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Mental Juggling: When Does Multitasking Impair Reading Comprehension?

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ABSTRACT. The present study investigated the conditions under which multitasking impairs reading comprehension. Participants read prose passages (the primary task), some of which required them to perform a secondary task. In Experiment 1, we compared two different types of secondary tasks (answering trivia questions and solving math problems). Reading comprehension was assessed using a multiple-choice test that measured both factual and conceptual knowledge. The results showed no observable detrimental effects associated with multitasking. In Experiment 2, the secondary task was a cognitive load task that required participants to remember a string of numbers while reading the passages. Performance on the reading comprehension test was lower in the cognitive load conditions relative to the no-load condition. The present study delineates the conditions under which multitasking can impair or have no effect on reading comprehension. These results further our understanding of our capacity to multitask and have practical implications in our technologically advanced society in which multitasking has become commonplace.

Keywords: cognitive load, dual-task, multitasking, reading comprehension, task switch

TECHNOLOGICAL ADVANCEMENTS have now made it commonplace for people to engage in multiple tasks simultaneously. The practice of multitasking manifests itself in a number of situations in our everyday lives. For example, people speak on cell phones while driving, listen to music via their smartphones while cooking, and frequent social media Web sites while reading an assignment. Hence, it is not surprising that in a survey of 1,649 college undergraduates enrolled at a 4-year public institution in the United States, 51% of respondents reported that they send text messages, and 33% reported using Facebook, while doing schoolwork (Junco & Cotton, 2012). Although the notion of multitasking might lead students to believe that they are being more productive, research in cognitive...
psychology shows that attention is a limited resource (Pashler, 1994; Pashler & Johnston, 1998); therefore, multitasking can reduce performance on both primary and secondary tasks.

Several studies have investigated multitasking in reading comprehension using instant messaging as the secondary task (Bowman, Levine, Waite, & Gendron, 2010; Fox, Rosen, & Crawford, 2009; Tran, Carrillo, & Subrahmanyam, 2013). Bowman and colleagues (2010) and Fox and colleagues (2009) had half of their participants read a prose passage (e.g., personality disorders from an abnormal psychology textbook) during which they had to respond to IMs (Instant Messages) sent by a researcher. The other half read the passage without interruptions. The messages queried personal information of the participant’s life, for example, “What do you like to do in your spare time?”. Bowman and colleagues (2010) presented the parts of each passage separately, in which participants could not have gone back to review a previous part of the passage once they advanced to the next screen. However, in a similar study, Fox and colleagues (2009) presented the passages on paper and thus, participants could have gone back to reread parts of the passages. In both studies, the researchers reported no impairment on the reading comprehension test between the group that was interrupted with IMs while reading the passage relative to those who were not. However, in both studies, the authors reported that those who were asked to complete a secondary task spent more time reading the passages. Thus, if one takes into account time spent reading the passages (or speed of processing), one can conclude that there is a cost to reading comprehension while multitasking (i.e., a speed-accuracy tradeoff).

Tran and colleagues (2013) also had participants complete a secondary task that involved IM. In their study, the presentation of the prose passage was experimenter-paced—that is, each part of the passage was presented for 60 seconds. Tran and colleagues found no cost of multitasking on the reading comprehension test, which converges with the results of Bowman and colleagues (2010) and Fox and colleagues (2009). In fact, they found a slight facilitating effect of multitasking. However, there are two limitations with Tran and colleagues’ procedures. First, by making the task experimenter-paced, it is likely that all participants were given adequate time to process all the information on each slide. If multitasking reduces the speed at which participants read passages (see Bowman et al., 2010 and Fox et al., 2009, for evidence of this), that detrimental effect may have been masked in their study. A second and more problematic concern is that participants were allowed to respond to the IMs when they wanted to and that they could ignore the messages. Although the researchers noted that no participant ignored the messages, they did note that participants’ responses were short and the conversation one-sided. This observation suggests that participants were not engaged in the secondary task, thus reducing its cognitive demand. Thus, their failure to find a cost to multitasking could also be due to a weak secondary task that does not tax cognitive resources.
Pashler, Kang, and Ip (2013) also had participants read prose passages while completing an IM task. However, one difference between Pashler and colleagues and the previous studies discussed is that the nature of the questions participants had to answer in Pashler et al. (2013) was complex and, in principle, required thoughtful responses, for example, “What are your beliefs on animal research?,” “When is animal research justified?” In their first two experiments, there were three reading conditions: (1) control (no interruptions while reading), (2) paragraph interruptions (interruptions would occur only after each paragraph), and (3) random interruptions (interruptions occurred 5 to 15—decided randomly—seconds after they had started reading a paragraph). Not every single paragraph included an interruption. Of the seven to 10 paragraphs (depending on the passage), five paragraphs, determined randomly, included interruptions. In Experiment 2, the researchers presented the passages auditorily. This was done to prevent participants from reviewing parts of a paragraph—that is, spending more time on certain sentences of a paragraph. In addition, this procedure provided a test as to whether a mismatch in the modality of the primary (learning the passage) and secondary (answering questions presented via IM) tasks would impair reading comprehension. Everything else was the same as in Experiment 1. The researchers reported no difference on the reading comprehension test between the three conditions in both experiments. However, in Experiment 1, participants spent more time reading the passage in the random interruptions condition, relative to the passage read in the control condition, which required the least amount of time. Thus, as in Bowman and colleagues (2010) and Fox and colleagues (2009), if one takes into account time spent reading the passages, there is a cost in multitasking in Pashler and colleagues’ (2013) Experiment 1.

Pashler and colleagues’ (2013) final experiment was the same as their Experiment 2 with two exceptions: (1) they had only two conditions—control and random interruptions, and more important, (2) when participants were completing the secondary task, the auditory presentation of the passage continued. In this experiment, the researchers reported a cost associated with multitasking: Performance on the reading comprehension test was higher in the control condition than in the random interruptions condition.

While Pashler and colleagues (2013) demonstrated the conditions under which multitasking impairs reading comprehension, there are three elements of their study that deserve further consideration. First, the researchers did not ensure the quality of participants’ responses to the questions in the interruptions conditions. The only requirement was that they provide a response greater than 160 characters. Thus, it was possible that the participants were not taking the questions on the secondary task seriously, thereby reducing the cognitive resources needed to complete the task. This notion was further supported by the researchers’ instruction to the participants that the “most important goal would be to learn as much information as possible from the passages” (p. 595). If participants were not engaged in completing the secondary task, this would result in a weak manipulation of
multitasking and could explain the null effects on the reading comprehension test in Experiments 1 and 2. (This same issue is also present in the other multitasking reading comprehension studies discussed above). Second, in Experiment 1, because participants in the random interruptions condition spent more time reading the passages, there is a cost associated with multitasking (see also Bowman et al., 2010; Fox et al., 2009). Third, performance in these two experiments was close to chance, thereby introducing the possibility of a floor effect obscuring the detrimental effects of multitasking. Finally, in their Experiment 3, in which they reported a cost associated with multitasking on the reading comprehension test, the nature of the secondary task was changed. When participants were answering the question associated with the secondary task, the auditory presentation of the passage continued. This is unlike the other studies reviewed thus far and Pashler and colleagues’ (2013) Experiments 1 and 2, in which the presentation of the passage was halted when participants were working on the secondary task. If participants do not have an opportunity to encode parts of a passage, it is not surprising that they would perform poorly on the reading comprehension test.

The Present Study

The present study addressed the methodological shortcomings of the studies reviewed above and tested additional scenarios under which multitasking may impair reading comprehension. It is important for researchers to methodically investigate the conditions under which multitasking hurts or has no effect on reading comprehension given that the previous literature shows that multitasking can impair performance on various cognitive tasks (e.g., Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013). In addition, given the frequency with which college students multitask, knowing whether or not there is a cost associated with multitasking is important from both a theoretical and practical standpoint.

According to Cognitive Load Theory (CLT), participants acquire novel information through the use of schemas, which helps to integrate previously acquired information with the newly encountered information (Sweller, 1994). The use of schemas in knowledge acquisition and updating is believed to rely on working memory, a limited resource. Thus, when one’s working memory is taxed, which can arise when one is multitasking, the efficiency of schemas may be reduced, thereby reducing performance on a task.

The current study consists of two experiments. In both experiments, participants read prose passages (the primary task), as in the previous studies reviewed above. We collected the time spent reading passages so as to assess whether or not participants in the multitasking conditions would spend more time reading the passages. Unlike the previous studies, the secondary task in all of our experiments allowed us to objectively assess whether participants were engaged in the task.
In addition, because the secondary task contained multiple queries, as opposed to a single query, this makes it more likely that participants would be constantly engaged while completing the secondary task.

The present study also assessed additional conditions under which the act of multitasking may impair reading comprehension. These additional conditions were not examined in the studies mentioned earlier. In our Experiment 1, we directly assessed whether a mismatch in the nature of the information being processed in the primary and secondary task would impair reading comprehension. Specifically, we had two different types of secondary tasks—answering trivia questions and solving math problems. There is more overlap in the nature of the materials between the primary and secondary tasks when the secondary task involves answering trivia questions rather than solving math problems. Both answering trivia questions and reading passages require participants to read and process English words. Another extension of our study over previous research is that our reading comprehension test assessed both factual and conceptual knowledge, whereas previous research (e.g., Pashler et al., 2013) focused on factual knowledge. Assessing whether multitasking impairs acquisition of conceptual knowledge more so than factual knowledge is important because educators often emphasize to students that they should acquire a “deeper” (i.e., conceptual) understanding of what they read, rather than simply remember facts. Thus, the present study also assesses whether any detrimental effects of multitasking would interact with the type of knowledge that is tested.

**Experiment 1**

**Method**

**Design and Materials**

Participants read three passages under three different conditions: (1) control (no secondary task), (2) trivia questions, and (3) math problems. Each participant completed all three conditions, and the order in which the conditions were received was counterbalanced using a balanced Latin-square design.

**Passages and Reading Comprehension Test**

Three expository passages were taken from Butler (2010). These passages pertained to the history of bread, the formation of tropical cyclones, and types of bats. The average word count for these passages is 1,000 with a Flesch-Kincaid reading grade level of 11 (Kincaid, Fishburne, Rogers, & Chissom, 1975). For each passage, we created 16 reading comprehension questions, with half assessing factual knowledge and the other half assessing conceptual knowledge. Factual knowledge assessed information that can be directly obtained from the passage within a single sentence, that is, the correct response was stated directly in the text within a single sentence. In contrast, the correct response to conceptual knowledge
questions required participants to infer what the answer might be given what was stated in the passage or had to be synthesized from knowledge acquired across multiple sentences (Bloom, 1956). An example of each type of question is found in Table 1.

**Trivia Questions**

Thirty trivia questions (e.g., What is the largest desert on earth?) were selected from the updated Nelson and Narens norms (Tauber, Dunlosky, Rawson, Rhodes, & Sitzman, 2013). According to the normative data collected by Tauber et al. (2013), participants answered, on average, 44% of the questions correctly.

**Math Problems**

Sixty math addition problems were created. The math problems consisted of adding together two, two-digit numbers that were presented above and below the fixation or to the right and left of fixation.

**Participants**

Thirty-six participants from the University at Albany, State University at New York, whose self-reported native language is English were recruited. All
reported normal or corrected-to-normal vision and no known reading disorder. In exchange for their participation, participants were given research credit toward the fulfillment of their research requirement.

**Procedure**

Participants were told that they would be reading short passages for which their content would be tested later. The type of memory test was not specified. In addition, they were told that the questions queried specific information in the passage, and thus they should read the passages carefully. They were further told that while reading some passages, they would be given trivia questions to answer or be asked to solve math addition problems. The passages for which they had to complete trivia questions or math problems were not specified ahead of time. The research assistant reiterated these instructions to participants before they began. All participants read three passages, under three different conditions. In all conditions, the passages were presented one paragraph at a time, and participants were given an unlimited amount of time to read each paragraph. To advance to the next paragraph, participants hit the enter key on the keyboard. Participants who read a passage under the trivia questions or math problems condition solved a block of trivia questions or math problems after the first, second, fourth, fifth, and seventh paragraph. Each block of trivia questions contained six questions that were presented one-at-a-time in the middle of the screen for exactly 10 seconds each; thus, the task was experimenter-paced. Participants typed their response below each question; no feedback was given. Each block of math problems consisted of eight trials. Each math trial began with a 1000 ms fixation (+), followed by the presentation of the stimuli for exactly 6000 ms that was followed by a feedback screen for 1000 ms. The feedback screen informed the participant whether or not he or she provided the correct answer.

After reading the last paragraph of each passage, participants immediately completed the reading comprehension test. Participants were presented with each question one-at-a-time, with factual and conceptual questions being randomly intermixed and presented in a new order for each participant. Participants had an unlimited amount of time to answer each question but could not return to a question once it was answered. Each participant completed the task individually.

**Results**

In all the experiments, the effect size of the $F$ and paired $t$ statistics is reported using partial eta-squared ($\eta_p^2$) and Cohen’s $d_{CD}$, (see Dunlap, Cortina, Vaslow, & Burke, 1996), respectively. Unless noted otherwise, all $p$ values for $t$ tests are two-tailed, the numerical values associated with participants’ performance are means, and in parentheses, the standard deviation associated with that mean.
Trivia Questions and Math Problems

Participants correctly answered 38% (17%) of the trivia questions. Participants correctly answered 82% (8%) of the math problems.

Reading Comprehension Test

The results of the reading comprehension test are displayed in Figure 1. The grey and black bars denote factual and conceptual questions, respectively. In all conditions, performance was well above chance. A higher proportion of factual questions were answered correctly than conceptual questions, 61% (17%) vs 55% (16%), respectively, $F(1, 35) = 8.083, p = .007, \eta^2_p = .188$. However, there was no main effect of reading condition [control: 58% (17%), trivia questions: 58% (19%), math problems: 59% (22%)] and no interaction effect, $Fs(2, 70) < .900, ps > .8, \eta^2_ps < .01$. Thus, multitasking did not lead to an impairment in reading comprehension relative to the control condition.

Time Reading Passages

The amount of time spent reading the passages in the control, trivia questions, and math problems conditions was 5.44 (1.64), 5.47 (2.10), and 5.18 (1.94) minutes, respectively. These differences did not approach statistical significance, $F(2, 70) = .546, p = .582, \eta^2_p = .015$.

FIGURE 1. Percentage of reading comprehension questions answered correctly as a function of reading condition and question type in Experiment 1 (left) and Experiment 2 (right). Error bars denote ± 1 SEM. The dotted line represents chance performance.
Discussion

Overall, the results of Experiment 1 largely replicated those of Pashler and colleagues (2013). We did not find a cost associated with multitasking for performance on a reading comprehension test, measured using both accuracy on the reading comprehension test or time spent reading the passages. Previous research (e.g., Bowman et al., 2010; Fox et al., 2009; Pashler et al., 2013, Experiment 1) concluded no cost of multitasking on the basis that the multitasking group did not differ from the control group on accuracy in the reading comprehension test. However, in these studies, there was an increase in the time spent reading the passages, which introduces the possibility that there is a cost associated with multitasking due to a speed-accuracy tradeoff. In the present experiment, we reported null effects of accuracy and reading time among our multitasking and control conditions. Thus, the present experiment presents strong evidence that under some conditions, there is no cost to multitasking.

Experiment 1 extended the results of Pashler and colleagues (2013) by generalizing their null effects on reading comprehension test accuracy using different passages that are shorter and easier so as to avoid floor effects. Furthermore, although participants were more likely to correctly answer factual rather than conceptual questions, type of question did not interact with reading condition. Thus, it appears that answering trivia questions or math problems as distractions do not impair reading comprehension that tests for either factual or conceptual knowledge.

In Experiment 1, the secondary tasks can be seen as independent of the primary task of reading the passages. That is, when participants are completing the trivia questions or math problems, they are allowed to disengage completely from the reading comprehension task and vice versa. One might ask, what if the secondary task required participants to keep the information associated with the task in mind while working on the primary task. Under this condition, would multitasking lead to impairments in reading comprehension? Because the secondary task will place stronger demands on the participants’ working memory, the participant may have fewer cognitive resources to process the passage as they read it, thereby reducing overall comprehension of the passage and impair performance. This notion is tested in our Experiment 2.

Experiment 2

In this experiment, the nature of the secondary task was changed. Participants were now given a cognitive load task. In this task, participants are asked to remember a string of numbers, and after reading a few sentences in the passage (the number of sentences varied from 2–7 and was unknown to participants), they reported the numbers that they were asked to remember. The demands of this secondary task differs from those of the previous experiments and studies discussed.
earlier in that this secondary task requires participants to mentally “hold” or rehearse information while reading the passage, placing a greater demand on their working memory. Two variations of the cognitive load conditions were used: low (participants had to remember a two-digit number) and high (participants had to remember a five-digit number) so as to assess whether a more demanding cognitive load task further impairs reading comprehension. The exact same passages and questions as those from Experiment 1 were used. This was to ensure that if there were a cost associated with multitasking in this experiment, the null effects in Experiment 1 could not have been due to the particular materials that were selected.

Method

Design and Materials

All participants completed three conditions: (1) control (same as in Experiments 1), (2) low cognitive load (participants had to remember two digits), and (3) high cognitive load (participants had to remember five digits). In both cognitive load conditions, participants were presented with a total of 12 sets of numbers and were told to always report the numbers in the same order in which they were presented. The exact same passages and questions from Experiment 1 were used.

Participants

Thirty participants from the same population and with the same characteristics as Experiment 1 participated in the study. None had participated in the previous experiment.

Procedure

The procedure was the same as in the previous experiment with the following exceptions:

(1) Only one sentence was presented at a time. The number of sentences for the passages varied from 47–52, and as in Experiment 1, participants read these sentences at their own pace.

(2) Participants in the cognitive load condition were told to remember numbers (two if they were in the low load condition and five if they were in the high load condition) for which they had to report on the computer screen after reading a few sentences.

For both the low and high load conditions, participants were given 5000 ms to remember a two- or five-digit number, presented on the computer screen. The first set of numbers was always given before they read the first sentence of the passage. After 2 to 7 sentences (determined randomly by the researchers ahead of time), a screen appeared in which the participant was instructed to type the set of numbers
that they were asked to remember. Once participants reported the numbers, a new set of numbers was given to them. Participants had unlimited time to report each set of numbers.

Results

Cognitive Load Task

Participants performed better on the low cognitive load task than on the high cognitive load task, 85% (14%) vs. 58% (23%), \( t(29) = 8.075, p < .001, d_{CD} = 1.31 \). This finding shows that our manipulation of the difficulty of cognitive load task was effective and that participants had more difficulty remembering the set of numbers in the high cognitive load condition.

Reading Comprehension Test

Performance on the reading comprehension test is shown in Figure 2. Performance did not differ by question type, factual: 56% (16%) vs. conceptual: 53% (10%), \( F(1, 58) = 2.071, p = .161, \eta_p^2 = .067 \). More important, there was a main effect of reading condition, \( F(2, 58) = 6.337, p = .003, \eta_p^2 = .179 \). Participants answered more questions correctly in the control condition, 61% (18%) than in the low cognitive load condition, 53% (13%), \( t(29) = 2.247, p = .032, d_{CD} = .50 \), and in the high cognitive load condition, 48% (16%), \( t(29) = 3.603, p = .001, d_{CD} = .75 \). Although the high cognitive load condition resulted in numerically lower performance than the low cognitive load condition, the difference was not statistically significant, \( t(29) = 1.282, p = .210, d_{CD} = .33 \). The interaction of Reading Condition and Question Type was not significant, \( F(2, 58) = .793, p = .457, \eta_p^2 = .027 \).

Time Reading Passages

The amount of time reading the passages was comparable in the control and low cognitive load conditions [5.60 (1.69) vs. 5.47 (1.66) minutes, respectively]. However, participants spent the most time reading the passages in the high cognitive load condition [6.25 (3.43) minutes], though these differences were not statistically significant, \( F(2, 58) = 1.502, p = .231, \eta_p^2 = .049 \).

Discussion

The secondary task used in this experiment required participants to mentally “hold” or rehearse a set of numbers while reading a passage. Using this task, we found a cost to reading comprehension. Specifically, performance on the reading comprehension test was the highest in the control condition and lowest in the high cognitive load condition, with the low cognitive load condition being intermediate. In addition, in the high cognitive load condition, participants spent the most time reading the passages further demonstrating a cost to reading comprehension.
However, the increase in time spent reading the passages was not statistically significant.

Unlike in Experiment 1, in the present experiment, participants did not correctly answer factual questions at a higher percentage than conceptual questions. However, the pattern of the result was in the predicted direction: Conceptual questions were correctly answered at a lower percentage than factual questions. Nevertheless, this does not undermine the main finding that completing a secondary task impaired reading comprehension performance for both factual and conceptual questions.

One might ask whether presenting the sentences one-at-a-time as opposed to in a paragraph format (as in Experiment 1) may have led to our finding a multitasking cost in this experiment but not in the previous experiment. We believe that this is unlikely to be the case because in Experiment 2 of Pashler and colleagues’ (2013) article, their null effect was obtained when the sentences were presented auditorily, which is functionally equivalent to presenting sentences one-at-a-time visually. Hence, we believe that the cost associated with multitasking in this experiment but not in the previous experiment is due to the cognitive demands of the secondary task. These results suggest that the nature of the secondary task is an important moderator in creating an impairment to reading comprehension.

General Discussion

In two experiments, we investigated whether multitasking impairs reading comprehension in both the amount of knowledge that participants gained from text passages, as measured by performance on a reading comprehension test and the amount of time spent reading the passages. In addition, we investigated additional variables associated with multitasking that may impair reading comprehension that were not considered by previous researchers. In our experiments, we used a secondary task that (1) allowed us to score the responses objectively (Experiments 1 & 2), and (2) presented multiple queries to participants during each interruption block (Experiment 1). These two improvements allowed us to ensure that participants were working on the task and that the tasks kept them engaged.

In Experiment 1, we found no cost associated with multitasking on both the reading comprehension test and time participants spent reading the passages. The null effect on the reading comprehension test replicated those of Bowman and colleagues (2010), Fox and colleagues (2009), and Pashler and colleagues (2013), but without a speed-accuracy tradeoff. In our Experiment 1, time spent reading the passages was comparable in all three conditions. Thus, the results of our Experiment 1 provide strong evidence that under certain conditions, there is no cost associated with multitasking. Furthermore, the null effect was obtained using different types of distractor tasks and when participants were tested on their factual and conceptual knowledge.
One should always be cautious in drawing inferences based on a null effect. However, as noted by Frick (1995), null effects should be given credence when they are observed under conditions of high statistical power. To address the issue of statistical power, we computed a power analysis using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007). If there were a cost associated with multitasking in our Experiment 1 and the effect size was as large as the effect observed in our Experiment 2 in the Control vs. High Cognitive Load condition, which had a $d_{CD} = .75$, the power we had to reject the null hypothesis is .99. If we assume a smaller effect size such as the one observed using the Control vs. Low Cognitive Load condition in Experiment 2, which had a $d_{CD} = .50$, the power we had to detect the effect, if it exists, is .90 (one-tailed). Both of these levels of power meet the level of power (.80) recommended by Cohen (1992) in designing effective research studies to reject the null hypothesis. In addition, mean performance on the reading comprehension task and the time participants spent reading the passages showed no hint of a cost associated with multitasking. Thus, for these reasons, we do not believe that our failure to observe a cost associated with multitasking is due to the lack of statistical power.

In Experiment 2, the nature of the secondary task was changed such that participants had to retain information from the secondary task in working memory while completing the primary task. Under this condition, we found a cost associated with multitasking. Although Experiment 3 in Pashler and colleagues’ article reported a cost associated with multitasking, the primary task continued to be presented while participants were completing the secondary task. It was, therefore, not surprising that under those conditions there was a cost to multitasking (see also Lee, Lin, & Robertson, 2012, who showed a cost associated with multitasking when both the primary and secondary tasks occurred simultaneously). In Experiment 2 of the present study, we demonstrated a cost associated with multitasking even though the primary task was paused when participants were working on the secondary task.

According to CLT, we acquire newly encountered information using schemas (Sweller, 1994). However, because the use of schemas requires mental effort and therefore taxes one’s cognitive resources, increases in cognitive (or working memory) load will decrease the efficiency of schemas. Specifically, Sweller (1994) asserts that cognitive load can impair learning and problem solving by preventing the use of schemas. Applying this notion to the present study, multitasking can impair reading comprehension by making it more difficult for participants to integrate different parts of a passage that would help facilitate overall comprehension. However, the present study identifies important boundaries under which multitasking impairs reading comprehension. Contrary to popular belief, multitasking does not always impair reading comprehension. The participants in our study were able to cope with the demands of multitasking under certain conditions. Specifically, if the secondary task does not occur simultaneously with the primary task (see Pashler et al., 2013; Experiments 1 & 2 and Experiment 1 of the present...
study), or require rehearsal when working on the primary task (Experiment 2 of the present study), there is no cost associated with multitasking. Thus, the specific requirements of the secondary task serves as an important moderator as to when multitasking hurts or has no effect on reading comprehension.

Multitasking is commonplace in our daily lives. For example, it is typical for students to read their textbook (the primary task) while frequenting social media websites (the secondary task). A recent article by Levitin (2014) recommended that people do not switch between working on different tasks (e.g., reading status updates on Facebook and answering e-mails). Levitin argues that switching between tasks may affect one’s attentional resource for more important tasks. The results of the current study suggest that such a conclusion may be too broad. Specifically, if one does not wish for the secondary task to interfere with the primary task, the multitasker should ensure that the secondary task does not tax or overload working memory resources. This would preclude the multitasker from the burden of “holding” information from the secondary task in mind while working on the primary task, which as shown in Experiment 2, impairs reading comprehension. Thus, switching between tasks, per se, does not impair reading comprehension. However, switching between tasks when the secondary task requires one to remember information associated with the secondary task (our Experiment 2) does. Therefore, before students resume reading their textbook, they should finish reading a blog post or watch a video in its entirety, rather than pausing midway and switching over to the reading assignment. Of course, it could be the case that with longer passages (or tasks) that switching between tasks will always impair reading comprehension.

Given the prevalence of multitasking in our society, it is important for future researchers to identify other moderators that can interact with multitasking to affect reading comprehension. The secondary tasks we used in our experiments might have been unfamiliar to our participants in that they are not tasks that they practice in their everyday lives. One might, therefore, question whether there is a cost to multitasking when the secondary task is familiar to participants and well-practiced (see Rubinstein, Meyer, & Evans, 2001, who reported a decreased cost in a task switching paradigm when the rules of the tasks were low in complexity and were well-learned and therefore familiar to participants).

Another line of research that deserves consideration is the extent to which frequency of multitasking can reduce the cost associated with multitasking. This is an important question given that there is some research suggesting that frequency with which participants report that they multitask (Ophir, Nass, & Wagner, 2013) is negatively related to performance on basic cognitive tasks. This shows that many people overestimate their multitasking abilities (Sanbonmatsu et al., 2013). Although technological advancement has made it possible for us to work on multiple tasks simultaneously, it is still unclear whether it is prudent to do so. Thus, it is important for researchers to delineate the conditions under which multitasking hurts or has no effect on task performance.
NOTES

1. Reaction time was not recorded in their Experiment 2.
2. Chance performance in Pashler et al. (2013) was 43%. (There were 18 true/false questions and 7 multiple-choice questions with 4 response options). In their Experiments 1 and 2, performance for the highest-scoring group was 60% and 53%, respectively.
3. We did not give feedback in the trivia task because we believe that it would be more likely that participants would perseverate on the feedback, especially if they were incorrect, for these types of questions while working on the primary (reading) task. We did not have this same concern for the math problems because it is a more mundane task.

AUTHOR NOTES

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REFERENCES


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