Divided Attention: How Sleep Deprivation and the Testing Effect Interact with Divided Attention

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Distractors are everywhere, which means full attention can be hard, if not impossible, to achieve. Distractions lead to divided attention, which is commonly known to decrease memory and performance. In addition to that, a lack of sleep can also lead to a decrease performance. Students, especially college students, are commonly trying to perform multiple tasks, such as studying for a test while attending a lecture, or trying to perform a single task with multiple distractors, such as reading their textbooks in a crowded library with their phones besides them.

Since divided attention and sleep deprivation is common, studies have been conducted in order to find out the full scope of their effects. In addition to that, there have been studies on divided attention and the testing effect. The testing effect has been shown in previous studies to encourage memory retrieval, which leads to better performance.

Combining all of these factors can lead to an effective studying pattern that students can utilize in order to have the best performance, despite divided attention and sleep deprivation. Teachers and schools could also benefit from this information.

Literature Review

Divided Attention and Sleep Deprivation

Many people study while listening to background music, and some have their phones with them. Even those who attempt to study in complete silence by going to the library will undoubtedly still have distractors whether it’s the person next to them or background noises. In addition to that, many students are sleep deprived due to all-nighters and other environmental factors such as work.

Middlebrooks, Kerr, and Castel (2017) and Chua, Feng, and Gooley (2017) both found that distractors, no matter how cognitively demanding, result in similar performance levels. Middlebrooks et al.'s (2017) study was created in order to see how distractors and divided attention affect people's ability to remember information. They hypothesized that lesser distractors will have smaller costs, which means those distractors will be less of an impediment to memorization.

The distractor of this experiment was background music. The conditions were familiar background music and unfamiliar background music. In addition to the music, there was one condition, the divided attention, where participants would hear a list of digits while they studied (Middlebrooks et al., 2017). In total, there were four different conditions: full attention, divided attention, familiar music, and unfamiliar music.

Experiment 2 was created in order to address the divided attention task in Experiment 1. In this experiment, instead of numbers, attention was divided using different tone-detection tasks. Using tone-detection would take away the possibility that the number task was too complicated and that contributed to the lower recall performance in that condition. (Middlebrooks et al., 2017).

Middlebrooks et al. (2017) discovered that even though participants in divided attention and distractor conditions exhibited lower recall performance, there was no difference between the divided attention conditions. Experiment 2 also showed that the distractor conditions had lower recall performances than the full attention condition, but there were not any notable differences between the tone-detection conditions. This suggests that the distractor type does not matter, and the cost of low and high distractors are the same.

As mentioned before, students are usually sleep deprived as a result of pulling all-nighters in order to study or to finish their assignments. Even though they are sleep deprived, students are still expected to finish all their responsibilities, which may cause them to multitask. Chua et al. (2017) conducted a study in order to find the effect of sleep deprivation and divided attention on performance.

Participants in the Chua et al. (2017) study had to maintain a fixed sleep-wake schedule the week before. Participants then stayed in the research facility for four days. There was no natural light or anything that participants could have used to tell time. In order to eliminate the learning effect on performance, participants underwent an orientation to study the procedures of the tasks.

Every two hours, participants would complete three 5-minute task blocks. The first block was a single task, which consisted of an auditory task. Participants would press a button whenever they heard an even number called. The second block was a dual task, and in addition to the auditory task, participants would have to press a button every time a square target changed its color to orange. The third block was a triple task, and the square target would move. Participants had to track the movement of the square while also fulfilling the previous tasks (Chua et al., 2017).

The study discovered that the response times for the dual and triple task were similar to each other, and both were slower when compared to the single task regardless of time since wake. This is unsurprising as divided attention leads to poorer performance. Errors performed during the tasks were primarily false negatives. Sleep deprivation was shown to have an effect on divided attention as well. The response times for the triple task was slower than the dual task only when subjects where sleep deprived. (Chua et al., 2017).

Divided Attention and the Testing Effect

The testing effect has been shown to be an effective method to learn information. In previous studies, it has been found that participants who are given a test after they are presented with the material perform better on the final memory test compared to participants who restudy the material (Buchin & Mulligan, 2017). The second experiment was designed to "better equate secondary task performance across the restudy and retrieval conditions" of Experiment 1 (Buchin & Mulligan, 2017). Experiment 3 sought to equate performance on the digit-classification task across retrieval and restudy conditions.

The first experiment used 60 weakly associated pairs of words, which were split into four sets. There were four conditions, full attention retrieval, full attention restudy, distracted attention retrieval, and distracted attention restudy (Buchin & Mulligan, 2017). Each participant would go through three phases. Phase 1 was when participants encountered all of the possible words. There were no distractors during this phase. The second phase is when the four conditions came into play. Participants in the full attention blocks had no distractors. Those in the distracted attention conditions heard four extra words and were told to sort the words into natural or man-made by pressing the appropriate buttons. The restudy condition showed the participant both words from the pair. Participants in the retrieval conditions were given the first word and encouraged to recall the second word out loud. Experiment 2 and 3 of this study were similar to Experiment 1, but the latter experiments had different distractors and secondary tasks.

In the first experiment, the testing effect was greater in distracted attention conditions. In the restudy condition, the effect of the distractor was greater when compared to the retrieval condition. As expected, the performance of those in the distracted attention condition was lower than the full attention condition. However, the retrieval conditions, no matter if it was full

attention or distracted attention, had higher results in Phase 3. In fact, the results were very similar to each other.

Experiment 2's results were similar to Experiment 1. The testing effect was also present during this experiment. However, participants' performance on the distractor task was equivalent between conditions. This experiment also showed that while verbal tasks often impact memory retrieval significantly, the verbal task in this experiment only produced a small decrease during Phase 2 (Buchin & Mulligan, 2017).

The last experiment showed increased performance compared to Experiment 2, which is mainly due to the changes to the secondary task. Once again, this experiment showed the testing effect. Generally, the testing effect was larger in the distracted condition than the full attention condition (Buchin & Mulligan, 2017). Those in the full attention condition performed better than those in the distracted condition.

Discussion

Limitations

Reductionist Limitation

All three studies did not account for different social or environmental factors. Different backgrounds and habits may have resulted in different results. For instance, a musician would have had an easier time with the tonal secondary task in Middlebrooks et al.'s (2017) study compared to somebody who is not familiar with music. All of the studies adopted a reductionist viewpoint and assumed that everybody would have the same or similar cognitive functions.

Demographic Limitations.

Going along with the lack of social and environmental representations, the study by Chua et al. (2017) only had male participants, which means there is a potential confound. Males and

females are physically different, so having female participants could have shown different results. The other two studies also did not account for gender differences as well.

In addition to that, two of the studies had few participants, and the few participants also came from similar areas geographically, which could have resulted in a lack of generalizability. Adding more participants can help generalize the results across the nation and even to different countries.

Extraneous Distractors

None of the studies besides the one by Chua et al. (2017) provided an in-depth description about the participants' environment during the study, which means there could have been other possible distractors. For instance, some people can get distracted by the sounds of a ticking clock or by the room itself.

Future Studies and Conclusion

It is widely known that distractors lead to a decrease in memory. However, as shown with the results from first study, the complexity of the distractor does not matter much as the performance will remain the same despite the difference in complexity (Middlebrooks et al., 2017) In addition to that, the second study also showed that the second and third task had the same performance despite the increase in distractors (Chua et al., 2017). The testing effect was more prominent in the divided attention condition compared to full attention (Buchin & Mulligan, 2017).

The first and second study discovered that performance was similar despite the different distractors. This could imply that since our resources are limited, distractors can impact performance so much. This brings up the question of where is the limit or breaking point in our performance. In other words, can somebody who has hundreds of distractors and still have the

same performance level as somebody who only has one distractor? In addition to that, perhaps there would be a difference in performance if the distractors competed for the same resources as the main task more. In the first experiment of the first study, participants would hear numbers while they tried to memorize words (Middlebrooks et al., 2017). If participants heard an audiobook instead of numbers, would their performance have changed? Numbers and words are different, so an audiobook may have a different impact on performance.

Many students go to lectures but end up becoming distracted by their laptops or phones. However, the lecture is still in the background. Connecting the results of the studies together, if students were tested after each lecture, would their performance and memory retrieval be better than students who just come to lectures and leave? Despite the complexity of the distractors, performance should be relatively similar, so students who are distracted by technology or by other schoolwork should still remember the same amount from the lecture. Even if students were sleep deprived, their performance would be similar despite the distractors as well. By implementing a small quiz or test after classes, teachers could potentially increase memory retrieval and performance.

In addition to that, perhaps students can study for two classes at a time and still have good performance. Since two studies have shown that different types of distractors have the same performance level, students can work on an assignment for one class while playing a recording of a lecture from another class. At the end, students could have a quiz on both classes in order to boost memory retrieval. Subsequently, Buchin and Mulligan (2017) discovered that the testing effect was larger in the distracted attention condition, which means the testing effect would be higher if students listen to a lecture while doing an assignment.

The study by Buchin and Mulligan (2017) mentioned how there were no distractors during the first phase, the studying phase. However, finding the effect on distractors during the studying phase versus distractors during the retrieval or restudying phase may be beneficial, especially since students are probably distracted at both phases normally.

More studies on divided attention can help us get closer to figuring out how attention really works. Furthermore, it can help students strategize and find a better studying plan in order to get higher grades. It can also help teachers form lesson plans and activities. All in all, divided attention is something that is common in our society, especially with the use of technology, so learning how to work around it will be beneficial to everybody.

References

Buchin, Z. L., & Mulligan, N. W. (2017). The testing effect under divided attention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *43*(12), 1934-1947. doi:10.1037/xlm0000427

Chua, E. C., Fang, E., & Gooley, J. J. (2017). Effects of total sleep deprivation on divided attention performance. *Plos One,* 12(11). doi:10.1371/journal.pone.0187098

Middlebrooks, C. D., Kerr, T., & Castel, A. D. (2017). Selectively Distracted: Divided Attention and Memory for Important Information. Psychological Science, 28(8), 1103-1115. doi:10.1177/0956797617702502

Abstracts

The testing effect under divided attention

Memory retrieval often enhances later memory compared with restudying (i.e., the testing effect), indicating that retrieval does not simply reveal but also modifies memory representations. Dividing attention (DA) during encoding greatly disrupts later memory performance while DA during retrieval typically has modest effects— but what of the memory-modifying effects of retrieval? If these effects are similar to study-based encoding, they should be greatly disrupted by DA, a possibility consistent with elaborative and effortful accounts of the testing effect. Alternatively, the mnemonic consequences of retrieval may be largely resilient to distraction, like retrieval itself. In 3 experiments, participants studied word pairs (Phase 1) then engaged in restudy of some pairs and retrieval of others (Phase 2), followed by a final cued-recall test (Phase 3). Phase 2 restudy and retrieval occurred under full attention (FA) or DA. The experiments were designed to induce either material-specific (Experiments 1 and 2) or material-general (Experiment 3) interference, as well as to produce comparable secondary task performance between the restudy and retrieval groups (Experiments 2 and 3). Consistent with prior research, retrieval improved final recall (i.e., the testing effect) whereas DA disrupted final recall. Critically, the 2 factors interacted such that the negative effect of DA on final recall was substantial in the restudy condition but quite modest in the retrieval condition—resulting in a larger testing effect in the DA than FA condition. The encoding effects of retrieval seem resilient to distraction which has implications for theories of the testing effect.

Effects of total sleep deprivation on divided attention performance

Dividing attention across two tasks performed simultaneously usually results in impaired performance on one or both tasks. Most studies have found no difference in the dual-task cost of

dividing attention in rested and sleep-deprived states. We hypothesized that, for a divided attention task that is highly cognitively-demanding, performance would show greater impairment during exposure to sleep deprivation. A group of 30 healthy males aged 21±30 years was exposed to 40 h of continuous wakefulness in a laboratory setting. Every 2 h, subjects completed a divided attention task comprising 3 blocks in which an auditory Go/No-Go task was 1) performed alone (single task); 2) performed simultaneously with a visual Go/No-Go task (dual task); and 3) performed simultaneously with both a visual Go/No-Go task and a visually-guided motor tracking task (triple task). Performance on all tasks showed substantial deterioration during exposure to sleep deprivation. A significant interaction was observed between task load and time since wake on auditory Go/No-Go task performance, with greater impairment in response times and accuracy during extended wakefulness. Our results suggest that the ability to divide attention between multiple tasks is impaired during exposure to sleep deprivation. These findings have potential implications for occupations that require multi-tasking combined with long work hours and exposure to sleep loss.

Selectively Distracted: Divided Attention and Memory for Important Information

Distractions and multitasking are generally detrimental to learning and memory. Nevertheless, people often study while listening to music, sitting in noisy coffee shops, or intermittently checking their e-mail. The current experiments examined how distractions and divided attention influence one's ability to selectively remember valuable information. Participants studied lists of words that ranged in value from 1 to 10 points while completing a digit-detection task, while listening to music, or without distractions. Though participants recalled fewer words following digit detection than in the other conditions, there were no significant differences between conditions in terms of selectively remembering the most valuable

words. Similar results were obtained across a variety of divided-attention tasks that stressed attention and working memory to different degrees, which suggests that people may compensate for divided-attention costs by selectively attending to the most valuable items and that factors that worsen memory do not necessarily impair the ability to selectively remember important information.