Gloria Charite and Dr. Chris Baldassano
Dynamic Perception and Memory Lab
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Relaxing Breaks in Online University Lectures May Improve Learning Outcomes

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Abstract

The present study investigated the impact of relaxing breaks on learning outcomes for students enrolled in an introductory psychology course. Breaks consisted of one-minute breathing exercises. There were two experimental conditions based on the timing of the break. One group got a break around 10 minutes into a 36-min video recorded lecture (break 1) while another got it around 30 minutes into the lecture (break 2). We found that the earlier break had no significant impact on student performance while the break later in the lecture bore a slight improvement in performance. An investigation into whether breaks impacted low and high performing students differently revealed that while break 1 had no differential impact, break 2 improved the performance of high performers and decreased that of low performers. Future studies are needed to understand the factors driving this selective impact of the break and whether other types of breaks would be more effective at obtaining larger effects. This study contributes to the growing literature aimed at using cognitive psychology research to improve education outcomes.

Relaxing Breaks in Online University Lectures May Improve Learning Outcomes

Recently, there has been an increased interest in understanding the impact of technology usage on attention span–how long one can maintain continuous attention to target stimuli–due to the growing number of tasks like monitoring surveillance cameras and diagnostic medical screening (Alarfaj et al., 2023; Lima et al., 2020), where even momentary attention failures can have severe consequences. Understanding the effect of technology on attention, however, extends beyond its application in these fields. It's equally relevant to fields like education, where the main means of instructions are lectures that demand continuous attention (Young, 2009). This has become particularly important in recent years, as video-recorded lectures are frequently used to supplement classroom teaching (Gorissen et al., 2012) and often the primary mode of instruction in online learning platforms (Breslow et al., 2013). Attention is critical in determining what students later remember from lectures (Bunce et al., 2010; Wammes et al., 2017; Fenesi et al., 2018). It plays a prominent role in the formation of conscious memories, determining what sensory information is selected into working and eventually what gets into long-term memory (Atkinson & Shiffrin, 1968; Chun & Turk-Browne, 2007). These factors each call for research into ways to enhance student attention to, and in turn retention of, the content of lectures.

Furthermore, exploring the effects of technology usage on student attention is not only relevant but also urgent given the rate at which online learning has increased over the past few years (Picciano et al., 2012; Fligio et al., 2013). For example, at Coursera, a popular international online learning platform, enrollment rates show significant annual increases going from 21 million in 2016 to 92 million as of 2021 (WEF, 2022). Fligio et al. (2013) reported that the top ten largest four-year universities in the United States enroll more than 10,000 students in at least one online class each semester. Expectedly, this trend has been escalated by the COVID-19 pandemic (García-Morales et al., 2021; Mishra et al., 2020). Vaccinations have largely made in-person learning possible again, however at many institutions classes are still recorded (Le, 2022). This allows students the option to watch recorded lectures instead of coming to class, suggesting that online learning may be here to stay. Yet, there is accumulating evidence that online teaching reduces learning outcomes (Figlio et al., 2013; Schacter & Szpunar, 2015; Alpert et al., 2016; Bettinger et al., 2017; Cacault et al., 2021; Le, 2022). The goal of the present project, therefore, was to find an effective intervention to improve students' learning outcomes in online learning spaces, specifically video-recorded lectures.

One of the major barriers to lecture learning is the difficulty in sustaining attention for the entire length of the lecture, also known as vigilance decrement. Indeed, it has been found that in classroom lectures there are increases in attention lapses as the lecture progresses with parallel decreases in note taking and retention (e.g., Johnstone & Percival, 1975; Bunce et al., 2010; Unsworth et al., 2012). Similar difficulties in sustaining attention have been observed in video-recorded lectures (Risko et al., 2012; Fenesi et al., 2018), albeit at a more worrying rate (Le, 2022). It is not well understood why this is the case, but one notable contributing factor to the pronounced attention decline rate in video-recorded lectures is the lack of instructor real-time adaptivity to student's waning attention. That is, in live classes instructors can dynamically adapt their content delivery by, for example, giving a short break to refocus students' attention (Bligh, 2000). This suggests that finding interventions that improve student attention and then building them into video-recorded lectures could be one way of improving these lectures' adaptivity and efficacy. The present study examined one such intervention, namely incorporating breathing breaks in lectures. The intervention was based on the predictions made by two competing theories that attempt to explain why vigilance decrement occurs: the "neural fatigue hypothesis" and the "goal habituation theory" (Tulving & Rosenbaum, 2006; Ariga & Lleras, 2010).

The neural fatigue hypothesis posits that the execution of cognitive tasks (e.g. paying continuous attention) fatigues the involved neuronal network such that it is less efficient in accomplishing at time T2 what it did at time T1 (Tulving & Rosenbaum, 2006). Cognitive tasks are supported by energy resources that deplete during sustained periods of high activity (Tulving & Rosenbaum, 2006; Hobfoll, 2002; Hunter and Wu, 2016), providing a potential explanation for why later episodes in a temporal succession suffer from reduced performance as is often the case in lecture learning (e.g. Wammes et al., 2017). Thankfully, these resources have been hypothesized to replenish over periods of low activity, behaving like rechargeable batteries that periodically need recharging (Hobfoll, 2002; Tulving & Rosenbaum, 2006; Hunter and Wu, 2016). On the other hand, the goal habituation theory argues that vigilance decrement stems from the failure of the supervisory attentional/executive control system to keep one attentional goal active for a prolonged period of time (Ariga & Lleras, 2010). As such, momentarily deactivating the vigilance task goal by switching to a content-unrelated task may disrupt the ongoing goal habituation and in turn stop the vigilance decrement. Taken together, we hypothesized that punctuating video-recorded lectures with relaxing breaks would improve student attention and in turn increase memory for the lecture material by either stopping the resource depletion or disrupting the ongoing goal habituation.

While both of these theories predict an overall positive effect of the breaks, they differ in their predictions on the impact of the breaks on certain types of students, namely high and low performing students. The goal habituation theory predicts that low-performers would benefit most from the breaks. Indeed, prior work suggests that low-performing students are especially susceptible to goal habituation. For example, Unsworth et al. (2012) showed that low-performing students struggle with attention control experiencing more attention lapses both in everyday life and classroom contexts than their high-performing peers (Unsworth et al., 2012). Therefore the break could be helpful in re-focusing their attention while having little to no benefit for high-performers who were not struggling to stay on task to begin with. On the contrary, the neural fatigue hypothesis predicts that high performers would benefit most from the breaks. Finding the material to be difficult, low-performers may exert a lot more cognitive resources such that a short break is not enough to have any significant impact in restoring the depleted resources while still being useful to high-performers who did not expend as much resources.

Furthemore, the alternative hypothesis arguing that incorporating breathing breaks in the lecture may reduce student performance is also plausible. Instead of acting as a cognitive break, there is a possibility that the breathing task could act as a second cognitive task; thus, consuming resources necessary for the main task, a phenomenon known as resource competition (Helton & Russell., 2012). We chose breathing breaks because practices used in mindfulness meditation such as breathing exercises are not as cognitively demanding as processing lecture material (Lutz et al., 2008; Semple, 2010). However, the breaks were embedded in the lecture such that participants continued to stare at the same screen in addition to attending to the instruction in the break task demonstration. Further, that a content-unrelated break may act as a second cognitive task is also consistent with previous research finding that including content-unrelated cues in sustained-attention tasks has a detrimental impact on vigilance performance (Seli et al., 2012; Helton & Russell., 2012). Switching between two cognitive tasks has been shown to deplete attention and impair performance on both tasks (Rogers & Monsell, 1995, Wylie & Allport, 2000). If the breathing breaks indeed functioned as a second cognitive task we predicted that they would hurt, other than improve, performance in subsequent learning episodes.

To test these conflicting hypotheses we showed participants a video-recorded lecture in which there was a break either around 10 minutes or 30 minutes into the lecture depending on the experimental condition. Breaks consisted of one-minute breathing exercises chosen as breaks for two main reasons. First, breathing exercises have been reported to improve attention in different settings (e.g. see Simpson & Nelson, 1974; Telles et al, 2008). Second, breathing exercises are not only low-effort activities but also draw on different resources than those utilized during lecture learning (Hobfoll, 2002). This is critical because according to the neural fatigue hypothesis the greater the neurocognitive similarity between events 1 and 2, the greater the likelihood of recruiting the same neural network (Tulving & Rosenbaum, 2006). This suggests that the breaks with task demands that are most divergent from those in learning will be most successful at relieving the strain incurred by the neuronal network involved in paying attention to and encoding the lecture material. Similarly, according to goal habituation theory, the efficacy of a given break at deactivating the goal of the main task depends on the extent to which it is dissimilar to the main task (Ariga & Lleras, 2010).

Student performance was assessed using a 40-question comprehension test administered immediately after the lecture. We chose a comprehension test for two reasons. First, tests are the most common way undergraduate performance is evaluated, typically in the form of multiple choice questions (MCQ) (Butler, 2010). However, there is a long standing criticism of MCQ tests arguing that they do not give an accurate assessment of what students know/remember from lectures as students can guess answers thereon (Simkin & Kuechler, 2004; Roediger III & Marsh, 2005). Additionally, the literature on recognition memory identifies two dissociable types of memory, namely recollection of previously studied information and mere familiarity with the target stimulus (Yonelinas, 2002). Critics of MCQ tests argue that MCQs are poor measures of recollection memory and mostly reflect familiarity (Reder & Ritter, 1992). To address this issue, the test we used contained both multiple choice questions and fill-in-the-blanks questions, the latter which has been associated with recollection memory (Simkin & Kuechler, 2004). Second, using a comprehension test allowed us to make an assessment that followed the lecture's temporal structure. That is, question 1 was, for example, about the content presented in the first minute of the lecture. This made it possible to evaluate the impact of the breaks on subsequent learning episodes. Meaning if one group just took a break, do they perform better (or worse) on questions following the break than the group that did not?

Methods

Participants

Using an online recruitment portal, SONA, we recruited 94 participants enrolled in an introductory psychology course. Students varied in reasons for taking the course with n=22 being prospective psychology majors, n=45 taking it for a science requirement, n=12 taking it for a pre-med requirement, n=2 both science and pre-med requirement, and n=10 others. The gender and racial breakdown were as follows: Gender–18 Men, 43 Women, and 33 gender not reported; Race–2 American Indian, 34 Asian, 9 Black, 37 White, 10 Multiracial, and 2 Other. The study was approved by the IRB office at Columbia University. All participants provided informed and voluntary consent and were compensated with course credit for their participation.

Materials

Lecture

Participants watched a 36-min video-recorded lecture on personality. It was taken directly from the course in which participants were enrolled and scheduled to appear later in the semester. We used an actual recorded live lecture in a lecture hall from a previous semester. When recording the lecture, the camera was focused on the lecturer and the slides; students were not included in the shot. This lecture was chosen because it increased the ecological validity of the experimental paradigm as it was on authentic class material. Further, research on the region of proximal learning has shown that students are more curious and motivated to learn when the material is not so well known that they are bored, so difficult that they can't possibly understand it, and/or irrelevant to them (Kornell & Metcalfe, 2006). Given that all the participants were taking this class, it's safe to assume that it was within their region of proximal learning. The content covered in this lecture would also be included in the final exam for the course, providing students with an extra incentive to pay attention because they would be graded on it later in the semester.

Breaks

The breaks consisted of a one-minute box-breathing exercise also known as the "four-square breathing" technique. One round involves four exercises that alternate at a four count, namely inhaling, holding the air in the lungs, exhaling, and holding the lungs empty. The breaks were edited into the lecture video and played without requiring any intervention from the participant. At the scheduled break time, a screen appeared alerting participants that a break was about to begin, and then participants were led through the one-minute box-breathing exercise.

Everyone took a break, but at two different times, thus creating two experimental conditions. Participants in condition 1, henceforth referred to as Group 1, got a break approximately 10 minutes into the lecture. We chose 10 minutes because although there is not a consensus on the average length of student attention span (a proxy for neural fatigue), the extant literature suggests that it is around this time (Johnstone & Percival, 1975; Bunce et al., 2010; Wammes et al., 2017; Fenesi et al., 2018; Forrin et al., 2021). Participants in condition 2, henceforth referred to as Group 2, got a break approximately 30 minutes into the lecture. We chose 30 minutes into the lecture to increase the practicality of the intervention; we reasoned that it would be easier to convince instructors to segment the lecture into 30-min sections as an intervention, compared to 10-min segments. Further, having breaks at two different times allowed for each Group to serve as a comparison for the other allowing for the break no-break comparison; the impact of each break could be assessed by looking at performance differences between the two Groups just after the break.

Learning outcomes

Memory for lecture material was assessed using a 40-question (33 MCQ, 7 Fill-in-the-blank) comprehension test administered immediately following the lecture. To assess the impact of the breaks on subsequent learning episodes we looked at performance on questions immediately after the breaks. We defined “immediately after” as three questions following the break (i.e. Qn 14, 15, 16 for Group 1 and Qn 33, 34, 35 for Group 2) because they corresponded to about one minute, meaning all participants who just took a break should have high attention during that period.

Procedure

Upon arriving in the lab, participants were briefed on the broad purpose of the study and signed the consent form. They were informed that they would be watching a lecture on a topic they will be covering later in the course and to expect to be asked to take a break at some point in the lecture. Participants were also told about the comprehension test they would take upon completion of the lecture. Figure 1 provides a schematic of the experimental design. Participants were then randomly assigned to Group 1 (N= 47) and Group 2 (N=47). To control for any effects of time of day we had two participants in each condition at each trial.

Student performance was assessed by a comprehension test administered immediately after the lecture. The test questions were formulated by the researchers based on the lecture content. To reduce ceiling and floor effects, we ran a pilot study N=27 and adjusted the questions that 1) all or almost all participants got right by making them a little more difficult and 2) all or almost all participants got wrong by making them a little easier. The whole experiment lasted for about an hour.

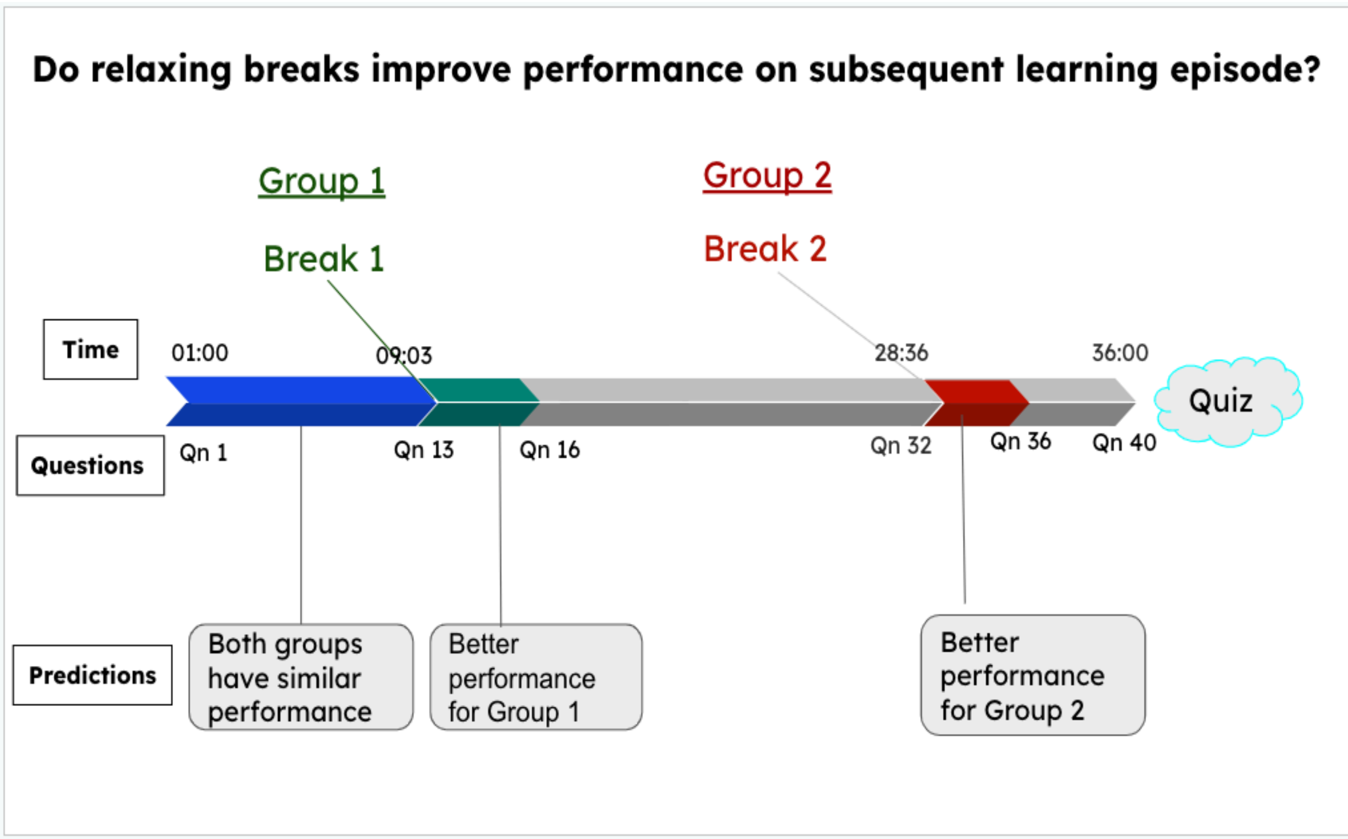

Figure 1: Experimental design. The lecture was 36-min long. Group 1 got a break at around 10 minutes into the lecture whereas Group 2 got it around 30 minutes. Quiz testing memory for lecture material was administered immediately after watching the lecture.

Results

Learning outcomes prior to break intervention

As a manipulation check, we wanted to make sure there was no difference in group performance on the baseline questions where neither group had taken a break. We used a t-test and plotted two bars indicating the mean and the standard error of the performance in the two groups for each question (see Figure 2). The bars are generally close to each other indicating that there is no group difference as expected, an observation confirmed by the t-test; $t(95)= 0.972$, $p=0.331$.

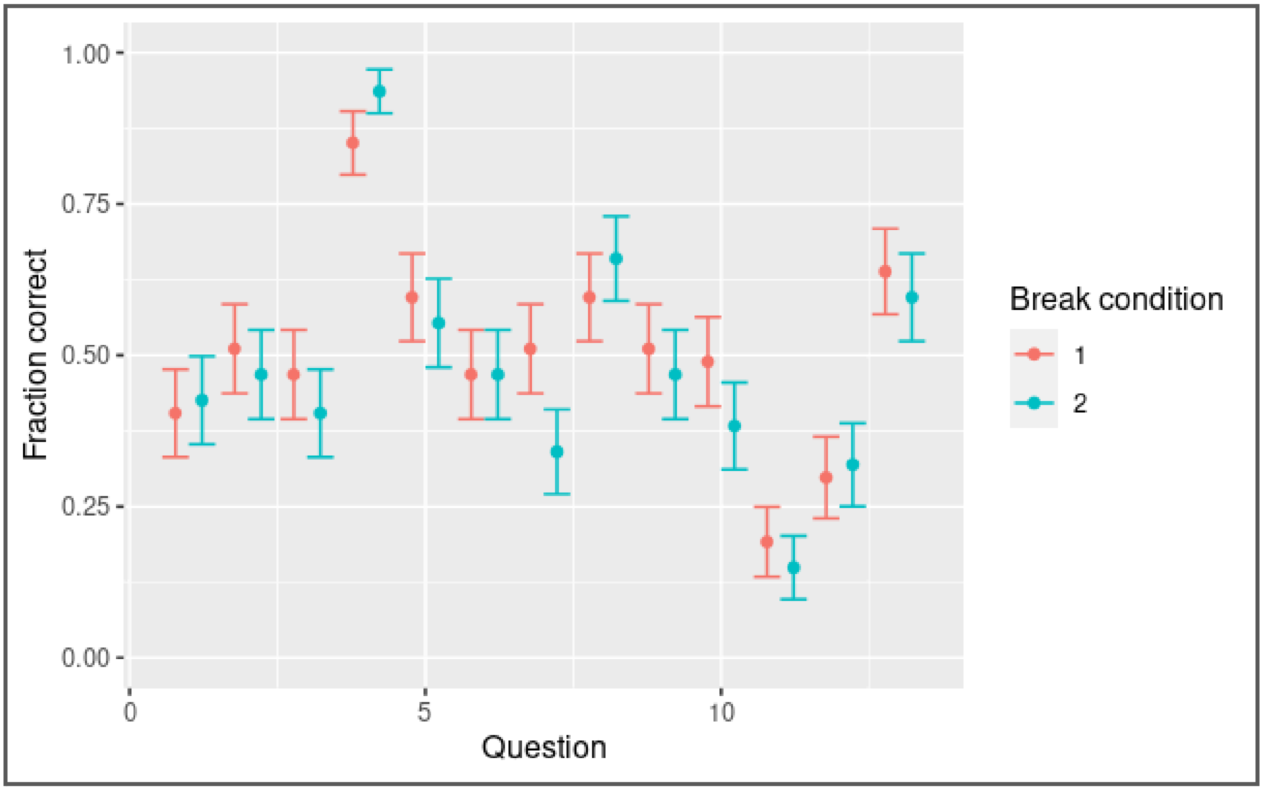

Figure 2: For the section where no one had taken a break, there was relatively similar performance between groups.

Learning outcomes-Break 1

We were first interested in whether a break early (~10 min) in the task would benefit subsequent memory for Group 1 measured by questions immediately after the break (i.e. Qn 14, 15, 16). Contrary to our hypothesis, we did not see any statistically significant differences between the groups; t(45)= 0.684, p=0.494 (see Figure 3).

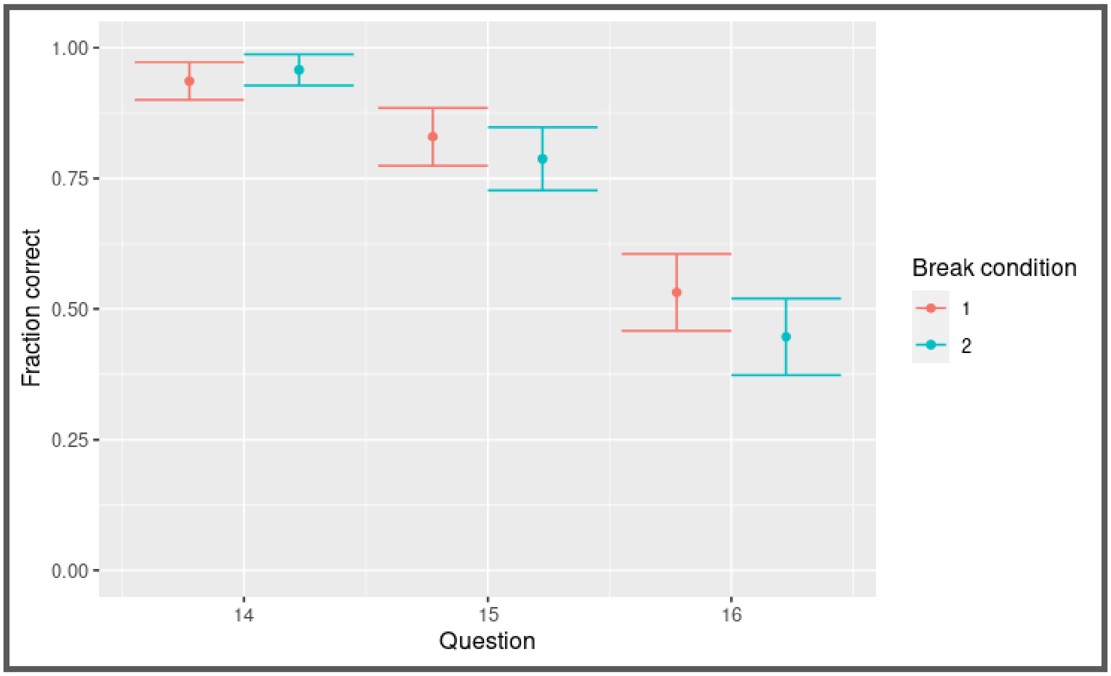

Figure 3: Group-1 and Group-2 performance immediately after break 1. There was no significant impact of the break.

Comparing High-Performers and Low-Performers–Break 1

Next, we looked at whether break 1 impacted low and high performers differently. To categorize Group 1 into high and low performers we used the average baseline score before neither group had taken a break (i.e. performance on Questions 1-10). Here, the baseline score was calculated from the first 10 questions and not 13 questions to avoid an overlap between the baseline score and the pre-break and post-break difference measure for Group 1. To find out the differential effect of the intervention on performance, we averaged their performance immediately following the break (Qn 14-16) subtracting their performance on questions preceding the break (Qn 11-13). In order to show how this baseline performance relates to group 2 (the no-break comparison) we subtracted out the mean baseline score for group 2. We then ran a linear regression, B=-0.33, t(45)=2.72, p=0.23. There was no statistical relationship between baseline performance and the impact of break 1 on Group 1 (see Figure 3).

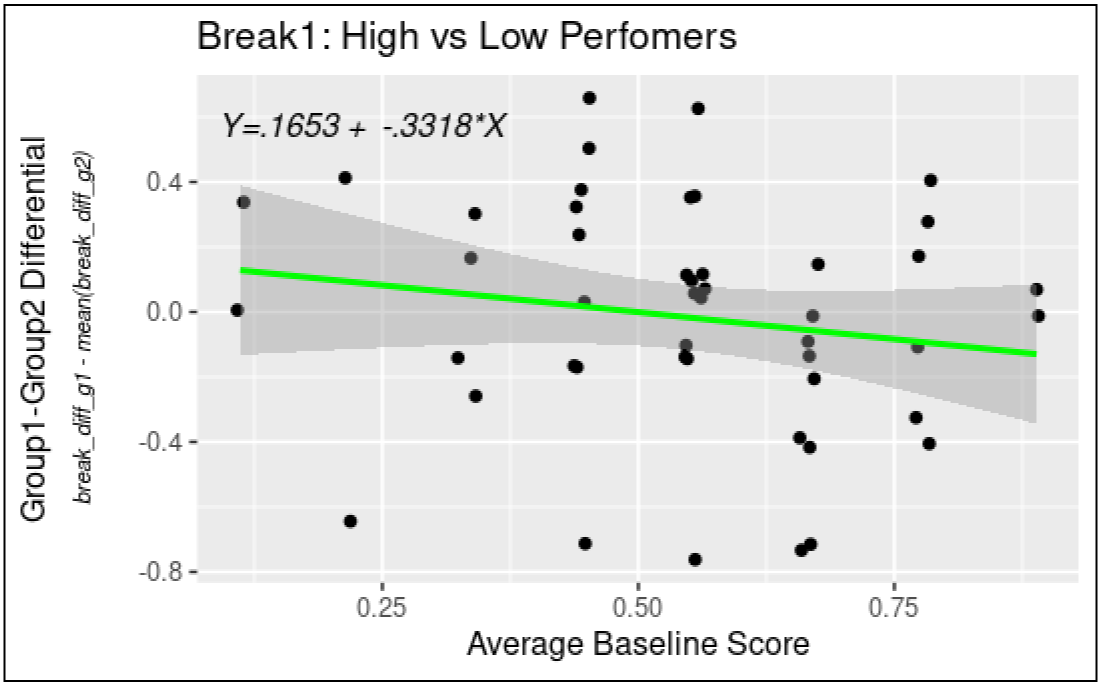

Figure 3: Comparing the impact of break 1 on high and low performers. There was no statistically significant difference in the performance of low and high performers following the break.

Learning outcomes-Break 2

We then examined whether a break 30 minutes into the lecture would benefit subsequent memory for Group 2 also measured by questions immediately after the break. (i.e. Qn 33, 34, 35). There was no overall significant group difference when we averaged performance on the three questions, $t(45)$=t = -0.37, p=0.71. However, Group 2 performed significantly better than Group 1 on one of the questions Qn35$\Rightarrow$ $t(45)$=-2.51, p=0.01 (see Figure 4), and the effect persists even after correcting for multiple comparisons using the Bonferroni correction.

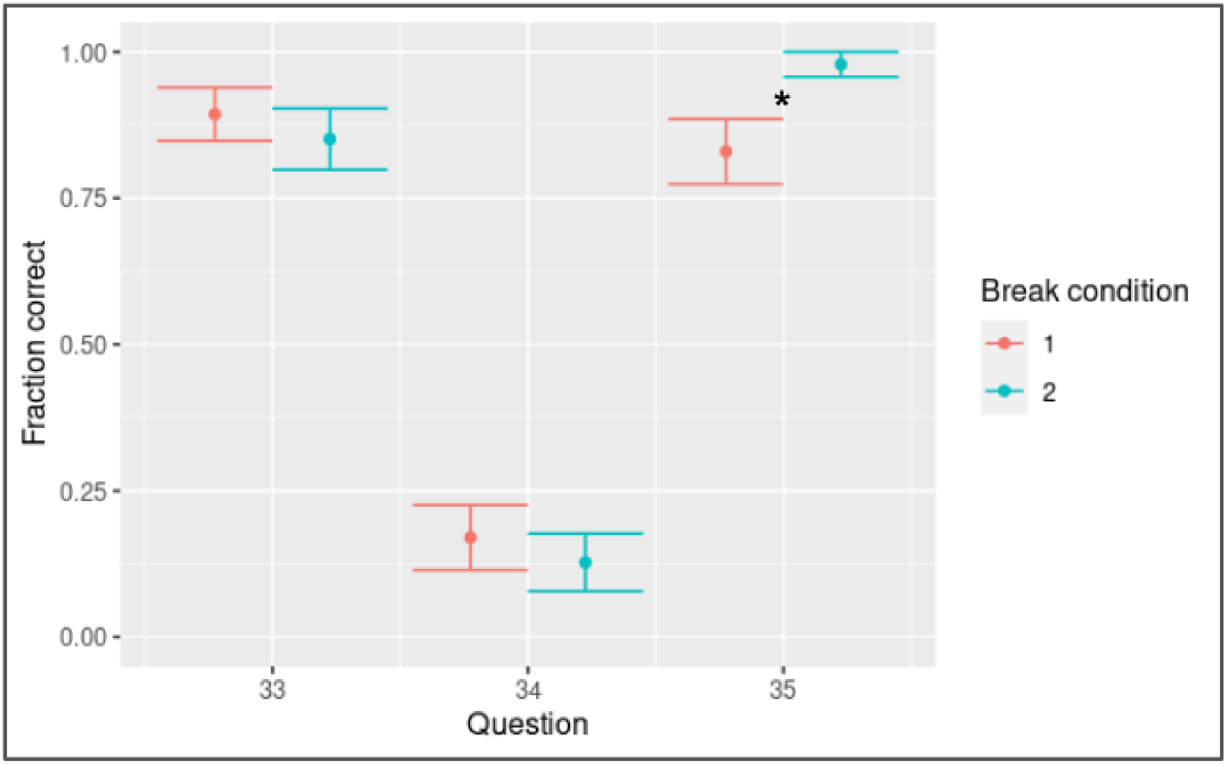

Figure 4: Group-1 and Group-2 performance immediately after break 2. Group 2 performed significantly better on one question, Qn 35, with relatively similar performance on the other two.

Comparing high and low performers–Break 2

Next we tested whether break 2 impacted low and high performers differently. To categorize Group 2 into high and low performers we used the average baseline score before neither group had taken a break (i.e. performance on Questions 1-13). To find out the differential effect of the intervention on performance, we averaged their performance immediately following the break (Qn 33-35) subtracting their performance on questions preceding the break (Qn 29-32). In order to show how this baseline performance relates to Group 1 (the no-break comparison) we subtracted out the mean baseline score for Group 1. We then ran a linear regression analysis which revealed a statistically significant slope; B=0.5845, t(45)=2.719 p=0.009, showing that the impact of the break 2 on Group 2 was positive for high performers and negative for low performers relative to the no-break condition in Group 1 (see figure 5). Specifically, the 95% confidence interval for the impact of the break was entirely positive for baseline scores greater than 0.72 and entirely negative for baseline scores less than 0.28. So, higher performers benefited from the break while lower performers were hurt by the break.

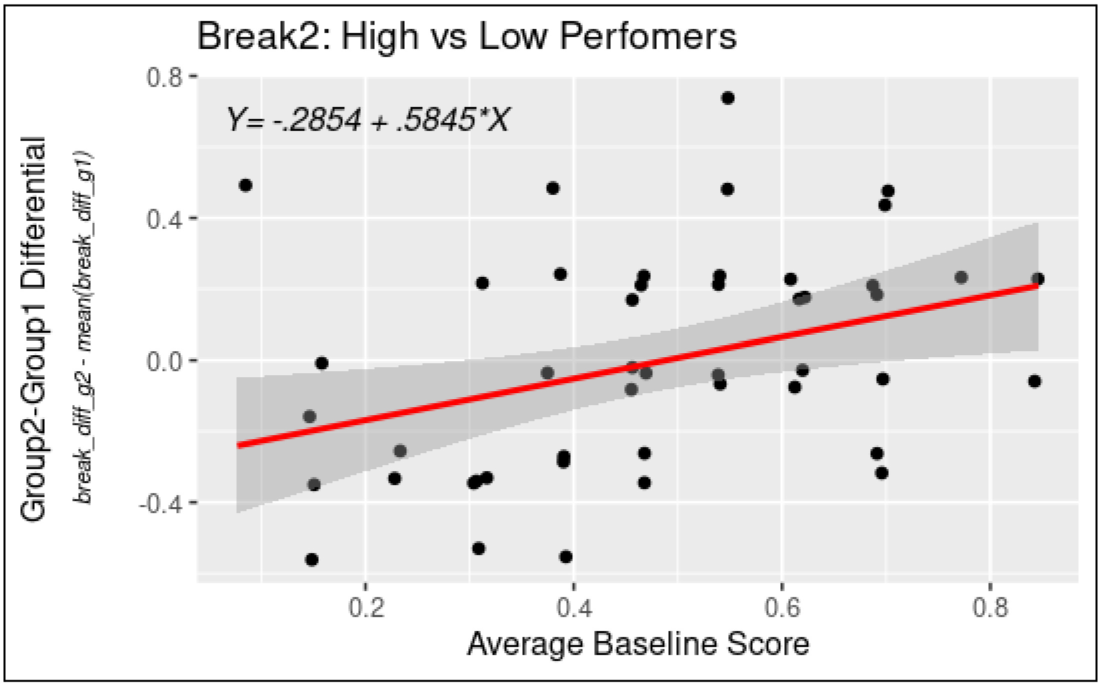

Figure 5: Comparing the impact of break 2 on high and low performers. The performance of high performers improved while that of low performers decreased following the break.

Discussion

The present study showed some evidence that incorporating relaxing breaks in video-recorded lectures can improve student performance. Specifically, there was a slightly superior performance associated with the break given in the latter part of the lecture compared to the null effect obtained from the break earlier in the lecture. While inconsistent with our hypothesis that both breaks would improve performance on the subsequent questions, this result is consistent with the broader predictions of both the neural fatigue hypothesis and goal habituation theory. The neural fatigue hypothesis posits that there is a continuous reduction in available cognitive resources during a given cognitive task. And, by extension, predicting that the greatest benefit of breaks would coincide with the latter parts of the lecture in which the resources are most depleted. The goal habituation theory also predicts greater benefits for the break later in the lecture because the longer the time on-task the higher the possibility of habituating to the goal of the main task.

A question remains of why the break 10 minutes into the lecture did not have a significant impact despite the growing studies estimating the average student attention span (a proxy for neural fatigue) to be around 10-min (e.g. Johnstone & Percival, 1975; Bunce et al., 2010; Wammes et al., 2017). Could it be that students do not habituate or deplete attention resources that quickly such that 10 minutes is not a relevant threshold at least for certain lectures? A study by Risko et al. (2011) examining the rate of student attention lapses in the form of mind-wandering using lectures from three different courses (i.e. psychology, economics, and classics), found an across-lecture variation. They found the highest mind wandering rates in the classics lecture, least in the economics lecture, and intermediate amounts in the psychology lecture. This may partly explain the inconsistency of our results with the aforementioned studies as they used lectures from different courses such as Chemistry (e.g. Johnstone & Percival, 1975; Bunce et al., 2010; Wammes et al., 2017). Secondly, it could also be that other kinds of breaks or longer breaks would be more effective at alleviating the strain incurred by the neural network involved in lecture learning and thus have more detectable effects. More work is needed to investigate these unanswered questions.

To better gauge the efficacy of the breathing breaks as well as other kinds of breaks, future studies could use brain imaging techniques such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). It would help in identifying the exact brain regions involved in processing the lecture material as well as those involved in attending to the break task. This is crucial because the efficacy of a given break depends on the extent at which it is supported by neural networks that are non-overlapping with those utilized during learning (Tulving & Rosenbaum, 2006). That is, it is important to establish that the break task is indeed acting as a cognitive break rather than a second cognitive task, as switching between two cognitive tasks has been shown to deplete attention and impair performance (Rogers & Monsell, 1995, Wylie & Allport, 2000). This is especially relevant because there seems to be some, although weak and inconclusive, evidence pointing towards break 2 impairing performance before becoming beneficial. That is, the impact of break 2 did not take effect until a few moments later (Qn 35) contrary to immediately after (Qn 33 and Qn 34). In fact, although insignificant, Group 2 who had just taken a break performed numerically worse on Qn 33 and Qn

34 than Group 1. Additionally, break 2 hurt the performance of low performers, further suggesting that the break task might have acted as a second cognitive task at least for some individuals.

The differential impact of break 2 on low and high performers showed the opposite trend than we had anticipated. Contrary to our hypothesis from the goal habituation theory that the breaks would be most beneficial for low performers, their performance actually suffered a decline following break 2. This could have been due to the issue discussed above, namely the break acting as a second cognitive task as opposed to a cognitive break for low performers. It leaves the question, however, of why this was not the case for high performers. A more plausible explanation is that low performers could have had more difficulty understanding the material and exerted a lot more cognitive resources to stay on task such that a one minute break was too short to have any significant impact in restoring the depleted resources. This interpretation is consistent with Helton & Russell (2012) findings that brief mental breaks are not effective at preventing lapses of sustained attention in highly demanding cognitive tasks.

On the other hand, high performers may have found the material relatively easy to understand and needed not to expend much cognitive resources to stay on task. That is, while the perceptual load of the lecture was the same for both groups, the cognitive load of the lecture was subject to individual differences in cognitive capacities with high performers likely to perceive it as a low cognitive load and low performers as high cognitive load. Compared to high cognitive load tasks, vigilance to low cognitive load tasks (e.g. monotonous tasks) have been shown to benefit from brief mental breaks (Manly, 2008). From the goal habituation theory viewpoint, this also makes sense as easy (vs. difficult) tasks are easier to habituate to such that a brief task switch would reactivate the goal of the main task. Additionally, low performers generally struggle with attention control (Unsworth et al., 2012), and as such may have been struggling with paying attention from the very beginning. On the contrary, high performers likely had the needed resources to pay attention and were struggling to stay focused on only one goal for a prolonged period of time, an issue that could be fixed by a brief switch to another task and then back to the main task, providing a potential explanation for the post-break 2 boost for high-performers.

Future research can use 1) measures of perceived mental workload and feelings of mental exhaustion to test whether high performers indeed report low scores compared to low performers and 2) brain imaging techniques to see if the scores correlate with blood flow to areas necessary for maintaining vigilance (Shaw et al. 2009, 2012). It's been shown that the rate of vigilance decrement is proportional with the declines in cerebral blood flow to brain regions such as the anterior cingulate cortex (ACC), right prefrontal cortex, right inferior and parietal regions, and the thalamus (Hitchcock et al. 2003; Lim et al. 2010; Shaw et al. 2009, 2012). If low-performers are expending more resources than high performers, therefore, we would expect to see less activity in the relevant regions.

It's worth testing the above hypothesis, indeed, given the emerging evidence that video-recorded lectures may be widening the achievement gap by enhancing the learning outcomes of high performers while reducing that of low performers. For instance, in a study where students were randomly assigned to either a live lecture or watching the same lecture live streamed online, they found higher performance in in-person vs online lectures, a result that was particularly strong for lower-achieving students (Fligio et al., 2013). Using the same experimental design, Caucult et al., 2021 found that attending lectures via live streaming lowers and increases performance for low-ability and high-ability performance respectively. In another study examining the effects of flipped classroom instruction, Setren et al. (2021) found that low-achieving students as measured by ACT scores experienced no significant effects while their high-achieving peers experienced significant positive gains. And, Le Kein (2022) found that pre-recorded lectures reduced the outcome of low-performing students while they had no effect on high-performing students. Understanding the neural mechanisms driving these differences, therefore, would be critical in finding interventions that address the unique needs of different groups of students.

One of the main strengths of the present study is that we used authentic course materials. This said, however, many limitations sprung up from this fact. First, for the questions to better reflect a typical comprehension test they were of varying difficulty. This could have undermined or mute the effects of the breaks in the case that the majority of post-break questions were harder than pre-break questions for some participants. It also made it challenging to do within-group analyses examining whether there was an improvement in performance given the difficulty in parsing apart the contribution of the break from that of the difference in post-break (vs. pre-break) question difficulty level. Second, all the participants in our study were taking an introductory psychology course, however, they differed in reasons for taking the class ranging from being prospective psychology majors to fulfilling a science requirement. Past literature has shown that higher levels of intrinsic motivation to learn are correlated with higher concentration levels during learning (Dweck et al., 2003; Bester & Brand, 2013). It's unclear from our study that this had a significant effect on performance. However, to get an even less contaminated effect of the break intervention, future studies may use a sample with similar reasons for taking the target class.

Lastly, one of the greatest variabilities in student attention arises from differences between instructors (Bradbury, 2016). Although this does not disqualify the evidence that relaxing breaks improve attention, it may be a major contributing factor to the obtained results. Future research should examine the extent to which the effectiveness of relaxing breaks in improving attention varies with different instructors. Along the same vein, future studies may evaluate whether the obtained effect is replicable across different courses especially in the light of Risko et al. 's (2011) findings showing a significant across-lecture variation in student attention lapses. Taken together, these studies suggest that reaping the benefits of interventions aimed at improving student attention may require careful customization to the course in question.

In summary, the present study adds onto the growing effort to use cognitive psychology research to enrich education experiences (e.g. Metcalfe & Kornell., 2007). It provides some evidence that relaxing breaks can improve student attention during video-recorded lectures, thereby providing an important step towards finding effective interventions to sustain the ever-shortening student attention spans. In particular, it shows that taking brief cognitive breaks benefits high-performing students but worsens the performance of low-performers. From this result, we recommend a substantial degree of caution when introducing classroom interventions because even well-meaning interventions may result in unintended consequences such as widening the performance gap between low and high achieving students.

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