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Mixing topics while studying does not enhance learning

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ABSTRACT

According to a recent survey, it is common for students to study two topics at the same time using flashcards, and students who do so virtually always keep the topics separate instead of mixing flashcards together (Wissman, Rawson, & Pyc, 2012). We predicted that mixing might be a relatively easy way to increase learning efficiency because mixing increases the spacing between repetitions of a given item, and spacing enhances long-term learning. We compared two conditions: in the mixed condition, participants alternated on each trial between studying anatomy terms and Indonesian translations. In the unmixed condition they studied one topic and then the other. Items were interleaved within item-type in both conditions. Mixing did not have reliable effects when participants studied flashcards in a single day (Experiments 1 and 2) or on two different days (Experiments 3 and 4). Thus, the results seem to disconfirm two sets of beliefs: students' universal belief that mixing flashcards is undesirable and cognitive psychologists' belief that doing so should be encouraged.

Students constantly make decisions about how, when, and how much to study. These decisions can have a meaningful effect on learning (for a review, see Bjork, Dunlosky, & Kornell, 2012). Choosing to use flashcards is one common decision. In a recent survey of undergraduates, 68% of students reported using flashcards to study (Wissman et al., 2012), a number consistent with previous surveys (Hartwig & Dunlosky, 2012; Kornell & Bjork, 2008b). Given that there are over 10 million college students in the United States alone, it is evident that millions of students use flashcards. This fact alone makes it seem important to investigate whether students are getting the most from their flashcards, especially if students have mistaken beliefs about how best to use them.

One decision that can have a major impact on learning is whether students choose to mass or space items within and between study sessions. Numerous studies have demonstrated large positive effects of spacing, with many different materials, lag times between presentations of a given item, types of tests, and delays before the final test (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006; Dempster, 1988, 1996). It is effective to space learning events such that they occur in different study sessions (between session spacing) and to mix items together rather than studying one item repeatedly within a given session (within session spacing, also known as interleaving). Kornell (2009) demonstrated that learning benefits from both between session and within session spacing.

One way students could increase the spacing between flashcards would be to mix together flashcards from two different topics or courses. According to a recent survey, 59% of students at Kent State University said they had encountered a situation in which they were using flashcards to study for more than one course at the same time (Wissman et al., 2012). Suppose, for example, students were studying biology and history flashcards. Students could choose to mass their study—i.e. study all of their biology and then all of their history flashcards—or they could mix topics, alternating studying one biology and one history flashcard. Wissman et al. (2012) found, however, that 98% percent of students said they would study flashcards from one subject at a time, rather than mixing them, and of those 98%, 68% said they would not mix topics because it would be confusing. Cognitive psychologists, on the other hand, have considered that mixing topics could enhance learning. Roediger and Pyc (2012) suggested that students could easily capitalize on the positive effects of spacing and interleaving when they study by mixing topics within a particular subject, such as different concepts from biology. Roediger and Pyc then asked, "Might it be even more beneficial to intermix study on entirely different topics, such as biology and history?" but noted, "The evidence on this matter is not yet at hand" (p. 244).

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1. The present experiments

The present experiments were inspired by a practical question: should students mix topics together while studying. Previous research on interleaving and spacing has not directly addressed this question. As far as we know, the research presented here is the first to manipulate whether two different topics are studied separately or mixed together.

In Experiments 1 and 2 we explored the effect of mixing topics in a single study session on test performance 48 h (Experiment 1) or one week (Experiment 2) later. Participants studied Indonesian translations and anatomical definitions. Each definition was studied multiple times but as with real flashcards, individual items were not restudied consecutively. In the unmixed condition, participants studied all word pairs from one subject before switching topics (as if participants had two sets of flashcards). In the mixed condition, study trials alternated between Indonesian and anatomy word pairs (as if they mixed two sets of flashcards into one larger set). In Experiment 3, there were two study sessions that were separated by 48 h. Participants in the unmixed condition studied one topic on each day. In the mixed condition, both topics were studied during each session. Finally, Experiment 4 replicated Experiment 3 and we introduced an unmixed + spaced condition in which participants studied both topics on both days, but did not mix flashcards from the two topics. This final experiment allowed us to compare the relative benefits of mixing topics within sessions and spacing study trials across sessions.

2. Theoretical considerations

In addition to their practical importance, these studies have theoretical implications because they contrast the benefits of spacing and interleaving. The primary difference between interleaving and spacing is the activity that occurs in between repetitions of a given item: With interleaving, repetitions of an item are separated by other similar items; with spacing, they are separated by unrelated activities. The mixed and unmixed conditions both involve interleaving, because, for example, in between repetitions of a specific Indonesian pair there are always other Indonesian pairs. The difference between the conditions is a difference in spacing: the unmixed condition involves pure interleaving, whereas the mixed condition involves interleaving with additional spacing as well. The spacing comes from the unrelated trials that occur between repetitions of a pair (e.g., anatomy items, which are unrelated to Indonesian, create spacing between Indonesian trials). In the experiments reported here, if students study 16 anatomy and 16 Indonesian flashcards, mixing topics increases the number of items that intervene before participants restudy any given definition (31 versus 15 intervening flashcards). Therefore, the comparison of the mixed and unmixed conditions is actually a comparison of larger versus smaller amounts of spacing (which is sometimes known as lag). Previous research has demonstrated the benefits of increased spacing using word pairs and lags similar those of our mixed and unmixed conditions (Karpicke & Bauernschmidt, 2011; Pyc & Rawson, 2009, 2012). Thus, based on the increased spacing, we predicted a benefit of mixing topics.

At first glance, recent research might seem to suggest reasons why mixing could also have negative effects. The last few years have seen a considerable amount of research demonstrating benefits of interleaving in category learning (Birnbaum, Kornell, Bjork & Bjork, 2013; Kang & Pashler, 2012; Kornell & Bjork, 2008a; Wahlheim, Dunlosky, & Jacoby, 2011) and math learning (Mayfield & Chase, 2002; Rohrer & Taylor, 2007; Taylor & Rohrer, 2010; or for reviews see Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Rohrer, 2012). Some of this research points to a specific benefit of seeing related materials appear in consecutive trials. These results have been explained by the discriminative contrast hypothesis, which states that juxtaposing exemplars from similar concepts or categories helps people learn by highlighting the differences that distinguish among the concepts or categories (Birnbaum et al., 2013; Kang & Pashler, 2012; Wahlheim et al., 2011). For example, Kang and Pashler (2012) had participants study 12 paintings by three different artists. In the interleaved condition, paintings by all of the artists were mixed together. In the temporal spaced condition, participants studied paintings blocked by artist. The amount of spacing was equated in the two conditions by using unrelated filler material in the temporal spaced condition between presentations of paintings by the same artist. On a final test, participants more accurately classified novel paintings by the three artists in the interleaved condition than the temporal spaced condition, even though spacing was held constant. Interleaving helped participants notice stylistic differences that separated the work of one artist from another.

Mixing, in the present research, interrupts the juxtaposition of items (e.g., anatomy) by interposing unrelated items (e.g., Indonesian). Thus, one might predict that mixing could have a negative effect on learning of related flashcards. This prediction rests on the assumption that discriminative contrast applies when learning word pairs, however, when in fact there are important and relevant differences between learning word pairs and learning categories. In induction tasks, such as classifying paintings by similar artists, participants have to abstract general classification rules and learn to tell the difference between two categories. Discriminative contrast is crucial because the main challenge of the test is telling one category apart from the other (especially because many of the categories were very similar). When learning word pairs, telling the stimuli apart is trivial—the cue is a direct and unambiguous signal of which item the participant is meant to retrieve. Thus, discriminative contrast does not seem relevant when participants learn word pair associations.

If discriminative contrast does not affect learning word pairs, we would expect a positive effect of mixing topics, because of increased spacing, without any negative effect to balance it out. If discriminative contrast does affect vocabulary learning, however, we would expect the benefit of mixing to diminish or disappear.

3. Experiment 1

3.1. Method

3.1.1. Participants

Fifty-five participants (31 female, 24 male; median age = 26 years, range = 18–70 years) were recruited online using Amazon's Mechanical Turk and were paid $1.00 for completing the fist session and another $1.00 for completing the second session. All participants reported being fluent English speakers living in the United States, except for one who did not provide a country of residence. There were 27 participants in the unmixed condition and 28 in the mixed condition.

In addition to the 55 participants whose data were analyzed from Experiment 1, five more participants completed the experiment but were excluded. One of these participants was excluded for having a short median response time on the final test of 0.48 s; the next shortest median response time was 1.50 s. Another participant was excluded for not being a fluent English speaker. The remaining three participants were excluded for answering yes to a question that asked about previous knowledge of any of the word pairs being tested in the experiment.