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Do it twice! Test-taking fosters repeated but not initial study of multimedia instruction

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ABSTRACT

Are practice tests only helpful when having studied before taking them? We investigated this question in a multimedia learning scenario. Participants (N = 85) were randomly assigned to one of two groups, in which they did either not study or studied before taking a test. Afterwards, all participants (re-)studied with the same materials, and took the same test again. Participants had generally higher scores in the second than in the first test; however, taking the first test without having studied before did not improve subsequent learning. Only with repeated study and test-taking, performance in the first test predicted subsequent mental effort. Hence, test-taking fostered repeated but not initial study of multimedia materials, presumably because performance in the first test informed about the effectiveness of the initial study to which learners could adapt during restudy (cf. indirect testing effect). Knowing the test (high test expectancy) alone was not sufficient to foster multimedia learning.

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1. Introduction

Most students would likely be happy if they knew exactly the questions to be answered in the upcoming exam so that they can tailor their learning only towards these questions and potentially perform better. It is however subject to discussion whether such practice tests are helpful only when students studied before taking them or whether just seeing the (type of) questions asked in the practice test is sufficient to foster performance. The experiment reported in the present paper investigated this question. Other than most prior research, the present experiment used expository text with pictures (i.e., multimedia instruction) to study effects of testing on subsequent learning and performance. Moreover, beyond referring to cognitive factors the role of students' mental effort and goal orientations were taken into account.

1.1. Indirect testing effect

A large body of research revealed that aside from demonstrating what they know, students reorganize, elaborate, and consolidate knowledge through testing (e.g., Endres & Renkl, 2015; Karpicke & Roediger, 2008). Therefore, repeated testing was more beneficial for long-term retention than repeated studying (testing effect; see Rowland, 2014; for a recent meta-analysis). Aside from having direct positive effects on retention, testing can also yield indirect positive effects on learning; namely, testing not only consolidates information that could be recalled, but it also gives insights into which pieces of information could *not* be recalled and hence deserve more attention during subsequent restudying. Thus, when provided with the opportunity for restudy, testing enhances subsequent learning of information that one previously failed to recall (Arnold & McDermott, 2013). This is known as the *indirect testing effect* or test-potentiated learning (Izawa, 1971). It occurs when study-test cycles are repeated, because one's ability to recall items in the first study-test cycle informs about which items should be restudied with more effort, thus boosting performance at repeated compared to initial study and test-taking. Accordingly, Arnold and McDermott (2013) have found that restudy fostered recall in the final test especially when initial tests had been taken prior to restudy.

Importantly, beneficial effects of testing have been found for *re*study, whereas effects of testing on initial study have not been in

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the focus of research so far. Based on a metacognitive explanation of indirect testing effects (e.g., Roediger, Putnam, & Smith, 2011), one may argue that studying before taking the first test is required to make learning more effective. Specifically, students can use their (perceived) performance on a practice test as a valid cue to monitor their current state of learning with respect to their learning goals (e.g., Pintrich, 2000). Previous learning is thus required for testing to act as a valid cue for monitoring. Students then control their subsequent study efforts based on this monitoring, for instance by deciding whether to invest more effort and additional study time or not (cf. metamemory framework; Nelson & Narens, 1990). Hence, testing may foster subsequent learning because metacognitive monitoring and control is more accurate. Most prior research used unrelated word lists instead of more complex expository text with pictures (i.e. multimedia materials) to study indirect testing effects (e.g., Arnold & McDermott, 2013). However, especially for the latter monitoring is found to be inaccurate because it is partially based on heuristics such as ease of processing (Rawson & Dunlosky, 2002) or multimedia (Serra & Dunlosky, 2010). One exception is the study by Eitel (2016). He found that, during restudy with multimedia materials, learners adapted to the difficulties they had experienced with the first test – the worse their performance the more thoroughly their restudy. Hence, repeated study and test-taking was beneficial because performance in the first test was used as a metacognitive cue to foster adequate control of subsequent learning. As such, because of more accurate monitoring and control test-taking is expected to foster *restudy* of multimedia materials. However, the role that test expectancy plays in explaining indirect testing effects is still unclear.

1.2. Test expectancy

Aside from informing learners about the effectiveness of their initial studying, testing may be beneficial for restudying because one knows the test – at least when subsequent tests are identical or similar to the preceding one. In this situation, students have high test expectancy; that is, they know what and how it will be tested (e.g., Lundeberg & Fox, 1991; Thiede, Wiley, & Griffin, 2011). With high test expectancy, students may perform best in the test because they encode information that is specifically required for this type of test (cf. encoding specificity, Tulving & Thomson, 1973). In other words, students can use high test expectancy to optimize their processing with respect to the task – regardless of whether they had studied before taking the first test. This is known as transfer-appropriate processing (Morris, Bransford, & Franks, 1977). Supporting the idea of transfer-appropriate processing, Lundeberg and Fox (1991) found that knowing what type of test to expect can improve students' grades in school. Moreover, Thiede et al. (2011) found that test performance and monitoring accuracy were superior when students received the kind of test they expected as opposed to an unexpected test. Hence, learning activities can be better regulated the more students are aware of the goals and demands of studying (e.g., Eitel & Kühl, 2016). More specifically, they can better focus on the central concepts and principles demanded by the assessment, which should result in better learning outcomes (e.g., Renkl, 2015).

This may apply particularly in the case of learning with more complex instructional materials that comprise multiple representations such as text and pictures (i.e., multimedia). Learning with multimedia is a demanding task because students have to both select and organize relevant information from both representations as well as to integrate them into a coherent mental model to achieve comprehension (e.g., Mayer, 2014; Schnotz, 2014). Knowing what will be asked in the test may help selecting and organizing only the relevant information so that the whole learning process is facilitated. Accordingly, in multimedia learning scenarios providing information about which are the relevant parts of the instruction proved helpful to learning (e.g., Jamet, 2014; Mason, Tornatora, & Pluchino, 2013; Richter, Scheiter, & Eitel, 2016; Scheiter & Eitel, 2015; Schwonke, Berthold, & Renkl, 2009). Seeing the test prior to learning provides such information, even when not having studied before. Beneficial effects of repeated study and test-taking in multimedia learning may be attributed to knowing about what and how knowledge will be tested, and thus, to high test expectancy. Due to high test expectancy, testing should foster *initial* study of multimedia materials, meaning that studying before taking the test is not required to profit from it. To the best of our knowledge, the present study is thus the first to isolate the effect that test expectancy may have for explaining beneficial effects of repeated study and test-taking in multimedia learning.

1.3. Mediators and moderators of test expectancy and indirect testing effects

To what degree students make use of test-taking to improve initial or repeated studying may depend on their amount of invested mental effort, as more mental effort can lead to better performance (cf. Salomon, 1984). Mental effort, in turn, may vary as a function of test expectancy. Referring to the goal-free effect (Paas & Kirschner, 2012) learners invest more mental effort and potentially acquire deeper knowledge when they pursue goals that are more general during learning in contrast to very specific goals (see also Vollmeyer & Burns, 2002). Knowing the test, i.e. high test expectancy, thus may result in lower mental effort invested in the learning task. In situations with repeated study and test-taking, however, students may invest more mental effort (re-)studying materials the more they experienced difficulties solving the first test – especially when they expect the second test to be similar. This is in line with what one would expect based on metacognition theory (cf. Nelson & Narens, 1990), namely the perceived ability to perform (not) well in the test is used as a valid cue for monitoring that initiates control processes such as to invest more mental effort during restudying, which in turn should foster performance. Results by Eitel (2016) lend support to these assumptions: Lower scores in test 1 predicted longer restudy times that can be considered a proximal variable reflecting higher mental effort.

Aside from the potential mediating function of mental effort, effects may be moderated by students' goal orientations, that is, by their individual disposition toward developing or demonstrating ability in achievement situations (VandeWalle, 1997). Two major classes of goal orientations are usually distinguished –mastery versus performance (e.g., Darnon, Butera, & Harackiewicz, 2007). A high mastery orientation means that one wants to gain understanding of a topic, develop one's competencies and anticipate that this has to be achieved with hard work (e.g., Dweck, 1986). It thus means that a person with a high compared to a low mastery motivation may make more use of the opportunity to repeat study and test-taking to optimize one's understanding aside from just knowing the demands of the test, and hence show a strong indirect testing effect. Having a high performance orientation means that one is primarily concerned with demonstrating one's ability by outperforming others particularly if success is achieved with little effort (e.g., Ames & Archer, 1988). This applies directly to the situation of high test expectancy. Knowing what will be tested provides students with the opportunity to perform better without spending much effort, because they can adapt their studying closely to the demands of the test. Hence, especially students with high performance orientation might profit from knowing the demands of the test compared to students with low performance orientation.

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