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The Effects of Sleep Deprivation and the Consumption of Caffeine on High School Students' Academic Performance in Surabaya, Indonesia

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ABSTRACT

Sleep deprivation, commonly defined as sleeping less than the recommended eight or nine hours, is increasingly receiving attention as accumulating adolescents from aged 12-19 experience sleep loss (Loessl et. al., 2008). From then until now, those who have valued their work over their sleep, as they make up for their sleep loss from their weekdays to their weekends (Loessl et. al., 2008), have been affected by people's cognitive functions. In particular, standards for academic background have risen, resulting in the inevitable academic pressure upon students, especially high school and college students, who are working their way up to universities and colleges or jobs and internships. For example, Shur-Ken Gau and Wei-Tshen Soong (1995), who strived to investigate the cause and effect of the increasingly sleep deprived high school students in Taipei, reports that students in higher grade levels have increasingly less sleep because of the joint entrance examination (JEE) they have to pass to get into college. Although people under 15 may be sleep deprived, because sleep decreases with increasing age (Loessel, 2008), this paper will focus on the data of high schoolers that are above age of 15.

INTRODUCTION

To endure the pressure to sleep, adolescents generally consume caffeine for cognitive enhancement when finishing tasks. Because caffeine is a legal stimulant that is accessible to adolescents, the average intake of caffeine was "3.2 ± 2.0 mg/kg/day," which is more than research prior to this paper found (Bernstein et al., 2002, p. 3). Due to the accumulation of caffeine consumption, adolescents may undergo various effects that could potentially hinder their studies. Research on adults reveals that long term effects may prove to be harmful for the cognitive function, even if it may be satisfactory for a short period of time for the cognitive state (Nehlig, 2010). By connecting and comparing research conducted in the past supplies further understanding of the effects of sleep deprivation in relation to the consumption of caffeine, perhaps providing a general correlation between the former and the latter on adolescents and their studies; however, despite the countless studies that seem to have been gaining interest in the sleep deprivation of high school students, nearly no studies have went on to measure the effects of caffeine consumption on high school students after sleep deprivation, typically on analyzing the direct measure on their studies. Examining the effects on high school students is imperative as biological processes come into play. The fact that the majority of research focuses on adults arises the need to identify the effects on the less commonly studied group from which the question driving this study appear: How does sleep deprivation and the consumption of caffeine affect high schools students, typically in the age of 15 to 19, on their academic performance in Surabaya, Indonesia?

LITERATURE REVIEW

Before the discourse on the specific effects that affect high school students' studies, it is vital to examine the general impact of sleep deprivation and the consumption of caffeine yield. Even though the academic performance of high school students can be affected in many ways, as sleep deprivation and the chronic consumption may affect an individual's health and generate extreme, unfavorable thoughts ultimately hindering his/her learning (Meldrum & Restivo, 2014), those variables are beyond of the scope of this paper, which will focus on the more direct perspective, the cognitive function. It is also essential to analyze multiple sources regarding those effects as although the consensus is the decline in cognitive functions, the specific results differ from each study as the measure, type, and length of the motor task may affect the result (Pilcher & Huffcutt, 1996, p. 319). In regards to their cognitive performance, three significant and most studied aspects to investigate are working performance, memory, and mood.

In general, researchers Xue Ming et. al. (2011) at the Department of Neurosciences and Neurology, sought to understand the effects of sleep deprivation on high school students, whom only 33.7% surveyed had adequate sleep on the weekdays. The results showed that the lack of sleep leads to a superimposed circadian disadvantage, which intensifies the ability of high schoolers to fall back into their normal sleep cycle, ultimately hindering their academic performance as their school grades went down (Ming et. al., 2011). Similarly, research conducted in Taipei supported that claim by reporting that the JEE high school students studying for long hours showed a negative correlation between sleep and performance. In conclusion from the two studies, it is in concordance that students elicited an increase in complaints and sleepiness during daytime and showed a decrease in academic performance (Gau & Soong, 1995; Ming et. al., 2011). Following the effects of sleep deprivation, highlighting the general effects of consumption of caffeine after sleep deprivation on their studies is essential; however, there are no studies found that suggest those direct analysis, so looking at three factors would be necessary in order to deduce and imply to answer the research question.

Working Performance

Working performance refers to the extent to which one can perform cognitive tasks; the variables that require to measure working performance are primarily alertness and vigilant attention. Alertness and attention remain stable when on normal waking days, or in sufficient sleep; however, when it hits 16 hours of sleep loss, there seems to show "a substantial slowing of reaction time (RT) and worsening of performance accuracy on tests of psychomotor vigilance" (Killgore, 2010, p. 106). Furthermore, psychomotor vigilance decreases as the length of a task increases, also known as the 'time-on-task effect,' which is exacerbated by sleep deprivation (Killgore, 2010, p. 107). Yet, that is not to say that the sleep deprived individuals apply no effort. In a study conducted by researchers Pilcher and Walters (2010), sleep deprived individuals were reported to have expended more effort than the non-deprived participants even if their performance was worse. This report not only justifies the worsening of alertness and vigilant attention but also provides a further understanding of why this topic should be studied as students are forbidding sleep because they believe they are making progress when empirical results show otherwise.

Because of such drawbacks, adolescents generally consume caffeine to improve their cognitive functioning; however, the short-term and long-term effects reveal contrasting results. The short-term effects primarily concern the alleviation of the detriments on alertness and attentiveness when sleep deprived. Attention and alertness are alleviated in low doses of caffeine when anxiety is reduced and concentration is improved. In contrast, high doses may alternatively cause "anxiety, nervousness, and jitteriness" as it "increases tense arousal" (Nehlig, 2010, p. 88). More specifically, Lieberman et. al. (1987) with the Department of Brain and Cognitive Sciences and the Clinical Research Center and the Department of Applied Biological Sciences found that "caffeine at all doses, even the lowest (32 mg), significantly improved performance on the modified [visual] vigilance test" (p. 310). Although the consumption of caffeine at all doses may be questionable, it is deducible from these two studies that caffeine improves attentiveness at low doses and may impair at high doses.

Albeit such benefits, long-term effects, regarding prolonged sleep latency, may prove harmful. Sleep latency, typically used when attributing the effects of sleep deprivation, refers to the duration in which an individual goes from fully awake to sleep. But, quite often, caffeine has "a larger and more persistent effect on the ability to stay awake" (Kelly, 1997, p. 399), which may have a greater impact on leading individuals to prolonged sleep latency even if they may use it for the intended purpose of staying awake. Although many researchers strived to investigate the sleep latency after caffeine consumption, only a few went deeper to examine the effects of prolonged sleep latency caused by caffeine. Prolonged sleep latency can lead to delayed sleep phase disorder (DSPD), the "biologically mediated shift in sleep timing with a predisposition to a later sleep-wake cycle" (Kansagra, 2020, p. 205), as not being able to sleep for a longer period of time predisposes the circadian rhythm. Even though DSPD is investigated from the effects of sleep deprivation with pubertal onset, caffeine can induce more delay in the circadian rhythm as it prolongs sleep latency, ultimately deteriorating the capability to which people can go back to a normal sleep cycle. Because with less sleep comes exacerbated working performance, even if the short-term effects of caffeine on performance may prove beneficial, it is pertinent to account for the long-term effect.

Memory

Concerning academics, memory is needed not only for answering questions in tests but also for applying learned materials to any given task. Logically, as alertness and vigilant attention are impaired, it is virtually impossible to encode any materials as sleep is needed to not only consolidate new materials but prepare the brain to effectively retain them (Killgore, 2010, p. 116). In the findings of researchers Waters and Buck (2011), although there are varying results regarding short-term memory, there seems to be a general consensus that sleep loss negatively affects memory as it decreases response time and accuracy. To effectively obtain data on the impact of sleep deprivation on memory, researchers used an fMRI scan when testing the participants' memory retention. The scan displayed that "the sleep-deprived group showed significantly less activation of the posterior hippocampus relative to the normally rested group," indicating that sleep deprivation adversely affects the hippocampus, where the memory forms (Killgore, 2010, p. 117). Not to mention, positive and neutral memories were disrupted compared to the normally slept group who encoded both types (Killgore, 2010, p. 118). The hardship to encode materials into the brain, especially emotionally positive and neutral words, will, without doubt, hinder the learning process.

As sleep deprivation diminishes the ability to encode new information, whether or not caffeine aids memory retention should be investigated. According to Alhaider et. al. (2010), who aimed to explore the effects of spatial short term memory on sleep deprived and caffeine consumed rats, although chronic treatment of caffeine on sleep deprived rats showed prevention of short-term memory, the chronic treatment on normal rats showed no significant effect (p. 439). Spatial short-term memory may not be as useful to determine students' academic performance; however, it does provide telling evidence of whether or not caffeine may help prevent the deletion of memory. Results from research conducted on humans show that caffeine facilitates memory to a limited extent inconsistently. Furthermore, caffeine only serves if "energetic supplies increase up to a certain level, beyond which it may deteriorate" (Nehlig, 2010, p. 87). These are all to say that caffeine most likely isn't going to foster or even detriment high school students' academic performance, especially when the work is heavily memory dependent.

Mood

The mood is negatively affected by sleep deprivation which many concur in the research field. However, according to Pilcher and Huffcutt (1996), although the mood was significantly affected, the decrement in mood only played a marginal effect on performance. Despite this study, another claimed that the increased hours of sleep loss contributed to the increase in hostility towards others. Moreover, individuals were less willing to solve problems in given tasks

(Kahn-Greene, 2006). While mood may be the most indirect out of the three factors in affecting adolescents' studies when in hostility, academic performance is only obliged to decline. Furthermore, as stated before, mood plays a role in memory as sleep deprived individuals are inclined to encode only emotionally negative words. The most important factors to account for in mood are disorders such as anxiety and depression. When depressed, minimal work gets done, and when anxious, insomnia can worsen. All these factors in the end affect students' academic performance as less systematic thinking takes place in a poor mood.

Caffeine's effect on mood also elicits varying results. According to Nehlig (2010), the mood is shown to change the most in the late morning when consumed in minimal amounts as "negative mood impact [is] associated with over-arousal" (p. 88). The more fatigue an individual is, the more positive mood changes he/she experiences throughout the day. However, other studies have shown distinct results. Many studies report that there are little or no differences between the self-reported mood scales before and after caffeine consumption (Lieberman et. al., 1987; Loke, 1988). Because mood can only be measured by self-reported questionnaires may be conflicting as the participants might rate their current state more severely than others, it is important to have an in-depth analysis of how caffeine may or may not alter adolescents' mood.

All in all, the interconnected three factors seem to have an impact that leans more toward the negative spectrum. Because each factor has varying results from different studies, it is imperative to examine which effects apply to high school students. Furthermore, since most of the studies provided are on adults, conducting experiments and surveys is crucial to reach a correlation between the three cognitive factors and high school students' academic performance. For this study wishes to patch the gaps and aims to provide congruity between contrasting results from previous studies, this paper hopes to inspire further research, especially on high school students as they are the less-studied group in this area.

HYPOTHESIS

The researcher hypothesizes that high school students' academic performance will be heavily impaired by sleep deprivation. However, low levels of caffeine consumers will see benefits in helping their studies while the opposite will not. Working performance, memory, and mood will all be negatively impacted by sleep deprivation and the consumption of caffeine; however, working performance and mood may show to be the most as students are likely to stay up for a long period of time (even before the experiment is conducted) with consuming caffeine, which is likely to prolong their sleep latency, affecting the performance factor and increasing mood swings.

METHOD

In order to answer the research question effectively, the researcher targeted the participants with diverse backgrounds for this study. Unlike other research that does not study a heterogeneous sample (Ming et. al., 2011; Gau & Soong, 1995; Loessl et. al., 2008), this research focuses on students from Surabaya Intercultural School, an international school with students from various backgrounds, to lessen the gap of the unmeasurable effects from genes. To effectively measure the three cognitive factors, three instruments, the sleep journal, the MAZE passages, and a questionnaire, are implemented as a means of collecting qualitative and quantitative data.

Sleep Journal

The sleep journal is used for participants to record their sleeping hours, possible symptoms, caffeine consumption, and daily mood. The sleep diary is employed by researchers Loessl et. al. (2008) to solely obtain data on high school students' sleep patterns. However, as this study focuses on the three cognitive functions, participants should be required to not only record the amount of sleep and caffeine consumed but also document their mood or possible symptoms. Accordingly, the sleep journal will be an ideal measure to determine the sleep patterns due to sleep loss and the consumption of caffeine, conclusively allowing the analysis of the effect of prolonged sleep latency and the measurement of the cause and effect on their mood. As previously mentioned by research Sujay Kansagra, sleep latency is pertinent to examine as prolonged sleep latency can worsen performance. Also, because recording their mood is open-ended, there is also the possibility of obtaining a self-reported analysis on the theme of working performance.

MAZE Reading Assessments

Many studies have used a multitude of tests to measure working performance. For example, Pilcher and Walters (2010) used the Watson-Glasier Critical Thinking test to measure the cognitive performance of college students. Likewise, the researcher believes MAZE reading tests, "a task that measures how well students understand text they read silently" ("CORE Reading Maze Comprehension Test," p. 150), on high school students will elicit relevant outcomes as reading is an essential part in their learning and performing well on their studies. Furthermore, the Watson-Glasier Critical Thinking test may be difficult for high schoolers to complete in such a short period of time. Participants are required to take two of these assessments in order to compare the two results and determine the effect on students' cognitive performance in their sleep deprived state and their non-deprived state. The MAZE reading assessments contain a question that requires students to choose between three choices that fit the passage. Although the assessments require the time of three minutes, because the passages 10th to 12th-grade participants receive are in the 8th-grade level, the participants will receive two minutes to complete one.

Questionnaire

Asking participants to fill out a questionnaire or survey is a common approach in this field to obtain self-reported data. The self-reported data is primarily useful when assessing the participants' mood and effort when completing a task as only they can determine what they are feeling (Ming et. al., 2011; Pilcher & Huffcutt, 1996). However, the questionnaire is also going to be used to determine how and to what extent cognition, attention, understanding, and memory are affected by sleep deprivation and the consumption of caffeine with the account of other variables like age and the frequency of consumption.

The sleep journal and MAZE reading assessments will be taken in a span of 15 days. Although all the 17 participants who signed up using the consent form were obliged to complete them, one participant although started, didn't finish the sleep journal. Also, only 14 participants were able to complete the MAZE reading passages due to the difficulty of online learning. Fortunately, although not a profound amount, 30 participants filled out the form, allowing more possibility of finding the correlation. However, even with minimal participation, the researcher hopes it is still possible to obtain a general correlation that can contribute to the field of psychology.

Because of ethical measures, the Institutional Review Board (IRB) declined the researcher's initial method of conducting an experiment that required participants to sleep a specified amount of hours. Also, asking if their school grades went down like researchers Ming et. al. would not only raise ethical concerns but also be ineffective as nothing might change during the short time this is taking place. As a solution, the aforementioned sleep journal, reading tests, exit tickets, and self-reported questionnaire. Although this is a viable solution, the reading test, having to take one in a normal state and another in a sleep deprived state, might raise concerns. The researcher wishes to make clear that she will not be asking the participants to be sleep deprived more a specific amount of hours; instead, she will ask them to sleep for more than 8 hours when taking the test in a normal state for no more than 6 or 7 hours when taking the test in the sleep deprived state. As participants are suggested to be sleep deprived and not consume caffeine and are required to fill out a consent form that entails their and their parents' permission, they will be joining this experiment by will, which should raise no further ethical concerns.

RESULTS

Before analyzing the implications of the data, organizing the qualitative and quantitative comes first. The participants are addressed in alphabet letters and numbers to keep them anonymous due to ethical reasons. Each alphabet and number represents the same person; so, A is addressing the same person in Table 2a and Table 2b, and the same goes for numbers in tables 1 and 3. Table 1 is a summary of the sleep journal that provides some accounts of what the majority of the participants felt. Tables 2a and 2b are the results from the MAZE passages that are meant to be compared to each other for implications. Graphs 1a and 1b show the average of cognition, attention, understanding, and memory, with a 5% error bar of the ratings from 1-10. Table 3a is the account of all participants in the questionnaire that asks about the frequency of caffeine consumption, whereas Table 3b inquiries about how that affects their studies.

Table 1a. Sleep Journal Summary

Ages	Hours Slept (Average)	Hours Slept (Standard Deviation)	Status	Mood
18	6.12	0.98	Sleep Deprived	Insomnia, sleepy, tired, not alert, stressed, anxious, hyped up, not tired, energized
			Sleep Deprived with caffeine	Awake, okay, light headache, distracted
	8.4	0.53	Not Sleep Deprived	Okay, tired, awake, exhausted, burnt out, happy, disturbed sleep
17	5.69	1.36	Sleep Deprived	Tired, fatigue, burnt out, unconcentrated, moody, sluggish, excited, ready, headache
			Sleep Deprived with caffeine	Normal, energetic, awake, relaxed, motivated
	8.6	0.66	Not Sleep Deprived	Relaxed, tired, concentrated, unconcentrated, sleepy
16	5.82	6.77	Sleep Deprived	Tired, sleepy, drowsy, mood swings, unmotivated, muscle pain, accidental sleep
			Sleep Deprived with caffeine	Tired, energetic, awake, relaxed, motivated, anxious, loud heartbeats
	8.63	0.64	Not Sleep Deprived	Tired, energetic, relaxed

*few exceptions of people who consumed caffeine all the time

Table 1b. Sleep Journal Summary

% of Participants*	General Sleeping Patterns and Frequency of Caffeine Consumption	Mood/Possible Symptoms
29.4%	≥ 5 hours sleep, rarely consume caffeine	Tired, stressed, unconcentrated, dizzy, insomnia, headache
41.2%	< 5 hours sleep, rarely consume caffeine	Fine, tired, sleepy, okay
0%	≥ 5 hours sleep, sometimes consume caffeine	-
5.88%	< 5 hours sleep, sometimes consume caffeine	Fatigue, drowsy, lazy, lethargic
0%	≥ 5 hours sleep, almost always consume caffeine	-
23.5%	< 5 hours sleep, almost always consume caffeine	Happy, energized, tired, sluggish

*the percentages are only an approximation

Table 2a. MAZE Passages: Participants with sleep deprivation

Participants	**Hours Slept**	**Wrong**	**Omitted**	**Correct**
A	5	5	18	24
B	8	12	28	12
C	7	2	36	9
D	6	0	21	26
E	6	2	26	19
F	2	1	25	21
G	5	0	33	14
H	6	0	30	17
I	4	0	27	20
J	3	2	25	20
K	7	1	22	24
L	4	1	18	28
M	5	1	28	18
N	1	1	22	24

Table 2b. MAZE Passages: Participants with no sleep deprivation.

Participants	Hours Slept	Wrong	Omitted	Correct
A	7	6	15	26
B	8	4	25	18
C	8	6	23	18
D	7	2	7	38
E	9	1	24	22
F	9	4	11	32
G	7	1	26	20
H	8	4	21	22
I	8	1	18	28
J	8	4	6	37
K	8	2	19	26
L	8	1	16	30
M	6	1	25	21
N	12	7	14	26

Table 3a. Self-reported Questionnaire: Qualitative Data

Individuals #	Do you usually drink caffeine after being sleep deprived?	How much caffeine do you drink? Do you drink it even when you're not sleep deprived? Are you sleepy in the daytime?
1	Yes	I always drink a cup of coffee in the morning, and if I drink more it is before 12pm
2	Yes	I usually drink 1-2 cups
3	Yes	I drink caffeine once in a while. Sometimes I'll take drinks with caffeine for the taste even when I'm not sleep deprived, and I'm sleepy in the daytime.
4	Yes	Depends. I drink it whenever I'm sleepy. Generally 2-3 shots of espresso. I am sleepy in the daytime.
5	Yes	1 to 2 cups of coffee a day
6	Yes	I drink caffeine every morning and sometimes at night I have to study. I am sleepy in the daytime if I don't drink coffee.
7	Yes	Not that much, maybe a couple times a week. Yes, I do drink it when I'm not sleep deprived. Yes, I am sleepy I'm the daytime.
8	Yes	I drink three cups of coffee everyday. I drink it on a daily basis, even though I am not sleep deprived. I usually sleep in the afternoon if I don't drink coffee.
9	Yes	I usually drink tall size Americano. I don't drink coffee when I am not sleep deprived. I am always sleepy both during the day and night.
10	Yes	I drink it only when I need it. I drink at most only one cup of coffee. Yes, I am sleepy during the daytime.
11	Yes	2 shot of espresso/no/yes
12	Sometimes	I don't usually drink caffeine during the night time but usually after school. I get sleepy during the daytime but my consumption of caffeine is not that much.
13	Sometimes	I consume caffeine almost everyday, yes I do drink it when I’m not sleep deprived, and sometimes I could be sleepy in the daytime.
14	Sometimes	A cup of coffee in the morning, I do not drink when I'm not sleep deprived, I am sleepy in the daytime.
15	Sometimes	(1) probably 2 shots a day when I do drink (2) yes (3) yes

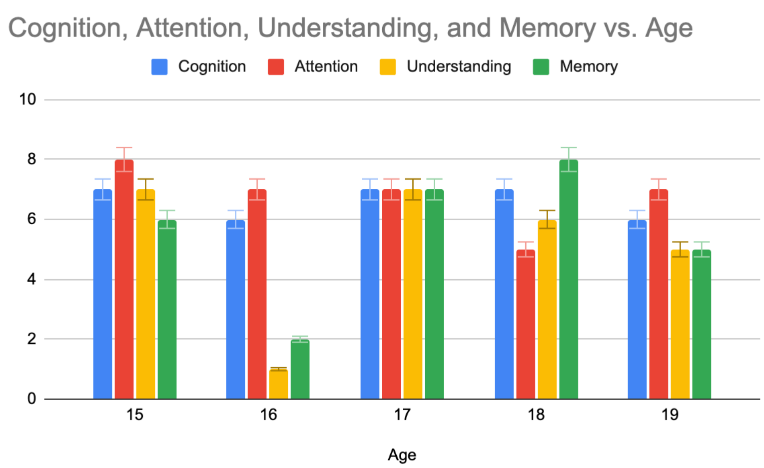
16	Sometimes	I drink caffeine only when I want to. I drink caffeine even when I'm not sleep deprived. I feel sleepy in the daytime only when I'm sleep deprived.
17	Sometimes	I drink a cup of coffee. Sometimes. Yes, often.
18	Sometimes	Around 250ml, I drink coffee almost everyday. Sometimes, I am sleepy in the day after I drink coffee
19	Sometimes	I barely drink caffeine. I drink it when I'm not sleep deprived. Yes, I am sleepy in the daytime.
20	Sometimes	4-5 times a week. Yes. Most of the time.
21	Sometimes	Not a lot.
22	Sometimes	5g of caffeine (Nescafe 240mL). I drink even if I don't feel sleep deprived. Sometimes I feel sleepy after lunch.
23	No	I drink several glasses of tea. I drink it when I am not sleep deprived, it's a common beverage for me. I am sleepy in the daytime especially when I stay up late for several days in a row.
24	No	Not that much, I just drink tea when I feel like it.
25	No	I consume caffeine frequently throughout the week but not everyday. Since it doesn't help me stay awake and focus, I rarely drink it when I'm sleep deprived. Yes, I am often sleepy in the daytime.
26	No	About 2-3 cold brew mugs per week. I usually drink after school as a refreshing beverage.
27	No	I don't drink much caffeine, maybe once every 2-3 days. Yes, I drink coffee or tea when I'm not sleep deprived. I am always sleepy in the daytime.
28	No	I don't drink caffeine at all. But, I do get sleepy at times during the day however I just try my best to stay up.
29	No	I drink one cup a day. I drink even when I'm not sleep deprived and I'm still sleepy in the daytime.
30	No	I drink caffeine about once a week. I drink it even when I'm not sleep deprived. I always sleep late, so I feel sleepy during the daytime.

Table 3b. Self-reported Questionnaire: Qualitative Data

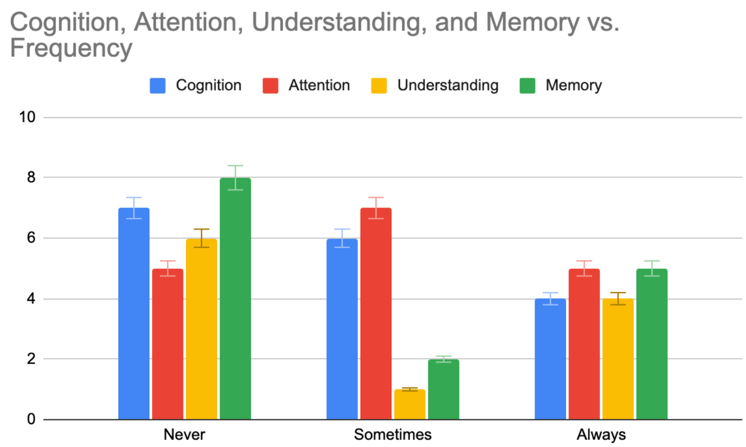
Individuals #	Do you think you score well on assignments and/or tests after drinking caffeine after sleep loss?	How does caffeine help/not help you in your studies?	Does caffeine prevent you from falling asleep at night or delay the timing of your sleep?
1	No	It does not have a specific effect, but too much caffeine makes me distracted.	No
2	Yes	It aids my late night study.	Yes
3	No	It doesn't help me.	No
4	Maybe	It's alright; it helps me stay awake but sometimes races my heartbeat to a point where I can't focus.	Maybe
5	Yes	It gives me energy.	Yes
6	Yes	Wakes me up to be more attentive in class.	Yes
7	No	It doesn't really help much, but it does give me some energy to study	No
8	Maybe	Caffeine seems to help enhance my memory and retention skills. It also helps me stay concentrated during long study sessions which I find hard to stay focused without coffee. It also has other positive effects, such as boosting my mood when I get tired of studying.	Maybe
9	Yes	They help me study awake, which enables me to study. Although my attention level is lower than usual, I still drink caffeine to study.	Yes
10	Yes	It helps me focus as I don't feel sleepy anymore. I feel more awake.	Yes
11	Maybe	Not sure	Maybe
12	Maybe	It only helps to a certain extent as it does help me stay awake sometimes. However, the effects are not always strong enough to keep me awake.	Maybe
13	No	So far, I haven't noticed any specific help	No

		towards anything from caffeine consumption.	
14	No	It helps me stay awake and pay attention, however retaining information and recalling memory becomes slightly more difficult.	No
15	I think I score the same whether I have caffeine or not.	It helps me become motivated to work in that when I have any beverage I like to drink, working seems doable. I think I get more attentive when I do work, but it doesn't affect my memory.	I think I score the same whether I have caffeine or not.
16	No	Caffeine helps me be more attentive to my task at hand, but it also causes me to become more jittery. With caffeine, I finish a task faster but with minimal effort. I do tasks without thinking too much and rush to get things done, causing me to forget what the task is actually all about.	No
17	Maybe	Caffeine makes me not fall asleep while studying.	Maybe
18	No	It help me to understand studies(classes) a lot	No
19	Maybe	Caffeine doesn't affect my study habits	Maybe
20	No	It does help me to stay focused and aware when it comes to studying especially when I'm staying up late	No
21	Maybe	It helps me focus	Maybe
22	Maybe	It only helps me stay awake at night so I have more time to study.	Maybe
23	Maybe	I do not consume caffeine for my studies. I never drink coffee but I drink tea like it's water. I don't expect any positive or negative effects.	Maybe
24	No	It helps me to focus more	No
25	No	It does not affect me very much as I feel the same after consuming caffeine.	No

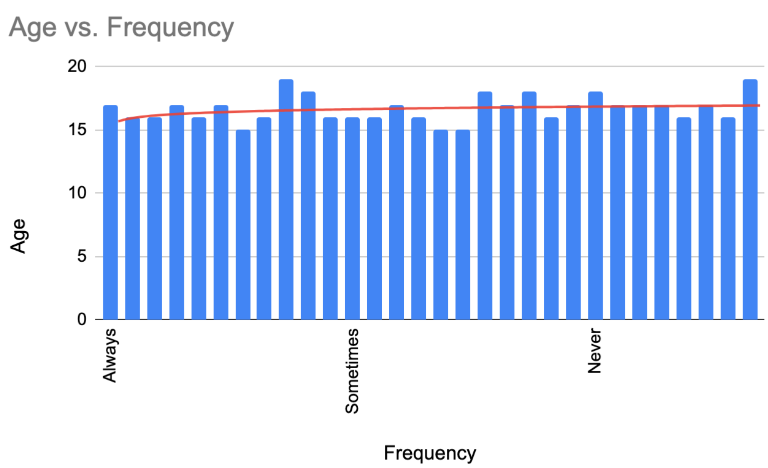
26	Maybe	Caffeine does make it possible for me to stay awake for studies in the evening. However, it only gets rid of the sleepiness I am experiencing and retains the tiredness. This makes my memory and attentiveness to what I am studying the equivalent of being in the school's last period.	Maybe
27	No	It affects my energy as sometimes I get bored and my attention span gets worse during tests.	No
28	No	It does not help.	No
29	No	It affects me on remembering things more clearly than not drinking caffeine.	No
30	Maybe	When I take caffeine, I feel sleepy, but I can't sleep and my body keeps getting tired, so it's painful.	Maybe



Graph 1a. Self-reported Questionnaire: Quantitative Data
Average of Cognition, Attention, Understanding, and Memory, vs. Age (Error bar: 5%)



Graph 1b. Self-reported Questionnaire: Quantitative Data
Average of Cognition, Attention, Understanding, and Memory, vs. Frequency (Error bar: 5%)



Graph 2. Self-reported Questionnaire: Quantitative Data (Age vs. Frequency)

DISCUSSION

Although the small sample size gives it little diversity for observation of extraneous but impactful variables like age and genes, the results give telling evidence and implications for the effects on high school students' studies from sleep deprivation and the consumption of caffeine. To answer the research question effectively by analyzing the results, the discussion is separated into three categories as organized before: working performance, memory, and mood. The three categories will focus more closely on the frequency as it is the variable that shows the most positive correlation between the rest of the dependent variables.

The reason why focusing on the frequency variable is most influential is because when comparing the age to the cognition, attention, understanding, and memory of participants, it is difficult to find a general correlation (Graph 1a); however, when comparing the frequency of those variables, the correlation is more defined (Graph 1b). Examining Graph 2 gives the reason for the lack of correlation when comparing the age. Age has nothing to do with how much a person drinks. Therefore, the frequency will be focused on the three aforementioned variables: working performance, memory, and mood.

Working Performance

In trying to obtain data on how the impact of working performance from sleep deprivation and the consumption of caffeine affects high school students' academic performance, the data from the three instruments should be thoroughly discussed. Because the qualitative data of the self-reported questionnaire and sleep journal gives insight into what participants believe, the quantitative data of the MAZE reading passages may provide confirmation. The summary of the sleep journal (Table 1a), although doesn't offer much about the working performance, implies that it is impaired through the three circumstances (sleep deprivation, sleep deprivation with caffeine, and no sleep deprivation) as their fatigue lasts the next day or two after sleep deprivation. However, some recorded with more positive words like awake and happy in non-deprived and caffeine consumed days and stressed, not alert, and unconcentrated in deprived days. The negative mood accounts for the working performance as their concentration and effort will wane (Kahn-Greene, 2006). Because the sleep journal is only in a span of 15 days, future research should take on a longer period of time to further verify this finding.

In the self-reported questionnaire, in terms of the ratings from 1-10 on how much they felt that caffeine enhanced their cognitive function, the results increasingly went down, meaning more frequent doses of caffeine gives a plateau in working performance. However, participants who rarely and always consumed caffeine after sleep deprivation rated a five in attention, whereas participants who sometimes consumed rated a seven. This could imply that constant doses of caffeine don't affect their attention positively while too little caffeine doesn't help, which is synonymous with previous findings. The qualitative data concerns comparing the frequency of caffeine consumed with the impacts on their studies. The data highlight the fact that people who generally selected the low consumption of caffeine saw no effect in their studies, implying that those participants recently stopped consuming caffeine as they saw no effect as studies previously mentioned argued that caffeine helps in low doses. Furthermore, those who always consume caffeine confessed that "[i]t does not have a specific effect, but too much caffeine makes me distracted" and "it helps me stay awake but sometimes races my heartbeat to a point where I can't focus." This report aligns with the findings of Nehlig (2010) as they both conclude that high doses of caffeine don't elicit good results; however, low doses of caffeine may not be more effective for high school students than it is proved to have been for adults.

Although the self-reported questionnaire can't be completely trusted as some people may take a feeling greater than others and the data takes the average with an error bar of 5%, the MAZE reading assessments may help confirm or disprove the previous analysis. By comparing Table 1a and Table 1b, it is identifiable that sleep deprivation worsens the cognitive abilities of the participants with few exceptions. Hence, it is evident that sleep deprivation impairs the working performance of individuals. However, because the participants weren't tested on the effects after the consumption of caffeine because of the lack of time, future research should go on and do so.

Memory

Memory can be assessed using the quantitative data of the self-reported questionnaire. Although there isn't another measure to confirm the participants' ratings, because the participants have gone through years of memory independent and dependent tests, trusting their ratings and filtering out the purported cause of such ratings are acceptable. Graph 1b shows that memory is heavily affected by sleep deprivation with minimal effect shown when participants sometimes and always consume caffeine. The unanticipated result is that more participants that consume caffeine sometimes saw less effect in caffeine after being sleep deprived than the ones who always consumed caffeine. Although the fact that participants who rarely consume caffeine even when sleep deprived saw more benefits in helping with memory retention than the other two is synonymous with the aforementioned research (Nehlig, 2010), the lower benefit from participants who only consume caffeine sometimes goes against the general consensus. This implies that either the participants who sometimes consume caffeine selected the extent to which they were affected by caffeine rated more harshly than the ones who always consume caffeine or the students between the age of 15-19 experience fewer benefits when consuming caffeine sometimes than ones who consumed all the time.

Mood

As established by previous research analysis, sleep deprivation shows a negative correlation with mood while the result from caffeine consumption is arbitrary. Although the discourse of the summary of the sleep journal (Table 1a) was pertinent in measuring the working performance, it would be most beneficial to look at the specific condition for the effects of mood. Table 1b shows that the mood of the participants who rarely consume caffeine and whose hours of sleep isn't far off the recommended hour of sleep isn't so negatively affected compared to the ones who slept less than or equal to five hours, one stating "I'm still feeling very anxious and jittery this morning though." This outcome is axiomatic considering the findings of previous studies that all reached a consensus on the impairment of sleep deprivation. The participants who consumed caffeine almost daily saw more positive mood results than the ones who sometimes or rarely consumed it. Although the participants who always consumed caffeine felt happy and energized on not-deprived days, stating "I felt fresh and calm," they also felt sluggish and tired when they were sleep deprived, quoting "I feel happy and energized but sometimes moody or annoyed easily." Despite the fact that there is only one person that slept a little more than five hours and sometimes consumed caffeine, it is deduced that that participant still feels drowsy and lazy even with the consumption. These accounts suggest that caffeine doesn't give high schoolers a profound effect on their mood or their cognitive state.

These findings clear up the discrepancies between the findings on whether caffeine helps stimulate positive mood or not. Caffeine doesn't seem to have a negative impact on mood; however, it might not be helpful for daily consumers and consumers of high doses as some recorded the heightening of anxiety and increase of loud heartbeats; this outcome is also synonymous with the finding of Nehlig (2010) who argued that caffeine only in low doses helps overcome negative mood. In support of the findings of Liebermann et. al. (1987), although caffeine may help induce a positive mood, it doesn't have a profound effect on high school students.

CONCLUSION

There are a few limitations future researchers could take into account. First, the sample size itself is very small, giving leeway to find a strong correlation. Because this was conducted specifically in Surabaya Intercultural School and was an experiment that lasted for 15 days, it didn't attract many people. For a bigger sample size, researchers should branch out to other schools in the specific region of interest and maybe offer incentives. Also, researchers should ask the participants to fulfill all the requirements when signing up as some participants weren't able to do the MAZE reading passages as online learning made it difficult. Because every participant has a different personality and some might value a certain aspect higher than others, the average ratings may be affected by some outliers. In particular, some people may rate the effect on cognition higher than others who purportedly could have had the same magnitude of impact. Although hopefully, other instruments could cover up the self-reported questionnaire, because of limited time, only measuring the sleep deprived and not deprived states was possible (not accounting for the caffeine consumption). Because of these biases, future researchers should conduct reading assessments in the three states: not deprived and sleep deprived with and without caffeine consumption. Furthermore, since memory was only measured using the self-reported questionnaire, researchers should develop a memory test and use the fMRI like researcher Killgore (2010) did; however, that method should be employed for high school students.

From the results of this paper, it is deducible that sleep deprivation impairs all three factors that ultimately hinder the studies of high school students. Caffeine is beneficial sometimes in low doses and may reach a plateau or not give any benefits when consumed daily. However, caffeine is harmful when consumed in high doses as it raises anxiety. This finding implies that although caffeine may not be detrimental, it doesn't help the learning of high schoolers. That is why it is vital to not be sleep deprived and depend on caffeine. It is also important for researchers to account for other variables as working performance, memory, and mood aren't all that affect high school students' performance. Because of such impairment, actions schools can take are delaying the start of school time and educating students about the effects. Possible solutions individuals can implement in their lifestyle are trying to follow a healthy sleep schedule and attempting to avoid consuming caffeine in high doses. Such solutions could lead to the heightened academic performance of high school students.

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