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# The Effects of Sleep Deprivation on Alpha Wave Brain Activity

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**ABSTRACT**

Sleep Deprivation has been associated to many detrimental ailments such as elevated heart rate, insomnia, depression, anxiety, and decreased cognitive functioning. The nature of my observational study is to analyze how sleep deprivation affects Alpha Wave Brain Activity as a measure of cognitive function. Eight subjects completed a health test on sleep quality/quantity and electroencephalogram for nature of alpha waves. ANOVA analysis of alpha wave amplitudes between subjects across all trials showed no significant difference. Scatter plot analysis shows sleep deprivation and % difference in amplitude is inversely related. This suggests that sleep deprivation affects amplitude of alpha waves hence indicating an alpha-block. This observational study reinforces current findings that sleep deprivation affects cerebral cortex function.

Keywords: *Sleep deprivation, EEG, alpha-block,*

## INTRODUCTION

Sleep Deprivation is defined as insufficient sleep or the act of short sleep. Over the past decades, sleep deprivation has become a more common problem amongst teenagers and adults in modern society. A variety of factors contribute to this cause such as earlier start schedules for school, extended shift hours at work, and social obligations among family and friends. The consequences of short sleep such as extreme tiredness, lack of focus, lack of concentration, decreased cognitive functioning, obesity, and imbalance of energy metabolism are all well documented (Barnett and Copper, 2008; Klingenberg and Sjodin, 2014; Erkki et al 2013, Kwan et al 2008). Short sleep has also been found to have its effects on energy intake and physical activity.(. (Patterson et al., 2014). The brain contains four distinct waves characterized by difference ranges in amplitude and frequencies. Alpha waves, are prominent when an individual is awake, non-focused and low levels of stimulation,.. Beta waves are prominent when an individual is alert, focused, attention, and is solving a problem solving.. Theta and Delta waves are normally observed during sleep. We hypothesized that there will be difference in amplitude of alpha waves between subjects when they are sleep deprived.

The objective of my study is to observe sleep deprivations and effects on alpha waves amplitude. . College students are the perfect group for this study as most don't get enough sleep due to academic and social obligations. This observational study seeks t to answer the question ‘Does Sleep Deprivation affect alpha wave brain activity? Sleep deprivation will be measured as sleep quality and quantity. Sleep quality and quantity can be measured using a sleep cycle application that relies on a gyro sensor present in most smart phones (iphones). The gyro sensor detects in movement as the subject sleeps.

## MATERIALS AND METHODS

The sleep Deprivation observational study was conducted between January 5 and January 25, 2015. The McPherson College Department of Natural Science Human Subject Board reviewed and approved a proposal to do the study. All participants consented to the research specifics of the . All participants were McPherson College students who were healthy, maintained a normal lifestyle and were aged between 18-27 Each participant recorded nine sleep sessions between January 5 and January 25 on specific dates using their smart phones..On the days, that the subjects recorded their sleep data, they also came to the lab to do electrocephalogram (EEG) analysis. During EEG testing,electrodes placed on the participants cephalic measured the frequency and amplitude of different brain waves. The settings were standardized and verified and recordings of EEG taken for 3-5 minutes. During the recording, subjects were asked to solve a simple multiplication arithemic problem that involved a two digits. for example, 12 x 16. participants were asked to solve this problem with their eyes closed. This test was repeated two additional times per trial period. Three trial periods on different days were performed per participant.

Statistical Package for the Social Science (SPSS) was used to perform one-way ANOVA test for differences in amplitude of alpha waves during rest period, problem solving period , and after the problem was. . Scatter Plot was used to examine possible correlations between sleep quality/quantity and difference in amplitude among subjects.

## RESULTS

Analysis of EEG recording generated left and right alpha wave and beta wave amplitudes. Only the left alpha wave amplitude analyzed during the rest period, during the problem solving problem and after problem

was solved were analyzed (Tables 1, 2 and 3)/ A reduction of alpha amplitude indicated an alpha-block. Also percentage difference in amplitude between the resting period and problem solving period were correlated to sleep quality and quality as a scatter plot (Figures 3 and 4)

**Table 1**. ANOVA Analysis Between Subjects showing Resting Period Amplitude

| source | SS | DF | Mean S | F | Sig |
|---|---|---|---|---|---|
| CM | $1.74x10^8$ | 7 | $2.48x10^6$ | 2.84 | .02 |
| Intercept | $1.34x10^7$ | 1 | $1.34x10^7$ | 15.4 | .00 |
| Group | $1.74x10^7$ | 7 | $2.48x10^6$ | 2.84 | .02 |
| Error | $3.06x10^7$ | 35 | $8.74x10^5$ | | |
| Total | $6.38x10^7$ | 43 | | | |
| C. Total | $4.80x10^7$ | 42 | | | |

(R-square: 0.363, Adjusted R-square=0.235)

**Table 2**. ANOVA Analysis Between Subjects Showing Problem-solving Amplitude

| source | SS | DF | Mean S | F | Sig |
|---|---|---|---|---|---|
| CM | $1.62x10^7$ | 7 | $2.3x10^6$ | .781 | .60 |
| Intercept | $2.80x10^7$ | 1 | $2.8x10^7$ | 9.45 | .00 |
| Group | $1.62x10^7$ | 7 | $2.3x10^6$ | .78 | .60 |
| Error | $1.04x10^4$ | 35 | $2.9x10^6$ | | |
| Total | $1.54x10^8$ | 43 | | | |
| C. Total | $1.19x10^8$ | 42 | | | |

(R-squared=0.135, Adjusted R-squared=-0.038)

**Table 3.** ANOVA Analysis Between Subjects showing Solved problem Amplitude

| source | SS | DF | Mean S | F | Sig |
|---|---|---|---|---|---|
| CM | $1.14x10^8$ | 7 | $1.6x10^6$ | 1.3 | .27 |
| Intercept | $1.55x10^7$ | 1 | $1.5x10^7$ | 12.3 | .00 |
| Group | $1.14x10^7$ | 7 | $1.6x10^6$ | 1.3 | .27 |
| Error | $4.40x10^7$ | 35 | $1.2x10^6$ | | |
| Total | $7.45x10^7$ | 43 | | | |
| C. Total | $5.55x10^7$ | 42 | | | |

(R-squared= 0.207, Adjusted R-squared=0.048)

## DISCUSSION

ANOVA analysis of alpha block amplitudes between subjects shows that there is no significant difference in left alpjha wave amplitude between the subjects before, during and after solving the simple arithmetic problem (Tables 1, 2 and 3).. This was expected and could have been caused by a myriad of uncontrollable variables including diet, amount of physical activity, and other many other variables.

I accept my null hypothesized that sleep deprivation

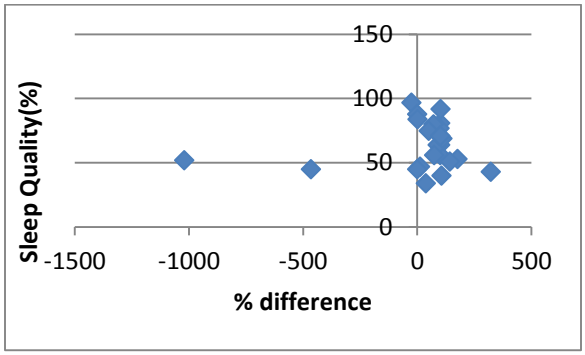


**Figure 1.** Scatter Plot Analysis of Sleep quality vs. % difference of amplitude among subjects.

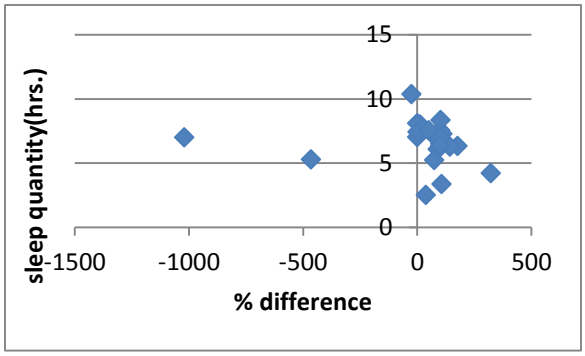


**Figure 2.** Scatter Plot Analysis of longevity of sleep vs. % difference of amplitude among subjects

had an effect on Alpha waves amplitude as seen by the negative correlation trend in figures 1 and 2. Scatter plot analysis of amplitude % difference among subjects shows a negative trend correlation for both sleep quality and sleep quantity. Because of this negative trend, it is safe to say that subjects that had less sleep time and poor sleep qualify had the lowest difference in alpha wave amplitude during the resting period and problem solving problem. There sleep deprived deprived participants showed a lower alpha block amplitude change. Barnett and Cooper (2008) derived the same conclusion, that poor night sleep was associated with increase in beta wave amplitude or activity.

In addition, EEG analysis was done for only the left side of the brain which is normally the conceptual and logical reasoning side of the brain. However, Kalbfleish and Gillmarten (2013) suggest that some people have visuospatial ability (VST), a discrete ability that uses visualization and imaging, normally attributed to right side of the brain, to perform concrete logical and mathematical problems. This might have possible effects on the accuracy of my results.

Additional tests such as a repeated ANOVA analysis could have been performed to detect any overall difference in amplitude within the same participant. bAlso, only left side brain was analyzed throughout study, but according to Kalbfleish and

Gillmarten (2013), analyzing right brain alpha waves might have potentially yielded different results. Another improvement to the test is to increase sample size so as to improve on power and accuracy of the results. Lastly, subjects varied in thickness of hair and numerous other variables which could not controlled for at the time of testing The use of an EEG cap, equipped with up to 64 channels, might improve current findings. More research can be conducted to gain further knowledge and understanding on the nature of sleep deprivation. This was an observational study to relate sleep deprivation with cerebral cortex activity.

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