Twenty-first century doodling: How does Facebook use impact memory of lecture content?

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As Facebook becomes increasingly popular, this question is important for students and educators alike. Participants in the present study were assigned to listen to a podcast while freely browsing Facebook, viewing an album of Facebook pictures, or doing nothing. Then, participants completed a surprise memory test on the podcast. Participants remembered best when they did not divide attention, at an intermediate level when they viewed pictures, and worst when they freely browsed Facebook. Evidence suggests that this difference resulted from differential engagement with the podcast. This research both contributes to theoretical knowledge on divided attention and memory, and has clear practical implications: to learn most, eliminate Facebook use during class. Future research should explore the differences between freely browsing Facebook and simply viewing pictures, and attempt to quantify the effect of Facebook in real college classrooms.

Introduction

In recent years, laptop computers have become increasingly common on college campuses. As a result, students frequently attend to laptops during lecture courses, and specifically to Facebook, a social networking site that now hosts 800 million users. In light of its explosive popularity, an important question for college students and educators alike is how dividing attention between Facebook and lecture content impacts memory and learning.

Cognitive psychology research suggests that dividing attention between two minimally demanding tasks can boost memory performance, while dividing attention between more demanding tasks can impair performance (Andrade, 2009; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). Applied research demonstrates that students who listen to a lecture with their laptops open remember the material less well (Hembrooke & Gay, 2003). While this could suggest that attending to Facebook is demanding enough to impair memory, no study has directly examined its effect on memory of lecture content. The present study seeks to fill this gap, and to determine if different types of Facebook content have different effects on memory.

Cognitive psychology research suggests mixed effects of divided attention on memory. On the one hand, dividing attention can increase memory when both tasks are minimally demanding. For example, participants in one study were asked to listen to and take notes on a long, monotonous telephone message about people that could and could not attend a party (Andrade, 2009). In one condition, participants were asked to doodle while taking notes, and in the other, they were just asked to take notes. They then completed a surprise memory test about the people and places mentioned in the message. Participants who doodled remembered 29% more pieces of information, suggesting that doodling enhanced memory. The author proposed that doodling might have decreased daydreaming by adding more demand to an undemanding primary task, thus improving concentration.

On the other hand, evidence suggests that dividing attention between more demanding tasks can decrease memory, because attention is a limited resource. In one study, subjects were asked to listen to and encode lists of 15 words while dividing attention or not, and then were asked to recall them (Craik et al., 1996). When they just listened to the words, subjects remembered an average of 9.4 words. When they divided their attention by also responding to visual stimuli with different keys on a keyboard, subjects remembered an average of 5.1 words, suggesting that diving attention between two demanding tasks impairs memory. Thus, the effect of divided attention on memory seems to depend on how demanding the tasks at hand are.

Applied research suggests that dividing attention between a lecture and a laptop may be sufficiently demanding to impair memory of lecture content. In one study, college students in a communications course listened to a lecture while their laptops were open or closed. When the lecture ended, participants completed a surprise memory test on its content. Participants in the open laptop condition, and especially those who chose to spend more time online, performed significantly worse than participants in the closed laptop condition (Hembrooke & Gay, 2003). While this result suggests that attending to Facebook might impair memory, it is not clear what online content participants in this study viewed, and specifically, if they used Facebook. Further, it is possible that participants who went online more were generally worse at learning or taking tests. Thus, the present study manipulated the precise content that participants attended to in order to draw causal conclusions about the effects of attending to different content on Facebook.

Which types of Facebook content are most likely to impair memory of lecture content? We based our predictions on research suggesting that attending to two sources of information in the same domain impairs memory the most. In one study, subjects were asked to divide their attention between different types of memorization tasks and a speech shadowing task, in which they listened to speech

in one ear and then repeated it back (Allport, Antonis, & Reynolds, 1972). Subjects performed best when the memorization task was to memorize pictures (and thus the two tasks were in different domains), at an intermediate level when the memorization task was to memorize visually presented words (and thus the tasks were both verbal, but one was visual and one was auditory), and worst when the memorization task was to memorize words presented in their other ear (and thus both tasks were verbal and auditory). This pattern suggests that attending to two tasks in the same domain impairs memory the most because in addition to general attentional resources, we have domain-specific resources.

On this basis, we hypothesized that Facebook content with more information overall should tax general attentional resources more, while content with more information in the same domain as a lecture should tax domain-specific resources more. Thus, we predicted that freely browsing one's Facebook account should impair encoding of a lecture greatly, both because it includes much information overall and because it includes text, which overlaps with the verbal domain of the lecture. In contrast, attending only to Facebook pictures should be less distracting, both because it includes less information overall and because pictorial information does not overlap with the verbal domain of the lecture. However, we predicted that both uses of Facebook would impair memory of lecture content relative to undivided attention.

Methods

Design and hypotheses

To test our predictions, we asked participants to listen to a podcast about the obesity epidemic, designed to simulate audio lecture content. In our Facebook condition, we asked participants to divide attention between the podcast and browsing their own Facebook account. In our pictures condition, we asked participants to divide attention between the podcast and a Facebook album of pictures. In our control condition, we simply asked participants to listen to the podcast. We then gave participants a surprise memory test about the podcast. We also offered participants healthy and unhealthy snacks and noted their choices, reasoning that participants who better encoded the message about obesity would be more likely to pick the healthy snacks. We hypothesized that participants in the control condition would perform best on the memory test and pick healthy snacks the most often, participants in the pictures condition would remember and pick healthy snacks at an intermediate level, and participants in the Facebook condition would remember worst and pick healthy snacks the least often.

Participants

Participants in this study were 60 Harvard College undergraduates, recruited in house dining halls, the Science Center, and over house and club email lists. Participants were 60% male and 40% female. Participants were 21.7% freshman, 13.3% sophomores, 50% juniors, and 15% seniors. 98.3% of participants reported having a Facebook profile. There were no significant differences between conditions on any of these variables.

Procedure

The study was conducted in the Science Center basement computer lab as well as various quiet study rooms in Harvard College residential houses. All participants signed an informed consent form, were instructed to listen to a short podcast about the obesity epidemic, and were told that they would later answer questions about their perceptions of the obesity epidemic. Participants in the pictures and Facebook conditions were also told that the researchers were interested in how priming social interaction influences perception of the obesity epidemic. In the Facebook condition, participants were then instructed to log onto their Facebook and browse through the website, including their newsfeed as well as profiles and pictures that interested them. They were told to freely comment on or "like" any content.

In the pictures condition, participants looked through an album of 143 pictures of people, events, and places at Harvard University. The album was posted from an account that was set up for the experiment and had no other content. The pictures were taken from the Harvard University Facebook page, as well as various websites including the Harvard Gazette and the Harvard Crimson. The pictures depicted a variety of events and locations, including Harvard's 375th birthday celebration, athletics competitions, commencement, freshmen move-in, artistic performances, and the Harvard community garden. Participants were instructed to scroll through the album as they listened to the podcast, and to go through a second time if they finished.

Participants listened to the podcast over headphones while the researcher covertly observed participants as they listened, to make sure that they followed the manipulation. The podcast was taken from the Yale University iTunes University website, and was shortened to be about four minutes long (Bittman, 2010). In the podcast, a speaker advocates a soda tax, arguing that soda causes diabetes and obesity. The podcast was selected to include a large number of factual statements, so that memory could be tested objectively and to ensure that the content was mildly boring, simulating content from a lecture course that one would elect to take but then would want to divide attention during. The following is a sample selection from the podcast: "If we just take it at the absolute bottom line that seven percent of our calories come from this one source and it's non-nutritive, that makes it pretty bad, I think...It's an engineered craving, we may be born craving sweets, but we're not born craving sugar in particular, it has no nutritional value, but it's worse than that, because being a major cause of obesity, soda is therefore a major cause of diabetes."

After participants finished the podcast, they played free online Tetris for two minutes. Tetris involves attending to and manipulating different shapes in order to form complete horizontal lines. Participants who did not know how to play received scripted instructions. Tetris was used to separate the memory test in time from the podcast and thus eliminate the recency effect, in which recently presented information is better recalled. Our question of interest is the effect of Facebook on long-term encoding, so we did not want our effect to result from differences in how well participants could repeat back what they just heard. Because Tetris is attention-demanding, we reasoned that two minutes of play would be sufficient to move any content from the podcast out of working memory and eliminate the recency effect.

After two minutes of Tetris, participants completed an online survey. First, they completed a memory test about the podcast including ten multiple-choice questions and six true-false questions. A sample multiple-choice question is: "What difference between calories in liquid and solid form does the speaker mention? A. Liquid form calories tend to be less nutritive; B. Liquid form calories engineer cravings; C. Liquid form calories make up roughly one third of Americans' calorie intake; D. Liquid form calories feel more innocuous; E. Liquid form calories are less filling." A sample true-false question is: "True or False: The speaker claimed that there is a smoking gun linking obesity to diabetes."

Second, participants reported their gender, year in school, and if they had a Facebook profile. Third, they reported the extent to which they typically doodle, daydream, go on Facebook, and use Gchat (Google chat) during class. For each activity, they reported the percentage of classes they sometimes do the activity in and, for those classes, the percentage of class time they spend on the activity. These questions were open-ended.

Fourth, participants used seven-point Likert scales ranging from "Strongly Agree" to "Strongly Disagree" to report their agreement with the statements "I believe going on sites like Facebook and Gmail during lectures HELPS my understanding of the material" and "I believe going on sites like Facebook and Gmail during lectures HURTS my understanding of the material." Fifth, participants used seven-point Likert scales to report how interesting, engaging, and familiar they found the podcast. They also reported how much prior knowledge they had about the podcast's content, and if they expected to be tested for their memory of the podcast. Finally, participants in the Facebook and pictures conditions also reported how much they engaged with Facebook or the pictures, and how personally relevant they found them to be. Participants in the Facebook condition reported the extent to which they commented, read text, and looked at pictures during the podcast.

Participants were then interviewed about their thoughts on podcast, the purposes of the study, and their expectations of the memory test. Responses were recorded verbatim. Finally, participants received a verbal debriefing as well as a printed debriefing form, and were offered a small candy bar or granola bar. Their choice was noted, including if they opted to take nothing.

Results

Memory test performance

Our first dependent variable was performance on the memory test, measured with a composite memory test score. This was calculated as the proportion of the 16 memory questions that participants answered correctly; thus, multiple-choice and true-false items were weighted equally. For multiple-choice questions that asked participants to select the two correct answer choices, responses of one correct and one incorrect choice were scored as .5. The mean score on our composite measure was .63. Scores ranged from .31 to

.94, the standard deviation was 0.15, and the skewedness was .182, indicating only mild skew.

To determine if participants who expected the memory test should be excluded from further analyses, we examined expectancy effects. However, a chi-squared test revealed no differences between conditions in the frequency with which participants expected the test ($\chi^2 = 1.64$, $p = .440$), and a t-test revealed no difference between the mean composite memory scores of participants that did and did not expect the test ($t = .37$, $p = .713$). Because participants in each condition were equally likely to expect the test and because expectations had no effect on memory scores, expectations seemed unlikely to explain any differences in memory scores between conditions, and participants who expected the test were included in further analyses.

Next, we analyzed memory test performance by condition. As predicted, memory scores were highest in the control condition ($M = .74$, $SE = .02$), intermediate in the pictures condition ($M = .63$, $SE = .03$), and lowest in the Facebook condition ($M = .55$, $SE = .03$). A 3-group ANOVA revealed that there were some significant differences between conditions ($F = 12.27$, $p < .001$). These differences were investigated using ANOVAs that compared composite scores between each pair of conditions. F was calculated as the ratio of the mean square between groups from the 2-group ANOVA to the mean square within groups from the 3-group ANOVA, which provides a more stable estimate of sampling error. P was calculated using this F value and the df value from the 3-group ANOVA. The results revealed significant differences between composite scores in the control and pictures conditions ($F = 8.27$, $p < .001$), the control and Facebook conditions ($F = 24.8$, $p < .001$), and the pictures and Facebook conditions ($F = 4.4$, $p = .017$). Thus, as hypothesized, participants remembered best in the control condition, at an intermediate level in the pictures condition, and worst in the Facebook condition. This pattern is shown in Figure 1.

We next examined the relationships between individual variables and memory test performance with bivariate correlations. This analysis was exploratory, but we predicted that participants who engaged more with the podcast would perform better on the memory test. Only four variables were significantly correlated ($p < .05$) with memory test performance. First, as predicted, participants who reported engaging more with the podcast scored better on the memory test on average ($r = .310$, $p = .016$). Second, participants who reported finding their newsfeed more engaging scored worse on the memory test on average ($r = -.49$, $p = .025$). Third, participants who reported spending more time doodling in classes that they sometimes doodle in scored worse on the memory test on average ($r = -.32$, $p = .012$). Finally, participants who reported spending more time on Facebook in classes that they sometimes go on Facebook during scored worse on the memory test on average ($r = -.29$, $p = .025$). In sum, an exploratory analysis revealed that four of our survey questions predicted individual memory performance.

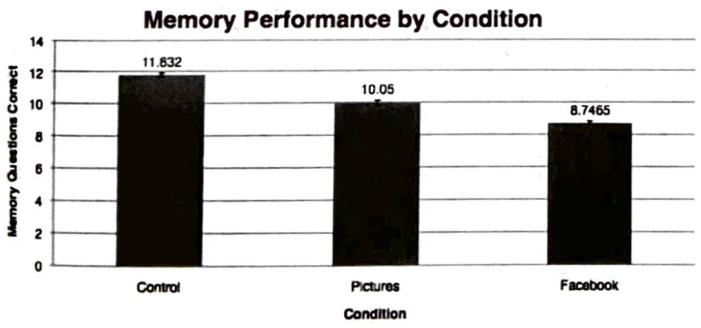

Figure 1. The mean number of memory questions answered correctly in each condition. Labels above each bar depict the value for the condition. Error bars are +/- 1 standard deviations; error bars using standard errors were too small to be visible.

Prize choice

Our second dependent variable was participants' choice of prize. The choice of candy was coded as 1, the choice of a granola bar was coded as 2, and the choice of nothing was coded as 3. 48.3% of participants chose candy, 25.0% of participants chose a granola bar, 25.0% of participants chose nothing, and 1.7% of data were missing. While we predicted that participants would choose healthy prizes most frequently in the control condition, at an intermediate level in the pictures condition, and least frequently in the Facebook condition, a chi-square test revealed no differences between conditions in the frequency of prize choices ($\chi^2 = 0.44$, $p = .979$). Thus, our manipulation did not impact the prizes that participants chose.

Differences in other variables by condition

Finally, we examined differences between conditions on variables other than our main dependent variables. We predicted that because condition was randomly assigned, participants would not differ between conditions on basic demographic variables. Thus, this analysis served to test if randomization was successful. In contrast, this analysis was exploratory for variables that could have plausibly been affected by participants' experience in the experiment, such as perceived interestingness of the podcast.

3-group ANOVAs revealed no significant differences ($p < .05$) between conditions in the frequency with which each of the three experimenters ran the study: participants' reported gender, year in college, frequency of having a Facebook account, prior familiarity with the podcast, prior knowledge of Tetris, as well as doodling, daydreaming, Facebook use, and Gchat use during class. These results suggest that randomization successfully created equivalent groups.

However, there were significant differences between conditions in participants' reported agreement with the statements, "I believe going on sites like Facebook and Gmail during lectures HELPS my understanding of material" ($F = 6.88$, $p = .002$) and "I believe going on sites like Facebook and Gmail during lectures HURTS my understanding of material" ($F = 5.90$, $p = .005$). Participants also differed in the extent to which they reported engaging with the podcast ($F = 12.78$, $p < .001$) and how interesting they reported finding it ($F = 3.759$, $p = .029$).

To examine these differences, 2 × 1 ANOVAs were used, as described above, to compare each pair of conditions on each of these variables. These comparisons revealed three sets of findings. First, participants in the Facebook condition reported spending more time doodling during class than participants in the control condition. Further, participants in the control condition reported spending less time on Facebook during class than participants in the pictures and Facebook conditions, who did not differ from each other. This pattern is shown in Figure 2.

Second, participants in the pictures condition reported believing that Facebook and Gmail help understanding of lecture material more and hurt understanding less than participants in the Facebook or control conditions, who did not differ significantly from each other. This pattern is shown in Figure 3.

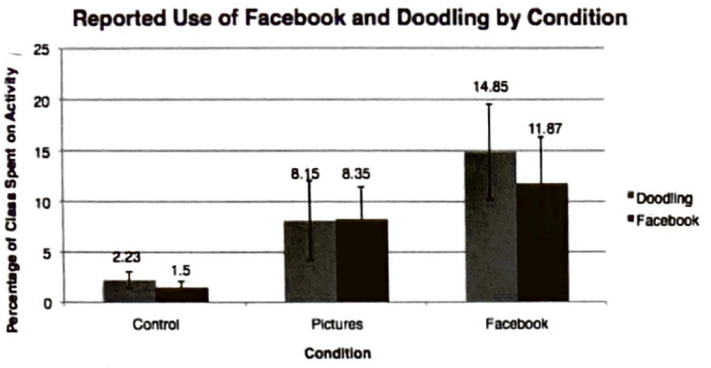

Figure 2. The mean reported percentage of time spent on doodling and Facebook by condition. Error bars are +/- 1 standard error; labels above each bar depict the value for the condition (for Figures 2-5).

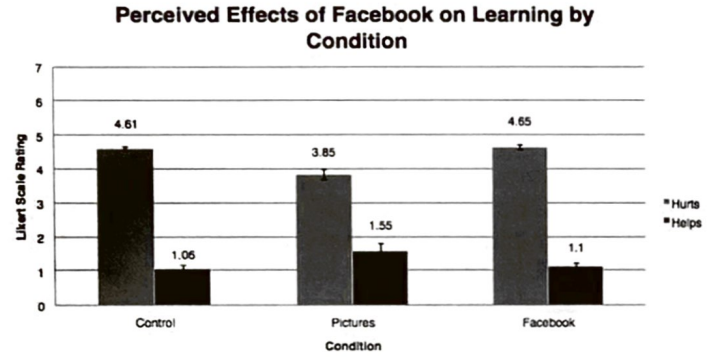

Figure 3. The mean agreement that Facebook helps and hurts learning by condition.

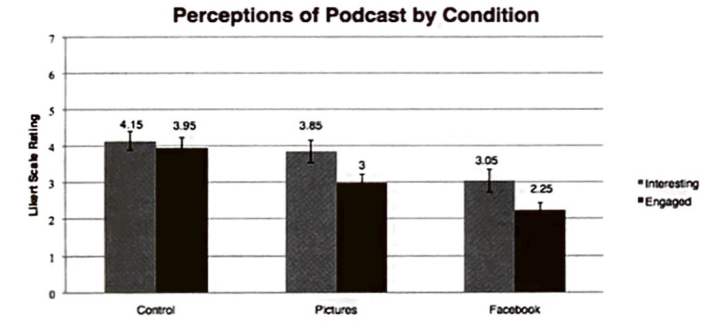

Figure 4. The mean reported interestingness of and engagement with the podcast by condition.

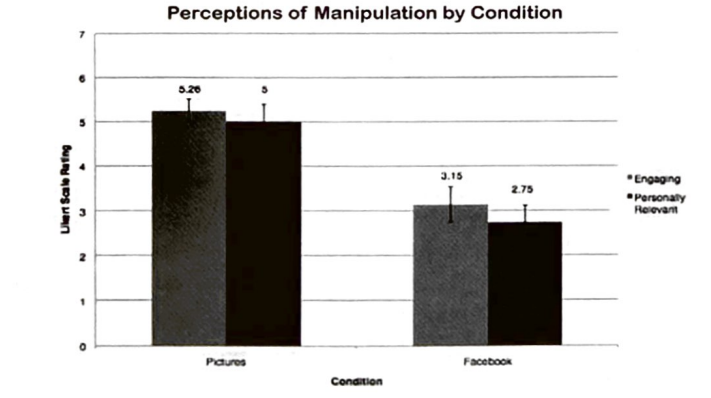

Figure 5. Mean reported engagement with and perceived personal relevance of the pictures (in the pictures condition) and participants' newsfeeds (in the Facebook condition).

Third, participants in the control condition reported engaging more with the podcast than did participants in the pictures condition, who reported more engagement than participants in the Facebook condition. Further, participants in the Facebook condition reported being less interested in the podcast than participants in the control and pictures conditions, who did not differ from each other. This pattern is shown in Figure 4.

Next, we assessed differences between perceptions of the manipulation in the pictures and Facebook conditions. Control participants did not answer analogous questions, as they simply listened to the podcast. Participants in the pictures condition reported finding the pictures more engaging ($M = 5.26$, $SE = 0.25$) than participants in the Facebook condition reported finding their newsfeeds ($M = 3.15$, $SE = 0.39$), and a t-test revealed that this difference was significant ($t = 4.53$, $p < .001$). Participants in the pictures condition also reported finding the pictures more personally relevant ($M = 5.00$, $SE = 0.40$) than participants in the Facebook condition reported finding their newsfeeds ($M = 2.75$, $SE = 0.37$), and this difference was also significant ($t = 4.15$, $p < .001$). These results are shown in Figure 5.

In sum, exploratory analyses revealed some unexpected differences between conditions on variables besides our main dependent measures.

Discussion

Results regarding memory test scores were consistent with predictions: attending to Facebook did impair memory of the podcast, and this effect was stronger in the Facebook than pictures condition. This suggests that attending to Facebook, even when it is just pictures, is demanding enough to impair encoding of a lecture.

In contrast, results regarding prize choice differed from predictions: we did not find that participants picked a healthy prize more frequently in the control condition than in the pictures or Facebook conditions. One explanation is that there is a threshold effect where even minimal engagement with the podcast is sufficient to encode the message that obesity is a problem, and that further engagement does not make selecting a healthy prize more probable. Alternatively, individual variation in prize choice due to factors such as personal preferences, general concern with health, and hunger level may have overwhelmed any effect of condition.

Our memory test results are unlikely to result from pre-existing differences between conditions: there were no significant differences between conditions in the experimenter that conducted the study, gender, year in college, familiarity with the material in the podcast, prior knowledge of how to play Tetris, as well as doodling, daydreaming, Facebook use, and Gchat use during class. Instead, our data suggest that differences in memory performance between conditions resulted from differences in engagement with the podcast. Participants reported engaging most with the podcast in the control condition, at an intermediate level in the pictures condition, and least in the Facebook condition. Additionally, participants that reported engaging more with the podcast scored better on the memory test, suggesting that dividing attention may have impaired memory by reducing engagement with the podcast.

Why did participants in the pictures condition perform better on the memory test than participants in the Facebook condition? One possibility is that they were less interested in the manipulation,

engaged less with it, and thus used fewer domain-general attentional resources. However, data negated this hypothesis: participants in the pictures condition reported engaging more with the pictures than participants in the Facebook condition reported engaging with their newsfeeds. Further, participants in the pictures condition reported finding the pictures more personally relevant than Facebook participants reported finding their newsfeeds.

Thus, our results are more consistent with the alternative explanation that limited domain-specific resources make freely browsing Facebook more distracting than attending to pictures. Participants in the pictures condition reported engaging more with both the manipulation and the podcast, suggesting that they were better able to divide their attention. They also performed better on the memory test, indicating that they were better able to encode the lecture. A plausible explanation is that attending to pictures drew on domain-specific resources that were not also used to process the lecture while processing text on Facebook drew on domain-specific resources that were also used to process the lecture. Thus, participants in the pictures condition had more attentional resources left for the lecture and remembered it better. Therefore, our results corroborate previous research supporting the theory of domain-specific attention.

Our results also demonstrate that individuals who multitask more often are no better able to divide attention or encode material. The effect of condition did not depend on the amount that subjects reported using Facebook during class, suggesting that individuals that use Facebook frequently have not learned to multitask more effectively. Further, participants who reported doodling and using Facebook during class more did worse on the memory test overall, suggesting that these individuals are generally worse at attending to and encoding lecture content. Thus, multitasking does not enhance attention and is associated with reduced learning, further supporting the conclusion that dividing attention during lecture should be avoided.

We found some unexpected differences between conditions in variables other than our main dependent variables. First, participants in the control and pictures condition found the podcast more interesting than participants in the Facebook condition. This is probably because they were more engaged with the podcast, as reported above. Second, participants in the Facebook condition reported doodling during class more than participants in the control condition, and participants in the Facebook and pictures conditions reported using Facebook during class more than participants in the control condition. One possible explanation for this unexpected result is that participants who divided attention during the experiment were reminded of dividing attention during class and thus more readily remembered and reported doing so.

Third, participants in the pictures condition reported believing that Facebook is more helpful and less hurtful for learning than participants in the Facebook and control conditions. While it is not clear how this finding might be interpreted, the fact that these effects are highly significant suggests that they are unlikely to result from pre-existing differences between participants in the different conditions. Thus, it seems more plausible that participating in the pictures condition had an effect on how participants perceive Facebook. Future research should attempt to elucidate this effect.

In conclusion, our data build on previous research on laptop use to send a clear message to students and educators: to learn most, avoid Facebook use during lecture. This should be applied to course policies regarding internet use during class.

This experiment has both theoretical and practical limitations that should be addressed by future research. On the theoretical side, our experiment cannot isolate the mechanism causing participants in the pictures condition to outperform participants in the Facebook condition on the memory test. Because we do not know exactly what participants in the Facebook condition attended to, it is difficult to evaluate how their experience differed from the pictures condition. While one plausible explanation is that the pictures condition required fewer domain-specific attentional resources, there are alternative explanations. For example, participants in the pictures condition reported being more engaged with the manipulation; perhaps, they also experienced more arousal or positive affect, improving performance on the memory test.

Thus, further research should attempt to address this by measuring possible confounding variables like mood. If controlling for such variables attenuates the effect of condition on memory, it would suggest that these variables are mechanisms for our result. Further, future research should either directly measure the content viewed by participants browsing Facebook, or manipulate the content directly. For example, to isolate the effects of text, participants could be asked to only browse their newsfeeds. If this were more distracting than viewing pictures, it would provide stronger support for the domain specificity hypothesis.

On the practical side, our results leave open the question of how detrimental Facebook is in a typical classroom setting. Because our experiment did not take place in a realistic setting, the effect size we found does not provide a meaningful reflection of effect size in actual classrooms. Second, actual students expect examinations and are motivated to do well on them. Thus, in a real lecture, students might use Facebook differently, perhaps only logging in when they perceive the content to be relatively unimportant. To test for such effects, students in a real class could either be allowed or not allowed to use Facebook over the course of a semester, and then their final exam scores could be compared. This would provide insight into the effects of Facebook in actual classrooms, further informing the debate over Internet use during class. Policies based on this research can improve learning, benefiting students and educators alike.

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