this prior study using more educationally relevant materials. Learners were presented with a series of steps involved in a novel procedure. During practice, learners either restudied each step one at a time or were asked to recall a missing piece of information from each step. On the final test, learners were provided with the previously-presented steps in a scrambled order and asked to re-order the steps in the original presentation order. Results showed that retrieval during practice did not disrupt memory performance in that learners in the test group and the restudy group performed equally well on the final test of order memory. These results suggest the boundary conditions identified in the prior study may not generalize to more educationally relevant materials.

**Keywords:** The negative testing effect, Educational material, Retrieval practice

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Research has established that retrieval practice has robust effects on memory and retention (for reviews, see Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Rawson & Dunlosky, 2011; Roediger & Butler, 2011; for meta-analyses, see Adesope, Trevisan, & Sundararajan, 2017; Rowland, 2014). Recently, there has been a concerted effort among researchers to identify a theoretical framework to understand this effect. In a series of papers (Mulligan & Peterson, 2015a, 2015b; Peterson & Mulligan, 2013), researchers argued that the multi-factor account is a candidate framework due to its ability to explain instances in which tests improve memory (i.e., the typical positive testing effect) and instances in which tests disrupt subsequent memory (i.e., the phenomenon dubbed the negative testing effect).

In the original demonstration of the negative testing effect (Peterson & Mulligan, 2013), participants learned a list of rhyming cue–target pairs (e.g., pickle–nickel, feel–steel), with targets belonging to one of six different taxonomic categories (e.g., nickel and steel belong to the category metal). During Phase 1, word pairs were presented to participants in a random order obscuring the relational structure of the targets. During Phase 2, participants were re-exposed to the word pairs in one of two manners. Participants in the restudy group were shown the intact word pair, whereas participants in the test group were shown the cue and asked to recall the target. During this phase, word pairs were shown one at a time and blocked by taxonomic category, such that all of the metal exemplars were presented contiguously. After a brief delay, participants completed a free recall test in which they were asked to recall as many of the targets as they could remember. Outcomes showed a negative testing effect such that performance on the free recall test was greater following restudy versus test.

In this work, Peterson and Mulligan (2013) sought to investigate how retrieval (typically) improves memory through the lens of the multifactor account. In this framework, *item-specific processing* refers to the processing of information that differentiates items from one another, whereas *relational processing* refers to the processing of associations among a set of items. The account further delineates relational processing as cue–target processing (i.e., processing the association between a cue and a target) and inter-target processing (i.e., processing the connections shared by targets). Broadly speaking, the multifactor account argues that a finite amount of attentional resources are available and that focusing on some types of information necessarily precludes one from focusing on other types of information. Peterson and Mulligan (2013) posited that retrieval focuses resources on the processing of item-specific and cue–target information, which in turn draws resources away from the processing of inter-target information. In the test group, participants attempted to recall the target, which focuses resources on the rhyming nature of the word pair at the cost of recognizing category membership of the targets. Given that the free recall test was reliant upon knowledge of the categorical relationship among targets (information most efficiently encoded through inter-target processing), the multifactor account predicts lower recall for participants who previously engaged in testing versus restudy. Indeed, outcomes on the free recall test were consistent with this prediction.

Using a similar three-phase design, Karpicke and Zaromb (2010) provide further evidence that testing can impair organizational processing. In Experiment 3, participants were presented a series of targets. In the second phase of the experiment, participants were re-exposed to the target in the form of cue–target pairs. Some of the participants were presented with intact cue–target pairs to study, whereas other participants were given the cue and target fragment and asked to retrieve the target. In the final phase, participants were given an order reconstruction test in which all of the originally presented target words were presented in a scrambled order. Participants were asked to arrange the targets in the original presentation order. Consistent with the multi-factor account, reconstruction of the original presentation order was worse for participants who previously engaged in retrieval versus restudy. Outcomes suggest that testing during Phase 2 impaired the inter-item relational processing, which in turn rendered later order reconstruction more difficult.

From an educational perspective, these outcomes are troubling in that they suggest contexts in which taking a test may be detrimental to long-term retention. Although researchers generally agree that some tests are more beneficial than others (e.g., Butler & Roediger, 2007; Glover, 1989; Kang, McDermott, & Roediger, 2007; McDaniel, Roediger, & McDermott, 2007), these studies merely suggest that certain kinds of tests may be less helpful than other kinds of tests. The notion that taking a test might be harmful to learning is novel and would necessitate non-trivial adjustments to the best-practice recommendations researchers provide educators. However, the extent to which the previously reviewed disruptions carry over to more ecologically valid educational contexts has yet to be explored. Although the design of these studies was appropriate for testing predictions born out of a theoretical framework, the designs are somewhat contrived when considering educational implications. Further, the material itself (lists of unrelated words) is not representative of the types of material students typically learn.

Originally, the goal of the present research was to evaluate the extent to which the negative testing effect extends to more educationally relevant material. For purposes of transparency, research exploring potential boundary conditions for when the effect occurs was published (Rawson, Wissman, & Vaughn, 2015) while outcomes from Experiment 1 were being prepared for publication. This research and more recent research (Mulligan, Rawson, Peterson, & Wissman, 2018) suggest that the generalizability of the effect may be limited. Thus, Experiment 2 was directed at independently replicating the original negative testing effect study (for the importance of replication, see LeBel & Peters, 2011; Pashler & Harris, 2012; Roediger, 2012; Schimmack, 2012; Simons, 2014) and Experiment 3, like Experiment 1, was directed at examining whether the effect generalizes to more educationally relevant material when using an appropriate participant population.

### Experiment 1

Similar to the previously discussed studies, Experiment 1 adopted a 3-phase design. During Phase 1, participants were presented with steps involved in drawing blood for initial study.

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