The Effects of Smartphone Breaks on the Cognitive Function of Sleep-Deprived High School Students

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ABSTRACT

The following study investigates the relationship between smartphone breaks and an increase in cognitive function for sleep-deprived high school students. A quantitative method using the Pittsburgh Sleep Quality Index, Stroop test, and reaction time test collected data on 37 students from a Northeastern Illinois high school. Students were administered a three-minute smartphone break in the middle of their class period to see if it had any effect on their performance on the reaction time and Stroop test. The results suggest that there was no significant relationship between smartphone breaks and an increase in cognitive function for sleep-deprived students. It was also concluded that there was no significant difference between the effects of smartphone breaks on sleep-deprived and adequately rested high school students. Theoretical and practical implications of the results were discussed, for example, teachers could enforce stricter cellphone policies in schools and improve mental breaks for their students by not allowing phones during a mental break.

Introduction

Sleep deprivation is a widespread issue around the globe. Multiple studies emphasize its crippling existence, especially in high school students. The American Academy of Sleep Medicine "recommends teens ages 13-18 years receive 8-10 hours of sleep per night" (Jackson & Cooper, 2020). A survey given out to seniors in high schools around Seoul, Korea determined that on average they slept 6.4 hours a day (Shin et al., 2003). Jackson and Cooper (2020) did a similar study on Rhode Island high school students, concluding that 1 in 4 students receive five or fewer hours of sleep a night. Sleeping less than the recommended amount causes sleep deprivation which is common among adolescents. This prompts some sort of solution to sleep deprivation. Smartphone breaks are a recent development for cognitive purposes but completely unexplored for sleep deprivation.

Literature Review

Causes of Sleep Deprivation

Some studies blame cell phones as the main culprit of sleep deprivation. Focus groups with middle school nurses and teachers reflected this belief with one participant stating, "The biggest thing generationally that I see is the addiction to the computer and the addiction to communicating with cell phones. They [kids] just can't go to sleep" (McCabe, 2011). Another study from the Indian Journal of Health and Well-being agrees, concluding from a series of questionnaires that social media and streaming are the primary reasons for sleep deprivation (Khemka et al., 2020).

On the other hand, the same study also found that over a third of respondents felt education pressure contributed to their sleep deprivation (Khemka et al., 2020). More studies suggest that school structure and academic requirements cause sleep deprivation in students. Estevan and colleagues (2021) did a study on how a mid-term test affected

Uruguay university students' sleep. On average, students delayed their bedtime by an hour the night before a test, even when it did not start till 1:15 pm. Tests and other educational pressures cause high school students to become sleep deprived which points fingers at school as a main cause of sleep deprivation. However, school and cell phones both likely cause sleep deprivation.

Effects of Sleep Deprivation

There are multiple negative consequences of sleep deprivation on cognitive function. Cognitive function is "the ability to process information and make decisions under conditions of divided attention" (Lowrie & Brownlow, 2020). Insufficient sleep affects cognitive function by leading to deficits in "memory verbal fluency, mental flexibility, logical reasoning, and executive functions" (Kiriş, 2022) and increasing reaction time (Patrick et al., 2017). Reduced reaction times detrimentally impact performance in competitive sports and the ability to drive (Patrick et al., 2017), which many high school students partake in. This is further seen in Lowrie & Brownlow's (2020) comparative study on sleep deprivation and alcohol's effect on driving on young adults. The study found that sleep deprivation negatively impacted their reaction times and lateral control of the vehicle. There is also a negative correlation between sleep deprivation and academic performance (Khemka et al., 2020), which is assumed to be caused by the negative cognitive effects of sleep deprivation.

There are also negative physical effects of sleep deprivation. A study from BMC Public Health had adolescents fill out surveys on their sleep patterns and calculated their body mass indexes. Short sleep duration was significantly associated with a higher prevalence of obesity and overweight adolescents in Bangladesh (Anam et al., 2022). Sleep deprivation has also been found to increase systolic blood pressure in university students after one night (Patrick et al., 2017).

Finally, many studies have discovered adverse mental effects from sleep deprivation. A study done by Pransh Khemka and others (2020) on young adults in Mumbai determined that average hours of sleep affected factors, such as "unreasonable sadness, lack of concentration, irritable nature, and anxiety". Sleep deprivation has a plethora of adverse effects across the human body. These negative effects of sleep deprivation institute some kind of solution, which can be seen in mental breaks.

Mental Breaks and Their Effects on Cognitive Function

Some studies and school districts have implemented mental breaks into the school day to reduce fatigue in students. A study from the University of Bem in Switzerland studied the effects of varying levels of physical exertion and cognitive engagement in mental breaks on primary school students. High cognitive engagement in breaks increased mathematics performance, but high cognitive engagement and high physical exertion in a mental break improved one out of the three executive functions (Egger et al., 2019). This suggests that a break involving something cognitively stimulating, like a smartphone, would improve cognitive function.

On the contrary, Steinborn and Huestegge (2016) did a similar study comparing the effects of active and passive rest on young adults, discovering that rest was beneficial to task performance, but found no difference between active and passive rest. Similarly, Kang and Kurtzberg (2019) did a study that compared the effects of different kinds of media during a mental break. The study revealed that cell phone breaks resulted in the same levels of cognitive depletion as taking no breaks, but interestingly, those with a break on the computer screen performed better after the mental break. Although a cell phone was used in this study, the beneficial effect of computer screens is evidence that a screen would improve cognitive function. The support for mental breaks, in general, being cognitively beneficial also supports smartphones.

Effects of Smartphone Use

Despite this, smartphones have been shown to have adverse health effects. A study done on patterns of phone usage and its impact on medical students revealed that students who use their phones for five or more hours a day faced effects like "increased eye strain, headache, irritation without phone, ring anxiety, neck pain, and car ache" (Kasulkar et al., 2022). In agreeance, a study focusing on the ocular health of university students discovered that eye redness correlated with prolonged use of smartphones but was found to be statistically insignificant (Issa et al., 2021).

However, cell phones have controversy surrounding their cognitive effects. A study done by Martjin Arns and others (2007) discovered that heavy phone users performed better on a word interference test similar to the Stroop test. The Stroop test was created "to measure selective attention and cognitive flexibility" (Siyami et al., 2023). This suggests that those who heavily use their phone perform better cognitively than those who do not and a smartphone break would produce the same result. A study from the Journal of Fundamentals of Mental Health has contradictory results, finding that extreme mobile phone users had a reduction in their attention, focus, and memory (Siyami et al., 2023). Unlike both studies, a study on primary school students and the effects of cordless versus mobile phones on cognitive function discovered that there was little evidence of a consistent association between mobile phone or cordless phone use with cognitive outcomes (Redmayne et al., 2016). Overall, there is a lot of conflicting evidence of whether phone breaks improve cognitive functioning or not, but there is some evidence that supports it would improve cognitive function.

Value

To reiterate, there are multiple negative consequences of sleep deprivation on cognition, such as increased reaction time (Patrick et al., 2017), which impacts performance in competitive sports and the ability to drive (Patrick et al., 2017). There is also a negative correlation between sleep deprivation and academic performance (Khemka et al., 2020). Suppose smartphones counteract some of the negative cognitive effects that sleep deprivation has on a student. In that case, the value of the study would be the use of smartphone breaks to improve cognitive function, and hence daily life, such as driving capability, sports, and academic performance.

Gap and Question

Due to the lack of consensus over the cognitive effects of smartphones, over-saturation of studies done on university students, and minimal research on the use of smartphones as a break, there is a major gap in this research field of psychology. Since there are detrimental physical, mental, and cognitive effects of sleep deprivation, it is crucial to study ways to offset these effects. With cell phones being readily available and showing promise in improving cognitive function, it is worth understanding this relationship by answering the question, "How do smartphone breaks impact the cognitive function of sleep-deprived high school students in Northeastern Illinois?"

Method

Hypotheses

There were two hypotheses in this study. Hypothesis 1 of this study was that a smartphone break would improve cognitive function. Hypothesis 2 was that a smartphone break's beneficial cognitive effects are more defined right after the break versus minutes later.

Population

The high school students were selected via random sampling of the teachers in a Northeastern Illinois high school. All of the teachers had their names entered into an online randomizer that was spun once. The teacher selected was sent an email debriefing the study and asking for their participation. They were asked to conduct the study with all the classes they taught during the day. The teacher chosen was a social studies teacher who taught every grade throughout the day. The teacher distributed the online parental and participant consent forms to all their students, which were returned to the researcher before the study began.[1] There were 37 participants in total.

Instrument & Measures

One instrument used was the Pittsburgh Sleep Quality Index (PSQI) to determine if students were sleep-deprived.[2] It was used in a study about excessive daytime sleepiness and sleep quality in medical students associated with smartphone and internet addiction and was described as “an effective self-rating instrument used to measure the quality and patterns of sleep” (Sathe et al., 2021). It contains ten questions, each scored on a zero to three Likert scale. The PSQI is internally consistent and reliable, causing it to be used in other studies, such as a study on smartphone addiction and its effects on sleep quality among nursing students in West Bengal (Ghosh et al., 2021). This made the PSQI a credible way to measure sleep deprivation in this study. It was important to measure sleep quality because high amounts of sleep did not always correlate to quality sleep. The test was used with the previous sleep recommendation from The American Academy of Sleep Medicine. Students revealed how many hours of sleep they got a night and if it was less than eight hours then they were considered sleep-deprived. If they got more than eight hours of sleep, the rest of the PSQI would be used to determine their sleep quality and if they could still be considered sleep-deprived.

The PSQI looks at sleep habits during the past month, so some questions were modified to apply to this study. The study asked students about their sleep patterns every day and the amount of sleep they got each night instead to get more precise data. This created some questions such as: “How many hours of actual sleep did you get last night?” instead of, “During the last month, how many hours of actual sleep did you get at night?” Some questions were completely omitted in the research study, such as, “During the past month, how often have you taken medicine to help you sleep?” The institutional review board did not approve nor are researchers allowed to ask about the medical history of participants. Therefore, the score was determined out of 18 instead of 21. Scores that are equal to or more than 12 were considered sleep-deprived since this indicated an average score of three, which leaned towards sleep deprivation.

The second test used was the Stroop test, originally “created in 1935 by Ridley Stroop to measure selective attention and cognitive flexibility” (Siyami et al., 2023). The test consists of a series of color names and the participant must state the color that the text describes.[3] Each color name is in a different colored font than what the text is describing, which forced cognitive attentiveness from the participants. Multiple studies have used the test to measure cognitive function. For example, in a study on sleep deprivation's effects on cognitive and physical performance in university students, one of the tests administered to measure cognitive performance was a version of the Stroop test in the form of charts (Patrick et al., 2017). Another study on executive function measures associated with frequent mobile phone use used a word interference test, which was equivalent to a Stroop test to measure executive function (Arns et al., 2007). These studies using the Stroop test to measure cognitive performance gave a valid reason for the test to be the primary way to measure cognitive function.

A reaction time test was also used to measure cognitive function in this study. The same study by Patrick and researchers (2017) also included a reaction time test to measure cognitive performance in their method in the form of a ruler drop test. Nurcihan Kiriş (2022) looked at the effects of partial sleep deprivation on prefrontal cognitive

[1] See Appendices A and B for the Consent Forms

[2] See Appendices C and D for the PSQI and Scoring Rubric

[3] See Appendix E for the Stroop test

functions in adolescents and used a computerized reaction time interval test to measure processing speed. The reaction time test used in this study was also a computerized version that had participants sit at a red screen.[4] The screen would switch to green, where then students had to click on the screen as fast as possible. The screens in Kiriş's study were all standardized as participants did their testing with the same computers at the university. To emulate this, students did all of their tests on their Chromebooks provided by the school to also standardize the device in case of latency in response times from different devices. Due to multiple studies using reaction time tests when measuring cognitive function, it had to be included in the study.

Procedure

The research study was conducted over three days. The teacher was sent two Google Forms each day with all the tests on each form. Each day, participants completed a form at the beginning and end of class. The teacher was also sent a video to show the participants how to complete the form. The class was instructed to go on as normal when students were not taking the tests.

Day 1 was purely a control group where cognitive function should not change from the beginning to the end of class because no smartphone break was administered. On Day 1, the participants completed the first form at the start of the class period.[5] The PSQI was asked first for all of these beginning-of-class forms. There were three questions asked only on the first day of the study because the questions were about habits throughout the month. Therefore, these answers would have been the same if asked repeatedly. After completing those questions, participants completed a computerized reaction time test by humanbenchmark.com that was linked at the top of the Google Form. The participants measured their reaction times for three trials and put each time into the form. The times were averaged to prevent any mishaps or oddities while taking the test. After the reaction time section, participants took an online Stroop test by memorize.link, which was also linked at the top of the form. They had to identify as many colors as possible within 60 seconds, recording their questions attempted, correct, and wrong in the form. Their accuracy percentage on the task was calculated since there was no upper limit on how many questions the students could answer so using a percentage was a universal means of comparing scores. They also took the same form at the end of class, excluding the PSIQ questions because questions such as, "What time did you go to bed last night?" would not change during the class period.

Day 2 was the experimental group that aimed to determine if a smartphone break would increase cognitive function. This tested for Hypothesis 1, meaning a smartphone break decreased reaction time and increased accuracy on the Stroop test. On the second day of the study, students answered a similar Google Form as the first day, excluding the three previously mentioned questions from the PSQI.[6] Halfway through the period, the teacher provided the students with a three-minute smartphone break where students were encouraged to use their smartphones. The smartphone break was three minutes due to a study by Siyami and colleagues (2023), which suggested that on average, students spend six out of 15 minutes distracted by the internet. This concluded that anything under six minutes, like three minutes, was more optimal for productive use, making smartphone usage more likely to be cognitively beneficial. Another study done by Michael Steinborn and Lynn Huestegge (2016) looked at the relationship between rest breaks, cognition, and self-control. Their method had participants taking a three-minute walking break or watching an education video for three minutes. Not only is three minutes for a break optimal for productive results but a similar study also set their breaks for the same amount of time, justifying the length of the smartphone break in this study. After the break, participants continued with class until the end of the period where they took the same end-of-class form as the first day.

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[4] See Appendix F for the Reaction Time Task

[5] See Appendices G and H for Day 1 Forms

[6] See Appendices H and I for Day 2 Forms

Day 3 of the study was identical to Day 2 except that the end-of-class form was taken right after the smartphone break.[7] Day 3 was used to see if time after the smartphone break affected its cognitive benefits, therefore testing Hypothesis 2. This meant that Day 3 should have higher decreases in reaction time and increases in accuracy on the Stroop test than Day 2. The data in this study was purely quantitative, so to analyze the data, a two-sample t-test was used to find the p-values of comparisons between each day. This meant averages and standard deviations were calculated. This study found average differences in reaction times from the beginning and end of class forms and average differences in accuracy percentage on the Stroop test from the beginning and end of class forms for each day.

Results

Population

According to Shin and colleagues (2003), students sleep 6.4 hours a day on average. This suggests that most students would be sleep-deprived and this study's findings supported this idea. On Day 1 of the study, 32 students were sleep-deprived while five had adequate sleep. On Days 2 and 3, 30 students were sleep-deprived compared to seven who were not, which the literature review supports since a majority of students were sleep-deprived.

Reaction Times

Table 1. Average Differences in Reaction Times for Sleep-Deprived Students. Note. Positive averages are a decrease in reaction time and negative averages are an increase in reaction time.

	DAY 1	DAY 2	DAY 3
AVG DIFF RT (ms)	13.61	0.29	9.59
STDEV	39.32	35.00	45.82

Table 2. Reaction Time P-Values for Sleep-Deprived Students

	DAY 1-2	DAY 1-3	DAY 2-3
P-VALUE	0.916	0.644	0.193

Hypothesis 1 was that sleep-deprived students would have quicker reaction times once they received a phone break rather than not. The average difference between reaction times at the beginning and end of class on Day 1 was a 13.61-millisecond decrease in reaction time. This was only the control group, so the average difference should have been closer to zero. The average difference between reaction times on Day 2, the day with a smartphone break, was a 0.29-millisecond decrease. This contradicts Hypothesis 1 since the phone break was supposed to decrease reaction time by a farther margin than the day without a phone break. The two-sample t-test between the average differences of Day 1

[7] See Appendices H and I for Day 3 Forms

and Day 2 was 0.916. P-values greater than 0.05 reveal no statistical significance. Therefore, the data is insignificant and likely to be caused by chance.

Day 3 also had a phone break, so it was compared to Day 1 to test Hypothesis 1. The average difference in reaction times on Day 3 was a 9.59-millisecond decrease while Day 1 had a 13.61-millisecond decrease. This contradicts the hypothesis once again since Day 1 quickened its reaction time more than Day 3 even though there was no smartphone break on Day 1. A two-sample t-test between these averages produced a p-value of 0.644, ultimately making this finding statistically insignificant and unreliable.

Hypothesis 2 was that the effects of the phone break would be more effective directly after the break than later. This was tested with a comparison between Day 2 and Day 3 since Day 2 had students take the reaction time tests at the end of class while Day 3 had students take their reaction time tests right after the break. The average difference in reaction time for Day 2 was a 0.29 millisecond decrease while Day 3 had a 9.59 millisecond decrease in reaction time average. This does support the hypothesis since the millisecond decrease was much more drastic on Day 3. The two-sample t-test between both averages produced a p-value of 0.193. Although this was much lower than other p-values in this experiment, the data is still insignificant and unreliable.

Stroop Tests

Table 3. Average Differences in Accuracy Percentage on Stroop Test for Sleep-Deprived Students

	DAY 1	DAY 2	DAY 3
AVG DIFF %	2.62	-1.48	-0.22
STDEV	10.85	4.00	4.30

Note. Positive averages are a decrease in reaction time and negative averages are an increase in reaction time.

Table 4. Stroop Test P-Values for Sleep-Deprived Students

	DAY 1-2	DAY 1-3	DAY 2-3
P-VALUE	0.974	0.911	0.122

Hypothesis 1 was also that sleep-deprived students would perform better on the Stroop test when they received a phone break rather than not. Day 1 had an average increase of 2.62% from the beginning of class to the end. This value should be closer to zero because no phone break was administered that day. Day 2 had a 1.48% decrease which contradicts the hypothesis since Day 2 was a day a phone break was administered, and it caused a decrease in accuracy on the Stroop test. A two-sample t-test between Day 1 and Day 2 produced a p-value of 0.974, which is way over 0.05. Therefore, the results of the data are insignificant.

Day 3 also had a phone break administered so it should also be compared to Day 1 under Hypothesis 1. The average difference between the percentage correct for the beginning and end of class on Day 1 was a 2.62% increase while Day 3 had a 0.22% decrease. This again contradicts the hypothesis since the smartphone break should increase the accuracy percentage. The two-sample t-test made a p-value of 0.911, making this finding insignificant and most likely caused by chance.

Hypothesis 2 was that the effects of the phone break would be more effective directly after the smartphone break than later. This would mean the percentage correct should increase more right after the break rather than several minutes after the phone break. This was tested by comparing Day 2 and Day 3; Day 2 had students take the Stroop test at the end of class while Day 3 had them take it right after the smartphone break. Day 2 had a 1.48% decrease while Day 3 had a 0.22% decrease. This somewhat supported the hypothesis because although neither day increased the accuracy, Day 3 decreased the percentage marginally less than Day 2, supporting the hypothesis. The two-sample t-test revealed this finding to be statistically insignificant though since the p-value is 0.122.

Sleep Deprivation versus Adequate Sleep

Table 5. Average Differences in Reaction Times for Not-Sleep-Deprived Students

	DAY 1	DAY 2	DAY 3
AVG DIFF RT (ms)	41.53	3.10	-15.76
STDEV	80.45	22.82	59.28

Note. Positive averages are a decrease in reaction time and negative averages are an increase in reaction time.

Table 6. Reaction Times P-Values for Sleep-Deprived versus Not-Sleep-Deprived Students

	DAY 1	DAY 2	DAY 3
P-VALUE	.243	.600	.161

Table 7. Average Differences in Accuracy Percentage on Stroop Test for Not-Sleep-Deprived Students

	DAY 1	DAY 2	DAY 3
AVG DIFF %	-0.44	-0.40	-0.79
STDEV	1.91	3.23	5.33

Table 8. Stroop Test P-Values for Sleep-Deprived versus Not-Sleep-Deprived Students

	DAY 1	DAY 2	DAY 3
P-VALUE	0.500	0.768	0.400

Although the study was initially only going to evaluate sleep-deprived subjects, data was also collected from students who were not sleep-deprived. It was beneficial to compare the data from each separate day between both populations to find nuances. Comparing sleep-deprived and adequately rested students on Day 1, sleep-deprived students had an average decrease in reaction time of 13.61 milliseconds from the beginning and end of class while not sleep-deprived students had a 41.53 millisecond decrease.[8] Interestingly, sleep-deprived students had a 2.61% increase on the Stroop test while not-sleep-deprived students 0.44% decrease on the Stroop test. Both cognitive tests contradicted each other which is supported by the p-values of 0.243 and 0.5 for both tests on Day 1, making this data insignificant.

Furthermore, analyzing Day 2 for both groups, it can be observed that sleep-deprived students had a 0.29 millisecond decrease in reaction time while adequately rested students had a 3.1 millisecond decrease. Sleep-deprived students had a 1.48% decrease in the Stroop test while not-sleep-deprived students had a 0.4% reduction. This suggested that adequately rested students cognitively benefitted more from smartphone breaks than sleep-deprived students, but the two-sample t-test had both p-values over 0.05, once again indicating that the data was insignificant.

Finally, on Day 3 sleep-deprived students had a 9.59 millisecond decrease in reaction time while not-sleep-deprived students had a 15.76 millisecond increase. Sleep-deprived students had a 0.22% decrease while not-sleep-deprived students had a 0.79% decrease on the Stroop test. This suggested that a smartphone break's effects are more beneficial right after the break for sleep-deprived students rather than for those with adequate rest. The p-value for the reaction time test was 0.161 and 0.4 for the Stroop test, meaning that this finding was also insignificant.

Discussion

Overall, the data from the research study did not support any of the hypotheses due to their insignificance and unreliability. The scores on both the reaction time and Stroop test were most likely caused by chance and did not relate to smartphone breaks, as shown by the p-values from the two-sample t-tests. Nonetheless, the average difference in reaction times for Day 1 proved to be a greater decrease than Day 2 and Day 3, contradicting Hypothesis 1 that a phone break would quicken reaction time. This agreed with a study by Siyami and colleagues (2023), which found that extreme mobile phone users had a reduction in their attention, focus, and memory. Both studies showed a detrimental effect on cognitive function from smartphone use. Day 3 did have a significantly higher decrease in reaction time than Day 2, which does support Hypothesis 2 that a smartphone break's cognitive benefits are most effective directly after the break. This finding was still insignificant though due to phone breaks suggesting to be detrimental to reaction times and the p-values exceeding 0.05.

The Stroop test had much of the same result with an average difference in accuracy percentage for Day 1 being a greater increase than Day 2 and Day 3. This contradicted Hypothesis 1 that a smartphone break makes students more accurate on the Stroop test. This finding disagreed with Martjin Arns and colleagues (2007) who discovered that heavy phone users performed better on a word interference test similar to the Stroop test. The study suggests that phone use increases performance on the Stroop test but days with smartphone breaks made students less accurate. Day 3 had a significantly less decrease in accuracy than Day 2 which somewhat supports Hypothesis 2. Regardless, the p-values were too large to make the data significant.

[8] See Table 1 & 2 for Day 1 Results of Sleep-Deprived Students

New understandings were explored by examining the differences between the sleep-deprived and not-sleep-deprived populations. On Day 1, sleep-deprived students had a smaller decrease in reaction time but a higher increase in accuracy on the Stroop test than not-sleep-deprived students. On Day 2, sleep-deprived students had lower decreases in reaction time and smaller increases in accuracy. On Day 3, sleep-deprived students had a higher decrease in reaction time and a smaller decrease in accuracy. These findings were once again shown to be insignificant due to the large p-values from the two-sample t-test. Overall, all the data from this study was found to be insignificant which is similar to Redmayne and colleagues' (2016) discovery that there was little evidence of a consistent association between mobile phone use with cognitive outcomes.

Conclusion

Overall, there was no significant relationship found between phone breaks and cognitive function in the form of reaction times and accuracy percentages on the Stroop test shown by the p-values from the two-sample t-tests. The conclusions of this study were limited due to confounding variables, such as caffeine consumption and intense physical activity. Unclear instructions and people who did not fully complete the experiment also limited the study by forcing the researcher to omit their data. This led to a limited sample size which is a potential reason for the insignificance of the data. As a result, it is suggested that future researchers sample equal amounts of sleep-deprived and not-sleep-deprived participants so the data can be less likely to be caused by chance. Future research should also identify participants who have consumed caffeine or been through rigorous physical activity before the research study to isolate the smartphone break as the variable affecting cognitive function.

Limitations

One limitation was the limited sample size. The population came from one Northeastern Illinois high school with 1,355 students. The random sampling method selected one teacher from the school and all of the classes that they taught. Although this teacher taught multiple grade levels throughout the day, the majority of the classes consisted of freshmen or sophomores. There were teachers in the school who had a more representative class and taught more classes than the selected teacher for this research study.

Another limitation is that several participants had their data omitted for several reasons. This included students who did not fully complete all three days of the study. Students who also did not fully complete the form or answered in a nonsensical manner were not included in the data. Some mistakes in the forms, such as putting in PM instead of AM for a wake-up time, were fixed and assumed for them. One student did not give a specific number for how many minutes it took them to fall asleep and another answered "all" when asked how many questions they attempted on the Stroop test even though there was no limit to the number of possible attempts. These types of mistakes where assumptions could not be made had to be omitted from the data.

All of these limiting factors led to a sample size of 59 being cut down to 37. Quantitative studies usually require thirty to forty participants to produce significant data. Although this goal was reached, this sample size is smaller compared to other studies in this field of inquiry. For example, Tracy Jackson and Tara Cooper (2020) did a study on sleep deprivation in Rhode Island's high schools which had 1,613 participants. Another study on the effects of sleep deprivation on cognitive and physical performance in university students had 64 participants (Patrick et al., 2017). The limited sample size is a potential reason for the insignificance of the data, therefore limiting the generalizability of the study's findings.

Implications

The value of this study was to increase the overall cognitive function of students, which would include their reaction times. Slow reaction times from sleep deprivation diminish sports performance and driving capability (Patrick et al., 2017), which would be improved if there was a positive relationship between smartphone breaks and cognitive function. Sleep deprivation also has a negative correlation to academic performance (Khemka et al., 2020). If the hypotheses of the research study were supported, smartphones would improve cognitive function and therefore academic performance. However, there was no significant relationship between smartphone breaks and cognitive function. This finding would be beneficial to educational settings where phones are not permitted because teachers can now enforce a stricter policy on cellphone use since there seems to be no cognitive benefit to them. This can also help improve the quality of mental breaks when teachers provide them during class. They should discourage the use of cell phones during mental breaks and instead have students engage in a break with high cognitive engagement and high physical exertion to improve cognitive functioning (Egger et al., 2019).

Future Directions

A study from Nutritional Neuroscience found that energy drinks can "maintain mood and performance during fatiguing and cognitively demanding test batteries" (Smit et al., 2004). Due to this finding, it is possible that participants' reaction times and scores on the Stroop test were influenced by energy drinks. Another study on physical activity's effect on cognitive function for adults discovered that physical activity boosted processing speed (Kekäläinen et al., 2023). This suggests that participants who had physical education or morning practice for a sport before participating in the study would score higher on the cognitive tests. This would be another confounding variable in my research that should be addressed by future researchers in the form of a question asking about caffeine consumption and physical activity to identify the affected participants. This will allow the researchers to omit their data or separate them into a different population to analyze.

The insignificance between the sleep-deprived and not sleep-deprived participants may be due to the low population size for the not sleep-deprived population. The sleep-deprived students consistently made up over 80% of the sample. There were five to seven not-sleep-deprived students, which was not a large enough sample size to draw conclusions. The disparity between the two populations makes the data of the not-sleep-deprived population more likely to be caused by chance. Future researchers should avoid this by randomly sampling an equal amount of sleep-deprived and not-sleep-deprived participants instead of randomly sampling a population since most students are sleep-deprived (Shin et al., 2003).

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