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RESEARCH INTO PRACTICE

Highlighting and Its Relation to Distributed Study and Students' Metacognitive Beliefs

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Abstract Use of highlighting is a prevalent study strategy among students, but evidence regarding its benefit for learning is mixed. We examined highlighting in relation to distributed study and students' attitudes about highlighting as a study strategy. Participants read a text passage twice while highlighting or not, with their readings either distributed or massed, and followed by a week-delayed test. An overall benefit of highlighting occurred, with highlighting being especially beneficial with massed readings of the passages. Importantly, highlighting did not impair knowledge of non-highlighted information. Interestingly, those students reporting that they did not think highlighting was beneficial or were unsure about its benefits actually benefitted more from highlighting than did students who were pro-highlighting. Overall, our results indicate that under some conditions, highlighting can be a beneficial study strategy for learning and argue for students being trained in how to optimize the potential benefits of their highlighting behavior.

Keywords Highlighting · Spacing · Text marking · Metacognitive beliefs about study strategies

One needs only to browse through used textbooks in a college bookstore to see that text-marking, either by highlighting or underlining, is a ubiquitous practice among students, with many believing that marking text will help them remember the selected information better or make a later study session more effective. Whether text-marking actually does benefit later recall, however, is debatable: Several studies have shown a significant benefit for underlined or highlighted text (e.g., Fass and Schumacher 1978; Fowler and Barker 1974; Nist and Hogrebe

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1987; Nist and Simpson 1988; Johnson 1988; Rickards and August 1975), whereas others have not (e.g., Arnold 1942; Hoon 1974; Idstein and Jenkins 1972; Peterson 1992; Stordahl and Christensen 1956; Wade and Trathen 1989). Given the prevalence of highlighting as a study technique among students, however, learning more about the circumstances under which it might be (or could be made to be) a more effective strategy seems a worthwhile goal from an educational standpoint, particularly if such research might reveal guidelines that could be given to students regarding how to make highlighting more beneficial for their learning.

Potential Advantages of Highlighting

There are several reasons to expect text-marking to benefit learning. From a depth-of-processing perspective, just the act of deciding what to mark and what not to mark may lead students to process textual information at a deeper, more evaluative level than they would when simply reading it (Craik and Lockhart 1972; Nist and Hogrebe 1987). Consistent with this idea, learner-generated highlighting tends to produce better test performance than experimenter-generated highlighting (Fowler and Barker 1974; Rickards and August 1975; Rickards and Denner 1979; but see Nist and Hogrebe 1987). Additionally, when students are trained in highlighting techniques (i.e., to read a paragraph, decide what is conceptually important, and then highlight that information), they perform better than students who do not receive such training (Leutner et al. 2007), indicating that appropriate cognitive activity during highlighting can enhance its benefits.

Another potential benefit of text-marking could be a type of von Restorff effect (Wallace 1965). Specifically, highlighting may make the marked portion of text more memorable because it stands out from the surrounding non-highlighted text. Indeed, some evidence supports this type of role for highlighting: When students read pre-highlighted passages, they recall more of the highlighted information and less of the non-highlighted information compared to students who receive an unmarked copy of the same passage (Fowler and Barker 1974; Silvers and Kreiner 1997).

Highlighting might also enhance the effectiveness of re-study opportunities via encoding variability. Varying the context or particular processes involved in repeated learning opportunities has been found to facilitate performance on later tests of retention and transfer, the explanation being that learning is less likely to become contextualized under such circumstances (e.g., Smith et al. 1978). Variability is presumed to be effective because it increases the likelihood that participants will encode to-be-learned information in slightly different ways, thus increasing their ability to retrieve that information when tested in another context in the future. By selectively marking text, learners change the text as they read it; consequently, when re-reading marked text, learners may read and encode that text in a new way, thereby making it more memorable.

Potential Disadvantages of Highlighting

In contrast to these arguments, others have argued that selectively highlighting text might be ineffective or even detrimental to learning (Dunlosky et al. 2013; Idstein and Jenkins 1972; Peterson 1992; Stordahl and Christensen 1956). One argument is that students often do not know how to highlight effectively, so such activity primarily amounts to a mechanism for tracking progress and does not involve deeper processing (Stordahl and Christensen 1956; Bell and Limber 2010). Another relevant factor is whether students are accustomed to using a highlighter (Brown and Smiley 1978). Forcing readers who never use highlighters to do so may interfere with their learning and prevent them from employing the type of encoding techniques they usually find beneficial (Howe and Singer 1975).

Additionally, students' metacognitive beliefs about highlighting may limit its effectiveness as a learning tool. Students who rely on highlighters and think they are particularly effective, for example, may suffer from an illusion of knowing or competence (Bjork 1999, 2013; Koriat and Bjork 2005). Specifically, such students may process highlighted material in a less meaningful way when re-reading than if that material were not highlighted. While re-reading, such students may only quickly glance over highlighted text, incorrectly assuming that because they have already highlighted that information, it is deeply encoded in memory, a misbelief that is probably supported by the apparent processing fluency that learners would experience during such re-reading. In this way, highlighting could ironically impair memory for critical information by preventing students from restudying the information in a way that effectively promotes long-term retention (cf. Peterson 1992).

Highlighting and the Distribution of Study

In evaluating the efficacy of text-marking, it is important to consider that students often mark text for the purpose of guiding their future study. For example, in a survey of 472 undergraduates, 60 % reported using marked passages as a guide for later restudy (Kornell and Bjork 2007). Thus, it seems critical to examine how text-marking might interact with the spacing of study activities. Distributed study, or spacing, is a *desirable difficulty* in that it typically results in greater long-term retention even though it can make learning feel more difficult during encoding (Bjork 1994; Bjork and Bjork 2011). Indeed, spaced study of educationally relevant materials has been repeatedly shown to improve retention compared to massed study (e.g., Dempster 1996; Kornell 2009; Sobel et al. 2011).

Highlighting, however, might actually be more beneficial in massed conditions than in spaced conditions. Massed study is often presumed to be inferior to spaced study because it involves less encoding variability and because it limits the effectiveness of the second study opportunity (Hintzman 1974). If highlighting attenuates these disadvantages by leading learners to encode the passage differently in a second reading, such beneficial effects should be relatively greater in massed than spaced conditions. Moreover, active highlighting might possibly dispel the misleading effects of fluency that tend to discourage deep processing of information upon re-reading. If so, because the sense of fluency would be stronger the closer in time the second reading follows the first, such an effect of highlighting should be more beneficial the sooner the second reading follows the first.

Overview of the Present Study

The goals of the present research were to assess possible benefits of highlighting as well as individual differences in the use of highlighting and to explore effects of highlighting in relation to distributed study and metacognitive beliefs about highlighting as a study tool. To this end, we asked students to study a passage twice, either massed (i.e., back-to-back with no separation between study opportunities) or spaced (i.e., successive study opportunities separated by a 30-min interval), with half studying the passages without using a highlighter and half studying the passage using a highlighter. All participants then took a test after a 1-week delay. We also collected data on students' highlighting preferences.

Method

Participants

A total of 184 UCLA undergraduates (M_{age}=19.9) participated for partial credit in a psychology course.

Materials

Participants read a passage about ground water (856 words) from the U.S. Geological Survey website. Twelve critical phrases, each containing a different keyword, were selected from the passage (e.g., the term *recharge* was the keyword in the phrase: *Water seeping down from the land surface adds to the ground water and is called recharge water*.). Then, 12 fill-in-the-blank questions were created from these phrases by deleting the keyword and asking participants to provide it on the final test (e.g., *Water seeping down from the land surface adds to the ground water and is called* _____ *water*).

Design and Procedure

Participants were randomly assigned to either the highlighting or no-highlighting conditions and to either the massed or spaced re-reading conditions; thus, our design employed two between-subject variables: highlighting and spacing.[1]

Upon arrival, participants were seated alone at a desk and asked to read the passage in its entirety, which they were given 6 min to do. Participants in the highlighting condition received a standard yellow highlighter and told to use it however they typically would while studying material for a class. Participants in the no-highlighting condition were not given a highlighter and were simply instructed to read the passage as though they were studying material for a class.

After the initial reading, participants in the massed condition were immediately asked to study the passage again, while those in the spaced condition participated in a 30-min unrelated distractor activity before re-studying the passage. In the highlighting condition, participants re-read their previously highlighted passage (with their markings still there) and were again told to use the highlighter however they typically would while studying for a class. Participants in the no-highlighting condition were simply instructed to re-read the passage as though they were studying for a class.

After the second reading, all participants were given a brief questionnaire asking them to indicate the extent to which they either agreed or disagreed with a set of statements exploring their metacognitive beliefs about learning and study strategies, such as, "I feel that highlighters

[1] As a separate manipulation, we also explored whether the benefits of testing (Roediger and Karpicke 2006) might interact with highlighting. Specifically, participants were given an immediate test on six of the twelve fill-in-the-blank questions shortly after the second reading of the passage. All twelve questions were then tested after the 1-week delay, allowing us to assess the benefits of the earlier test. Although we observed a large benefit of testing, $F(1, 180)=102.99$, MSE=4.24, $p<0.001$, with keywords tested immediately remembered significantly better on the delayed test (M=0.47, SE=0.02) than were keywords not tested immediately (M=0.26, SE=0.02), the effect of testing did not interact with either the spacing (p=0.83) or highlighting (p=0.33) manipulations. Consequently, for the sake of succinctness, and because educators are most likely to be interested in how highlighting affects long-term learning and performance, we collapsed all data from the tested versus non-tested conditions and report only one score to reflect the week-delayed final recall performance.

are an important part of my studying." One week later, all participants were given the fill-in-the-blank test for the 12 critical phrases from the passage.

Results and Discussion

How Do Highlighting and Spacing Affect Learning?

Average correct performance obtained on the final fill-in-the-blank test in each of our four conditions is illustrated in Fig. 1, and as indicated there, one of our pre-study conjectures—that highlighting might be more beneficial in massed than spaced conditions—did receive some support. Planned-comparison *t*-tests revealed that whereas a nonsignificant benefit of highlighting was observed in the spaced condition (M=0.04 benefit), $t(90)=0.92$, $p=0.36$, $d=0.19$, a robust and significant benefit of highlighting was observed in the massed condition (M=0.12 benefit), $t(90)=2.89$, $p<0.01$, $d=0.60$.

Additionally, we performed an overall analysis on our data using a 2(spaced vs. massed)× 2(highlighting vs. no-highlighting) between-subjects ANOVA. Not surprisingly, given the pattern of results shown in Fig. 1, there was no main effect of spacing, $F(1, 180)<1$, $MSE=0.03$, with performance averaged across the two massed conditions (M=0.37, SE=0.02) not differing from that averaged across the two spaced condition (M=0.36, SE=0.02); but, there was a significant main effect of highlighting, with the average performance of highlighters (M=0.40; SE=0.02) being significantly better than the average performance of non-highlighters (M=0.32; SE=0.02), $F(1, 180)=7.22$, MSE=0.57, $p<0.01$. The interaction between highlighting and spacing, however, did not reach statistical significance, $F(1, 180)=1.93$, MSE=0.15, $p=0.17$.

Given the typical robustness of the spacing effect that we did not find a benefit of spacing even for the non-highlighters would suggest that our particular spacing manipulation was not sufficiently strong. Indeed, because our to-be-leaned material was a three-page text passage requiring up to 6 min to read once, a participant's re-encountering of given key phrases would have been spaced by several minutes even in our massed condition. Thus, the interval between spaced encounters of the same key phrases may have not been sufficiently increased in our spacing condition versus our massed condition to allow a spacing benefit to emerge.

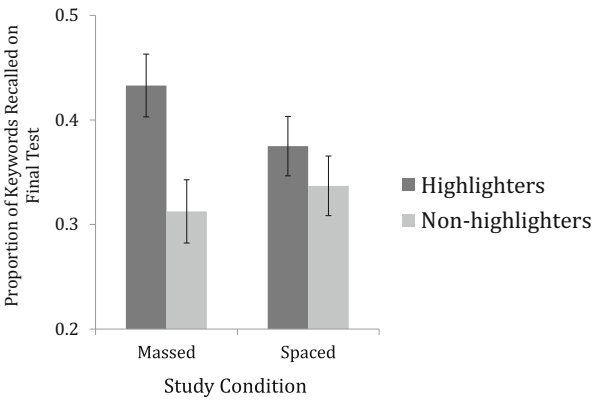

Fig. 1 Final test performance by spacing and highlighting conditions

How Do Individual Differences in Highlighting Behavior Affect Learning?

Overall, participants highlighted an average of 191.9 (SE=13.5) words (Mdn=175), and their highlighting behavior was quite efficient. Despite participants highlighting only 22.4 % of the passage, an average of 8.7 (SE=0.27) or 72.5 % of the 12 critical keywords were included in their highlighting. Eighty-one participants highlighted some keywords but not others, allowing for within-subjects comparisons of recall for highlighted versus non-highlighted keywords. We first examined whether highlighted information was better recalled than non-highlighted information, and importantly, it was. Participants were more likely to answer a test question correctly if they had highlighted information relevant to that question (M=0.44) than if they had not (M=0.30), $t(80)=3.67$, $p<0.01$, $d=0.50$. Furthermore, recall performance of highlighting participants for non-highlighted material was no different from the recall performance of non-highlighting participants (M=0.32), $t(174)=0.56$, $p=0.58$. Thus, highlighting appears to improve the retention of highlighted material without significant cost to the retention of the non-highlighted material—a finding inconsistent with the von Restorff effect.

To explore a possible relationship between highlighting activity and later recall, we conducted a median-split analysis separating participants into heavy highlighters and light highlighters. As shown in Table 1, heavy highlighters marked significantly more words than light highlighters, $t(90)=9.41$, $p<0.001$, $d=1.96$, including more keywords, $t(90)=3.81$, $p<0.001$, $d=0.97$. Importantly, however, heavy highlighters did not outperform light highlighters at final test. If anything, light highlighters numerically outperformed heavy highlighters, suggesting that the benefits of highlighting do not stem from the mere act of highlighting alone.

Possibly, the light highlighters put more cognitive effort and analysis into deciding what to highlight, resulting in fewer highlighted words, but deeper processing of those words compared to words highlighted by heavy highlighters. We explored this conjecture by calculating an efficiency score: the number of keywords highlighted divided by the total number of words highlighted. By this measure, light highlighters were significantly more efficient (M=0.08, SE=0.01) than heavy highlighters (M=0.03, SE=0.01), $t(89)=7.20$, $p<0.01$, $d=1.50$. Thus, it would appear that light highlighters were more selective in their highlighting than heavy highlighters, perhaps reflecting more cognitive effort being given to their highlighting decisions.

How do Students' Beliefs about Highlighting Relate to the Benefits of Highlighting?

According to the questionnaire responses, many students use highlighters and believe them to be an important component of their studying. When asked to rate the statement, "I typically read my text books while using a highlighter" on a scale from 1–9—with 1 meaning "completely disagree," 5 meaning "unsure," and 9 meaning "completely agree"—48 % of

Table 1 Highlighting activity and final test performance by highlighting-classification group

Highlighting classification	Total words highlighted (SE)	Keywords highlighted (SE)	Final test performance (SE)
Heavy highlighters	282.8 (17.7)	9.7 (0.3)	0.39 (0.03)
Light highlighters	101.0 (7.8)	7.8 (0.4)	0.41 (0.03)

the participants selected a 7 or above (M=5.5; SD=2.8). Furthermore, when asked to rate the statement, "I feel that highlighters are an important part of my studying" using the same 1-9 scale, 41 % of the participants selected a 7 or above (M=5.3; SD=2.6). If anything, these ratings probably underestimate student text-marking behavior, as participants may have restricted their responses to highlighting, discounting similar text-marking activities such as underlining.

To see whether differences in opinions about highlighting predicted differences in highlighting activity or recall performance, we separated participants into three groups: pro-highlighters, unsure, and anti-highlighters. Pro-highlighters were the 74 participants rating the statement, "I feel that highlighters are an important part of my studying" with a 7 or above; unsure participants were the 55 participants rating the statement between 4 and 6, and anti-highlighters were the 55 participants rating the statement 3 or below. Unsurprisingly, a main effect of group was observed on highlighting activity, $F(2,89)=4.39$, MSE=68,812.20, $p<0.05$. As shown in Table 2, pro-highlighters and those who were unsure highlighted significantly more words than did anti-highlighters, $t(63)=3.35$, $p<0.01$, $d=0.86$, $t(52)=2.19$, $p=0.03$, $d=0.60$, respectively, and a similar pattern was observed for keywords highlighted.

To see if opinions about the importance of highlighting were related to retention, we conducted a 2(highlighting vs. no-highlighting)×2(spaced vs. massed)×3(pro-highlighters vs. unsure vs. anti-highlighters) between-subjects ANOVA on the final test scores. Spacing did not interact significantly with any variable, so we collapsed across the massed and spaced conditions. Interestingly, a significant effect of group emerged, such that anti-highlighters (M=0.45; SE=0.03) outperformed unsure participants (M=0.37; SE=0.03), who outperformed pro-highlighters (M=0.30; SE=0.02), $F(2, 172)=9.60$, MSE=0.34, $p<0.001$, with individual t-tests confirming each of the between-group differences to be statistically significant, average $d=0.38$.

Although anti-highlighters outperformed pro-highlighters, we nonetheless expected pro-highlighters to benefit most from being allowed to use a highlighter. As shown in Table 2, however, the opposite was observed. Anti-highlighters benefited marginally from use of a highlighter (M=10 % benefit), $t(53)=1.69$, $p=0.09$, $d=0.50$, and unsure participants benefited significantly (M=17 % benefit), $t(53)=3.92$, $p<0.001$, $d=1.00$), but pro-highlighters did not benefit at all (M=0 % benefit), $t(72)<1$. The interaction between highlighting group and highlighting condition was statistically significant, $F(2, 172)=3.90$, MSE=0.14, $p=0.02$.

Table 2 Highlighting activity and final test performance by highlighting efficacy and belief classification

Experimental condition and belief classification	Total words highlighted (SE)	Keywords highlighted (SE)	Final test performance (SE)
Highlighters			
Pro-highlighters	219.9 (20.3)	8.9 (.4)	0.30 (0.03)
Unsure highlighters	212.2 (24.1)	7.6 (.6)	0.45 (0.03)
Anti-highlighters	132.1 (24.1)	9.6 (.3)	0.50 (0.04)
Non-highlighters			
Pro-highlighters	–	–	0.30 (0.03)
Unsure highlighters	–	–	0.28 (0.03)
Anti-highlighters	–	–	0.40 (0.04)

General Discussion

The goal of the present research was to explore potential benefits of highlighting in relation to distributed study and students' metacognitive beliefs about highlighting as a study tool. We found that highlighting improved later cued recall of highlighted information without impairing recall of non-highlighted information from a text passage, a finding that is inconsistent with a von Restorff-based explanation. That is, highlighting did not seem to enjoy its benefit merely by making highlighted text stand out upon re-study. Furthermore, we found that the benefit of highlighting was numerically greater when participants read the passage twice without delay, suggesting that highlighting may be particularly beneficial when students re-read text passages immediately.

The results of the present research suggest that highlighting, far from being an ineffective study technique (Dunlosky et al. 2013), can facilitate long-term retention—particularly when students, possibly owing to limited available study time, engage in massed re-readings or study sessions. In such situations, students could probably improve the effectiveness of their study via selective highlighting because such a practice would lead them to think about why they initially selected certain words or phrases to highlight, resulting in deeper processing during subsequent readings.

If initial highlighting does encourage learners to engage in such considerations about previously highlighted material, then highlighting might have some of its beneficial effects—as suggested earlier—by serving to dispel the misleading effect of fluency arising during a subsequent re-reading. Indeed, the sense of fluency typically felt during an immediate re-reading has been suggested as a major factor in why two back-to-back readings of a chapter result in no better learning than just one reading (Callender and McDaniel 2009). Accordingly, times when a sense of fluency is high and most likely to discourage deep processing on a second reading should also be the times when having previously highlighted the passage would be most beneficial—a pattern consistent with our finding of a greater benefit for highlighting when text readings were massed versus spaced.

A surprising finding of the present study is that participants who valued highlighters the most profited least from their use. One possible reason for this finding is that participants who were unaccustomed to highlighting put more effort into the act of highlighting, with the ultimate result of better retention. From this perspective, highlighting could be characterized as a desirable difficulty, at least for some students, because it forces them to think about and process text differently than they typically would and in a way that ultimately leads to better memory for that text. These results also suggest that even if participants were prevented from engaging in the type of study processes they normally employ, the costs of such prevention did not outweigh the benefits of using a highlighter.

Our results also indicate that training students how to highlight effectively could help promote useful study strategies. Students often re-read text passages as a study activity, and indeed, many rate it as their no. 1 study activity (Dunlosky et al. 2013; Karpicke et al. 2009; Kornell and Bjork 2007, 2009). Presumably, then, students are highly likely to persist in this activity. Accordingly, instructing them how to do so optimally would seem not just warranted, but obligatory. Highlighting training such as that proposed by Leutner et al. (2007), for example, could well be helpful in furthering this goal, even—or perhaps especially—for those who already believe that highlighting is a beneficial study technique. Such training should involve encouraging students to think carefully about which sections of the text should be highlighted and to justify their choices, as well as asking those questions again when re-reading a previously highlighted section. Such questioning during highlighting and re-reading should evoke two beneficial activities for improved retention: deeper processing and retrieval

practice, both of which have been repeatedly shown to improve retention (e.g., Craik and Lockhart 1972; Roediger and Karpicke 2006).

More generally, the present work provides another example of what Bjork (1999) and others (e.g., Koriat and Bjork 2005) have referred to as an illusion of competence. Specifically, learners can be fooled by objective and subjective indices of performance into thinking that a given manipulation is useful for learning even when it is not. In this context, individuals who become reliant on highlighters for studying—such as the pro-highlighters or heavy highlighters in the present study—may think that the act of highlighting is helpful in and of itself. As the present results confirm, however, simply the act of highlighting text is not sufficient to promote its retention. Indeed, despite the fact that highlighting a relevant portion of a text was clearly beneficial, more overall highlighting activity tended to lead to worse—not better—performance at final test. Clearly, it is not highlighting per se that is beneficial; rather, it is how highlighting changes the way students read and think about text that is beneficial.

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