How Do Students Use Self-Testing Across Multiple Study Sessions When Preparing for a High-Stakes Exam?

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Testing is a potent learning tool, but how do students use testing across multiple study sessions? In two studies, we investigated students’ use of testing to learn course materials for a high-stakes exam across four sessions. Of primary interest was (a) whether students used self-testing similarly across sessions and (b) whether students used self-testing to reach high levels of retrieval success across sessions. In each session, students learned the same key-concept definitions with the options to test, study (Studies 1 and 2), or judge the quality of their recall responses (Study 2). In earlier sessions, students relied less on testing than studying. In subsequent sessions—when students had better learned the concepts—they relied more on testing (relative to studying), presumably to evaluate their learning progress. Furthermore, students used testing and studying to successfully retrieve the concepts within each session and hence reached high levels of retrieval success across sessions.

General Audience Summary
In order for students to do well on their course exams, they need to use effective study techniques. One such technique—testing oneself—has been consistently shown to enhance retention of to-be-learned material more than if one were to simply study that material. Recently, research has shown that the benefits of testing oneself are even larger if those tests are successful and repeated across multiple days. So, although we know that students should be using self-testing across multiple study sessions to do well on their exams, we do not know how students would do so. Thus, the present study examined students’ use of self-testing to learn course materials for a high-stakes exam across multiple learning sessions. In each session, students regulated their learning of the same key-concept definitions that were drawn from their course and could appear on their exam. For each of these concepts, students had the options to test, study, or judge the quality of a prior recall response. Students’ use of self-testing increased across sessions, and importantly, students successfully retrieved the concepts an impressive number of times across the sessions. Thus, when practicing across multiple sessions, students use self-testing extensively to prepare for a high-stakes exam.

Keywords: Self-testing, Testing effect, Self-regulated learning, Criterion learning, Successive relearning

Since the seminal research on the benefits of testing in the early 1900s (e.g., Abbott, 1909; Gates, 1917), hundreds of studies have demonstrated that retention of to-be-learned material is greater when students test themselves over the material versus when they only study it (for reviews, see Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Karpicke, 2017: Roediger & Butler, 2011: Roediger & Karpicke, 2006a). Despite the convincing evidence that practice testing is an effective technique to enhance student learning, few studies have examined how students use self-testing, and none have

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examined students’ use across multiple study sessions. Thus, many questions of practical importance remain unanswered. Of particular interest for present purposes is how students use testing when they study across multiple sessions. Specifically, do they use it to a similar extent across sessions, or do they rely on testing more in later versus earlier sessions as they better learn the materials? Furthermore, do students use testing to achieve a given criterion of retrieval success within each session and hence reach a high cumulative criterion across sessions? To address these focal questions, we investigated students’ use of testing (both within and across study sessions) in an authentic educational context.

In the remainder of this introduction, we first describe testing as a learning tool, followed by a summary of research examining how students use self-testing when regulating their learning. Based on those findings and on theories of self-regulated learning, we then develop expectations about how students will regulate their learning across sessions and describe the methods and analytic approach used to answer our focal questions.

Testing as a Learning Tool

The benefit of testing has been demonstrated with educationally relevant materials (e.g., Butler & Roediger, 2007; Roediger & Karpicke, 2006b), in authentic educational contexts (Carpenter, Pashler, & Cepeda, 2009; Jones, 1923; McDaniell, Agarwal, Huelser, McDermott, & Roediger, 2011; Roediger, Agarwal, McDaniel, & McDermott, 2011), and across a wide range of age groups (e.g., Hopkins, Lyle, Hieb, & Ralston, 2015; Karpicke, Blunt, & Smith, 2016; Lipko-Speed, Dunlosky, & Rawson, 2014; McDaniel et al., 2011). Given that practice testing can promote academic achievement, a growing body of research has focused on identifying conditions in which it is especially powerful (for a recent review, see Karpicke, 2017). First, practice testing is more effective when it is combined with feedback (for reviews, see Dunlosky et al., 2013; Roediger & Butler, 2011), wherein students are presented with the correct answers after taking a test. Feedback enhances learning because it allows incorrect retrieval attempts to be corrected, thus increasing the odds that later retrieval attempts will be successful (e.g., Butler & Roediger, 2008; Pashler, Cepeda, Wixted, & Rohrer, 2005). Providing feedback is effective regardless of when it is provided, although some evidence suggests that delayed feedback is more effective than immediate feedback (e.g., Butler, Karpicke, & Roediger, 2007; Metcalfe, Kornell, & Finn, 2009).

Second, and of particular importance for the current research, practice testing is more effective when retrieval attempts are successful (versus unsuccessful), with later retention typically increasing as the level of criterion performance (i.e., the number of successful retrieval attempts) increases (Grimaldi & Karpicke, 2014; Karpicke & Roediger, 2007a; Karpicke, 2012; Pyc & Rawson, 2009; Vaughn & Rawson, 2011). Long-term retention is also enhanced when successful retrievals are spaced across multiple sessions, which is referred to as successive relearning (e.g., Bahrick & Hall, 2005; Bahrick, 1979; Pyc & Rawson, 2011; Rawson & Dunlosky, 2011; Rawson & Dunlosky, 2012). In particular, successive relearning occurs when students first repeatedly retrieve target materials until they correctly retrieve them in one session, and then use testing with feedback to relearn them to criterion in subsequent sessions. This evidence leads to the primary purpose of the present research, which is to explore how students use testing across multiple study sessions.

How Do Students Use Self-Testing?

Some students report using practice tests to prepare for exams (Bartoszewski & Gurung, 2015; Hartwig & Dunlosky, 2012; Morehead, Rhodes, & DeLozier, 2016), but many do not understand the mnemonic benefits of tests. Many students report testing themselves as a means to monitor their learning progress rather than as a technique to directly improve their learning—that is, they use testing more as a monitoring tool than as a learning tool (Hartwig & Dunlosky, 2012; Karpicke, Butler, & Roediger, 2009; Kornell & Bjork, 2007; McCabe, 2011). Moreover, students report using other, less effective strategies more frequently than self-testing (Hartwig & Dunlosky, 2012; Karpicke, Butler, & Roediger, 2009; Kornell & Bjork, 2007; McCabe, 2011; Wissman, Rawson, & Pyc, 2012). Most relevant to the present research, many students endorse the incorrect belief that learning is better after they restudy their notes or textbook than when they self-test themselves over that material (Agarwal, Karpicke, Kang, Roediger, & McDermott, 2008; McCabe, 2011; Roediger & Karpicke, 2006a,b; Tullis, Finley, & Benjamín, 2013). Thus, students are more likely to reread than self-test when preparing for exams (e.g., Karpicke et al., 2009). Overall, self-reports converge on the conclusion that many students do not understand the benefits of testing and may use it less than other relatively ineffective strategies.

In addition to survey studies, the few observational studies that have investigated students’ use of testing converge on a similar conclusion: students may choose to self-test, but they do not implement this technique as effectively as they could (Dunlosky & Rawson, 2015; Karpicke, 2009; Kornell & Bjork, 2008; Kornell & Son, 2009, Son, 2005). For instance, Kornell and Bjork (2008, Experiment 3) had participants study Swahili–English word pairs using a flashcard program. During the practice phase, the Swahili cue word was presented for 3 s, and participants were prompted to type the English response. After being shown the correct answer, participants could choose to drop the pair or keep it in the list for further practice. Participants dropped from study the majority of items after only one correct retrieval and reported dropping items they believed they knew. These findings suggest that once students believe they have learned an item, they no longer continue to practice it (for a review, see Metcalfe & Kornell, 2005). That is, students may exhibit a one-and-done strategy when self-regulating their learning (see Ariel & Karpicke, 2017). However, a more effective strategy would be to persist beyond a single correct retrieval, given the benefits of learning to higher criterion levels (e.g., Vaughn & Rawson, 2011).

Although students’ use of self-testing may have appeared to be somewhat ineffective in prior research, the typical conditions in which self-testing has been examined were highly controlled...
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