A Study on the Effects of Sleep on Children's Reaction Time

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Abstract

The goal of this project is to determine if a relationship exists between one's reaction time in milliseconds and how long they slept the night before in hours. Over twenty studies on the effect of sleep loss and reaction time confirm a likely association between sleep deprivation and longer reaction times. While it is generally true that a night of poor sleep leads to slower cognitive processing, this project is focused on finding if sleep deprivation has a noticeable effect on children's (ages 12 through 17) reaction speed. The data was collected from 116 respondents through a Google Form that was posted on Instagram® and sent to Stanford Online High School Skype groups. A Spearman Rank Correlation Coefficient test and a Mann-Whitney U-test or Kruskal-Wallis test were conducted for all data groups. The correlation test was used to find a monotonic correlation between sleep and reaction time, and the nonparametric tests compared the medians of different data groups. This project's results suggest that there is no relationship between sleep and reaction speed in children. This differs from other studies on sleep and reaction time in adults, which could mean that children are less affected by sleep loss.

Keywords
Sleep, reaction, SRCC, Mann-Whitney.

1. Introduction

Sleep loss can have a profound impact on physical and mental health. One physical effect that sleep deprivation can have is on reaction time, or how quickly a person responds to a stimulus. This has been shown to have important effects on activities such as driving (Philip *et al.* 2003), as well as daily activities (Cain *et al.* 2011) and aerobic exercise (Taheri & Arabameri 2012). This project is interested in finding if a relationship exists between how long a child (from between ages 12 and 17) sleeps and their reaction speed. This is of importance because the previously mentioned studies have focused on the effects of sleep deprivation on reaction time in adults rather than in children.

2. Methodology and Data Collection

To recruit respondents for this project, a Google Form was posted on Instagram® and sent to various Stanford Online High School (OHS) Skype groups; 116 respondents were recruited. These respondents included students attending OHS as well as other schools. Each respondent was asked for their age and how long they slept the night before. They were then asked to measure their reaction speed with this online test from the Human Benchmark. This simple reaction speed test has one stimulus and one response. When the red screen turned green, test-takers were supposed to click the screen as fast as possible. Survey-takers submitted their reaction time (which was given by the website) on the form. Respondents were asked to only take the test once because reaction time decreases after repeated tests due to practice effects (Del Rossi *et al.* 2014). Additionally, respondents noted what kind of device they used to take the test (touch-screen, trackpad, or mouse) and if their internet was stable.

By controlling for the respondents' age range, age was unlikely to affect final results as reaction time tends to slow with age. Getting survey-takers' device and stability of Internet was just a precaution to ensure that neither of these affected their reaction speed (for example, it is possible that students could click faster using a mouse than using a trackpad on a laptop).

2.1 Hypothesis

The null hypothesis is assumed to be true until there is reasonable evidence to suspect otherwise. The null hypothesis of this project is that there is no relationship between how much sleep an individual between the ages of 12 and 17 gets and their reaction speed. It is hypothesized that there is a negative relationship between these two variables: the less sleep that an individual of this age group gets, the slower they will react to a stimulus.

3. Data and Statistical Analysis

After collecting all the necessary data, all responses were imported into an Excel spreadsheet. Before looking at the respondents' sleep and reaction times, it was necessary to ensure that age did not affect how long respondents slept the night before taking the survey (because all respondents are between ages 12 and 17, they may be undergoing puberty, which can change sleep patterns). If sleep *does* affect reaction time, then it is imperative to ensure that a typical night of sleep does not vary significantly among this age group. Initially after plotting respondents' ages and hours of sleep on a scatter plot (the x and y variables respectively), it appeared that there was a slight negative monotonic relationship between the two variables (Figure 1).

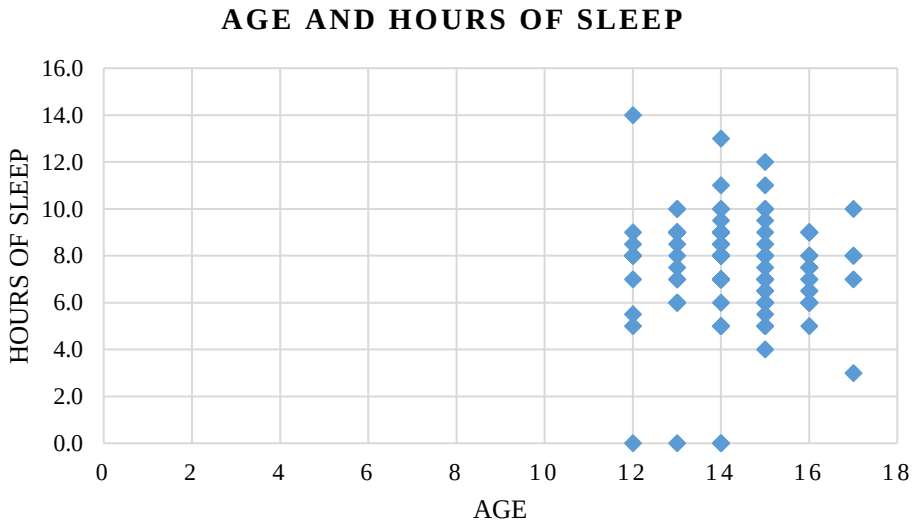

Figure 1. XY Scatter plot of Respondents' Age (X) and Hours of Sleep (Y).

To test whether hours of sleep decline with increasing age of respondents (as is suggested visually by the scatter plot), a Spearman Rank Correlation Coefficient (SRCC) test was conducted because it is less affected by outliers and more flexible than the Product Moment Correlation Coefficient test. This test is appropriate as age and hours of sleep are both ratio scale variables. The null hypothesis for this test is that there is no monotonic correlation between a respondent's age and how long they slept the night before taking the survey. With an r_s value of -0.1325 and a P-value of 0.155, the null hypothesis could not be rejected because the P-value is bigger than 0.05. Therefore, there is no evidence to support that age affected how long each respondent slept the night before taking the survey.

3.1 SRCC

Because there was no confoundment between respondents' age and hours of sleep, the hypothesis that sleep deprivation leads to increased (i.e. slower) reaction times was tested next. Frequency tables of all responses were made to check for normality. A scatter plot was made with sleep in hours (X-axis) and reaction time in milliseconds (Y-axis) to see if there is a clear visual relationship between the two variables (Figure 2).

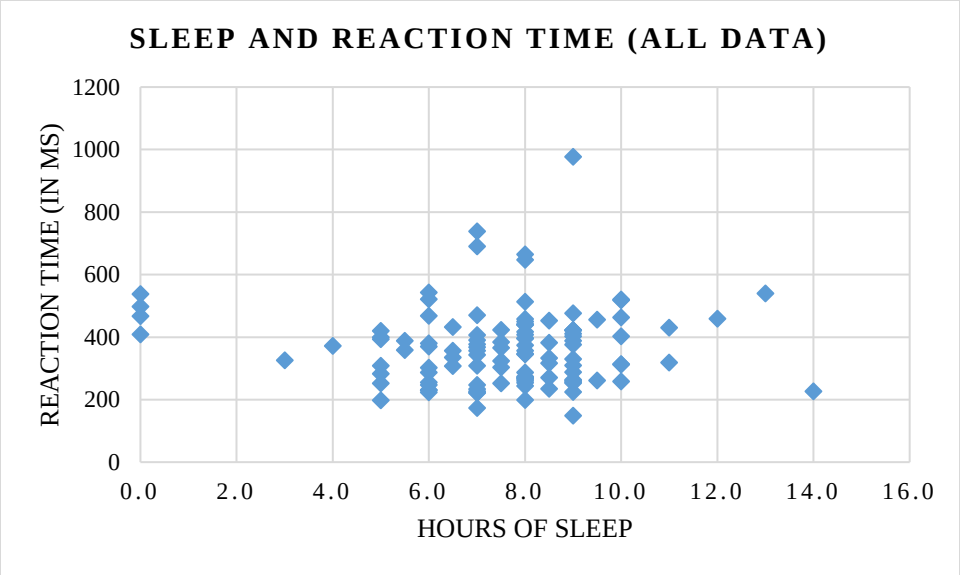

Figure 2. XY Scatter plot of Respondents' Hours of Sleep (X) and Reaction Time (Y).

An SRCC test was conducted with these data (again, because this test is more suitable than the PMCC, and the variables' scales are fitting). Hours of sleep and time in milliseconds are both ratio scale variables. The null hypothesis is that these two variables are not monotonically correlated. After running the test, these data had an r_s value of 0.0577 and a P-value of 0.536, so the test result is not statistically significant. The results of this test do not provide evidence to reject the null hypothesis that sleep is not monotonically correlated with reaction speed.

3.2 Mann-Whitney U-Test

Even though a negative correlation between sleep in hours and reaction was not found, it is still possible that participants who sleep fewer than the recommended 8 hours per night experience slower reaction times than those who do. To test this, a Mann-Whitney test was performed, comparing the median reaction speeds of respondents that slept few hours (fewer than 8 hours) and those who slept normal or high hours (8 hours or more), with n = 53 and n = 63 respectively. This test was chosen to use this nonparametric test over a two-sample t-test because the data are negatively skewed, which could be seen in the previously mentioned frequency tables. The null hypothesis for this test is that there is no difference in the medians between these two groups. After running the test, these data had a U-value of 1500 and a critical value of 0.939; because the U-value is greater than the critical value, the data are not statistically significant, and the null hypothesis cannot be rejected. Therefore, these results are consistent with the previous test results, and this evidence does not support that getting fewer hours of sleep significantly increases participants' reaction times.

3.3 Testing Internet Connection

The final two statistical tests used for this project were performed on the two groups of Internet connection: self-reported slow Internet (n = 27) versus fast Internet (n = 89). This was done to ensure that respondents' Internet did not affect their reaction speed. An SRCC test was conducted for both groups of Internet connection. The null hypothesis for both tests is that there is no monotonic correlation between hours of sleep and reaction speed. After running each test, the two groups had r_s values of -0.3198 and 0.1446 and critical values of 0.382 and 0.209 for slow and fast Internet respectively. Because both r_s values were smaller than their corresponding critical values, the null hypothesis could not be rejected, and this test result suggests that respondents' Internet connection did not affect their reaction speed.

A Mann-Whitney U-test was conducted to compare the median reaction speeds of these two groups to find if one of these groups had slower reaction times than the other. This nonparametric test was chosen because my data are negatively skewed. The null hypothesis for this test is that there is no difference between the medians of these two groups. After running the test, these data had a U-value of 1091 and a critical value of 0.722. Because the U-value is larger than its corresponding critical value, the test is not statistically significant, and the null hypothesis

failed to be rejected; the median critical values of these two groups are not significantly different. It is unlikely that respondents' Internet connection affected their reaction speed.

4. Conclusion

After conducting an SRCC test and a Mann-Whitney U-test, neither of these tests were statistically significant. Additional statistical tests on users' Internet connection were not statistically significant, which suggests that Internet connection did not affect results. This evidence does not support that there is a relationship between sleep and reaction speed in children ages 12 through 17 based on this project's test results; the null hypothesis of this project cannot be rejected, which differs from previous studies conducted studies on adults. The results of this project suggest that children are less affected by sleep deprivation than adults. Additionally, this project's findings imply that sleep deprivation's effects become more significant as the body ages.

5. Future Research Opportunities

It is advisable for future studies to limit participant responses to a single technology to decrease the possibility of bias. Kay *et al.* (2013) have found that reaction time tests designed for touch-screens are less effective at capturing the actual reaction time of participants as compared to "finger-lift" methods, which would include a mouse or trackpad device.

Additionally, it is also possible that other factors were overlooked during data collection that may have influenced respondents' reaction times. For example, hydration is a factor that can affect reaction time (Wittbordt & Millard-Stafford 2018), but this was difficult to take into account when gathering data. Some respondents submitted more precise numbers for how long they slept (for example, one person wrote 7 hours and 47 minutes, while others rounded to the nearest hour). More precise answers were rounded to the nearest half hour. The precision of time measurement may have had an impact on results, though it seems unlikely that it played a large role. Additionally, survey-takers were only asked how long they had slept the night before and did not account for sleep loss from previous nights. Studies have shown that the effects of sleep loss can carry over into the next few days (Webster 2008). The school that students attend was not taken into account, and it is possible that OHS students have faster reaction times on this online reaction test as they generally spend more time on their computers than the average teenager.

Further research is needed to get a more conclusive result. It may be useful to test respondents with more diverse backgrounds as most respondents were OHSers, and this group may be comprised of a certain type of student (generally middle to upper class families, so these students may have been able to afford and grow up with more technology). An offline, physical reaction test may rule out the added complication of children who are more accustomed to using technology (though this was not possible for this project). However, if this online test were used again for a future study, it would be useful to have respondents measure their Internet speed rather than a self-reported speed for a more precise result. In the sample for this project, it seems that most respondents slept well (the median sleep for all 116 participants was 8.0 hours) or did not lose more than a few hours of sleep the night before, so a sample with more respondents that slept poorly could yield a different result.

Overall, this study failed to find results consistent with those focused on adults (Jaffe *et al.* 2018) in which sleep deprivation leads to slower reaction times. It is unclear if this is because children's reaction times are unaffected by sleep loss (unlike adults), or if results are due to methodology or sampling. Follow-up studies are necessary to ascertain whether children ages 12 through 17 really do not suffer a similar slowing of their reaction time with sleep loss to their adult counterparts.

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Biography

Alina Zhong is a rising sophomore at Stanford Online High School. A music enthusiast, she is a competitive classical guitarist with three years of practice in her toolbelt. Currently, she is a writer in the Yearbook club and the graphics designer for The Ryan Lee Podcast, as well as a writer, researcher, and graphics designer for the World Awareness Association blog. Additionally, Alina competed in Public Forum debate for four years and was the Public Forum debate captain of the HuaXia Debate Team. In the future, she plans on studying botany, agriculture, and astronomy in hopes that her future research will help better society.