

The effect of sleep on memory.

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ABSTRACT

The present studies investigated the memory retention of words and its relationship to sleep. The studies involved 4 college students and the first study followed a series of longitudinal within-subjects correlational assessments of hypotheses relating overnight memory retention to the following three other variables: hippocampal changes during sleep, quality of sleep, and quantity of sleep. After finding the highest correlation between quantity of sleep and memory retention, the causal relationship between these two variables was further experimentally tested. Sleep quantity was manipulated by randomly assigning each day across a two-week period to one of two possible conditions: a day with a 3-hour nap versus a day with no naps. The results of the experiment supported the hypothesis that increases in the amount of sleep result in a greater memory retention. These results are of importance for college students in maintaining a healthier academic profile and suggest that greater memory retention is capable by having adequate sleep.

1. Introduction

Humans spend about one-third of their lives sleeping (if the average night's sleep is about eight hours). Many scientists raise questions about the occurrence of sleep in our daily life. Why do we need sleep? What is the role of sleep? Many studies have been conducted and researchers have found many advantages of sleep in everyday life, from energy conservation to tissue restoration. In recent studies, scientists have found an additional advantage of sleep: sleep helping in memory retention. A common complaint from many students, though, is that after studying all night they were not able to perform their best in exams and didn't get good marks as they could not recall many parts of what they had previously learnt.

This type of complaint has led many researchers to conduct studies in order to find the relationship between sleep and memory retention.

Many of these studies have compared individuals who had a good amount of sleep at night with those who had disrupted sleep at night to find the effect of sleep on memory. One of these studies was by Scullin (2013) in which he examined in young and old adults how changes in slow wave sleep and episodic memory are related across different sleep-wake conditions: 12-hr wake, 12-hr sleep, and 24-hr (night-to-night) sleep groups. He found a significant correlation of equal sleep and wake cycles with memory retention in younger adults but the contrasting results and even a negative correlation for the same variables in older

adults, highlighting some weakening of the sleep–memory linkage over time. However, it is possible that this could be the result of the different amounts of sleep that people of different ages have.

To investigate the relationship between the quantity of sleep and memory, Potkin & Bunny (2012) had a list of 10 words pairs administered three times in immediate succession and then sleep and non-sleep groups were tested 12 hours later. They found that increased quantity of sleep improves memory retention and they argued that this memory consolidation is independent of the time of the day in which it occurs. Hence, the present study hypothesized that as the quantity of sleep increases, memory retention increases.

A study by Jegou et al. (2019) investigated the effect of hippocampal activity during sleep on retention of words using EEG and fMRI. The experiment included two visits, each had three sessions taking place during the first half of the day: a learning session, a 3-hour maximum sleep session and a post sleep recall session. The results indicated that there is a positive correlation between the change between fast spindles and slow spindles during sleep in the right hippocampus during the learning night (as compared with the control night) and the post-pre sleep change in recall performance.

2. Methods

2.1 Participants

Four college students participated in the studies. The students were recruited from Camosun College, Victoria and ranged from ages 18 to 21. There were 3 females and 1 male in the present study.

2.2 Materials

The materials used in the current studies involved lists of 15 randomly generated words (sourced from www.randomwordgenerator.com) which were not repeated on any day of measurement and consisted of different 4 to 6 letter words. The words were different for each individual but involved similar length words.

2.3 Procedures

2.3.1 Correlational Study Procedure

All correlational studies happened in the same duration of 12 days. Each night, before going to bed, each participant memorized 15 words that had been randomized by the website. After waking up, the subjects recorded the number of words that they correctly recalled. For the hippocampus hypothesis, the participants also recalled and recorded the number of words that were correct before sleep and subtracted this number from the number of words recalled post sleep. They then rated the quality of sleep on that night on the scale of 1 to 10 on how satisfying they were. Their hippocampal activity during the night was measured by how many dreams related to locations there were and how clear they were on the scale of 0 to 100. The number of hours the participants slept was also recorded each night.

2.3.2 Experimental Study Procedure

The participants generated a random list of words before starting each experimental condition and control condition trial. In the experimental condition, during a 12-day period, the participants remembered the list of words and then slept for 3 hours from 12 PM to 3 PM for 6 days as compared to the control condition of having no sleep during

the same time period for 6 days. A box was prepared for each participant with 6 folded pieces of paper with the word “control” and another 6 with the word “experimental”. Each day, the subjects would shake the box and pick one indicating which condition of that day was. The participants when in control condition involved themselves in their routine daily chores for the same duration as in experimental condition. After 3 hours the subjects recalled as many words as they could from the list and then scored themselves based on the number of correctly remembered words from the list.

3. Results

3.1 Correlational Study Results

There was statistically significant correlation ($r = 0.35$, $p = 0.035$) between quality of sleep and memory retention (see

Figure 1). There was also a statistically significant correlation between quantity of sleep and memory retention ($r = 0.47$, $p = 0.004$, see Figure 2). For the hypotheses of hippocampal response changes during sleep and overnight changes in recall performance, there was no statistically significant correlation found ($r = 0.06$, $p = 0.750$, see Figure 3). Both the pooled raw data and pooled standardized data of the three studies shows the same results. The quantity of sleep and memory retention received the highest correlation value and hence became the experimental hypothesis.

3.2 Experimental Study Results

The mean of the number of correct words recalled in the 3-hour nap condition was 9 ($SD = 1.04$) and in the no-nap condition the

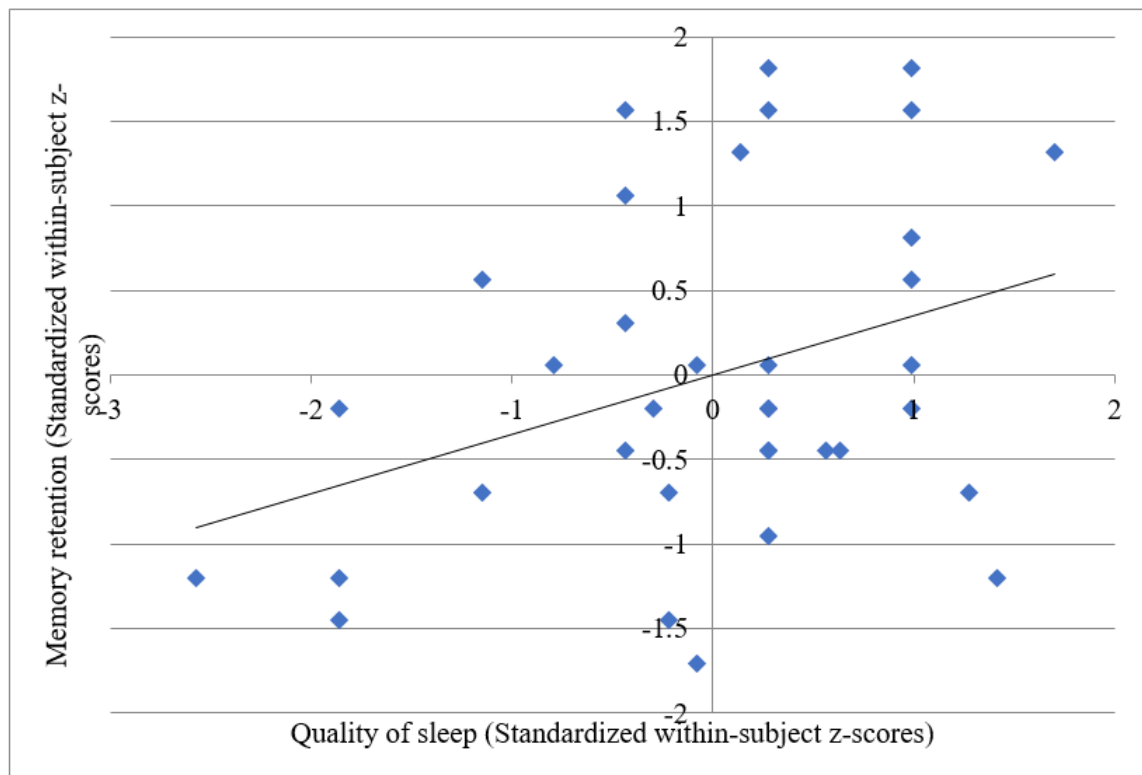


Figure 1. Scatterplot of quality of sleep and memory retention. Pearson's $r = 0.35$.

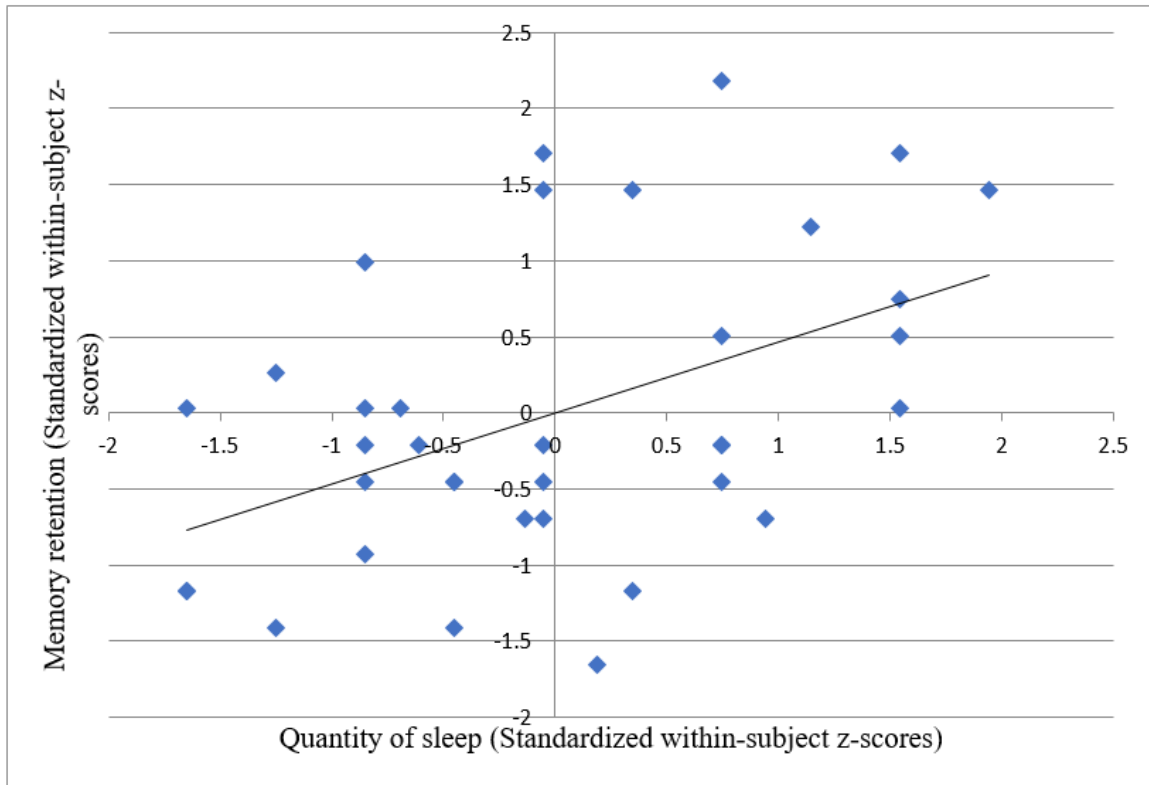


Figure 2. Scatterplot of quantity of sleep and memory retention. Pearson's $r = 0.47$.

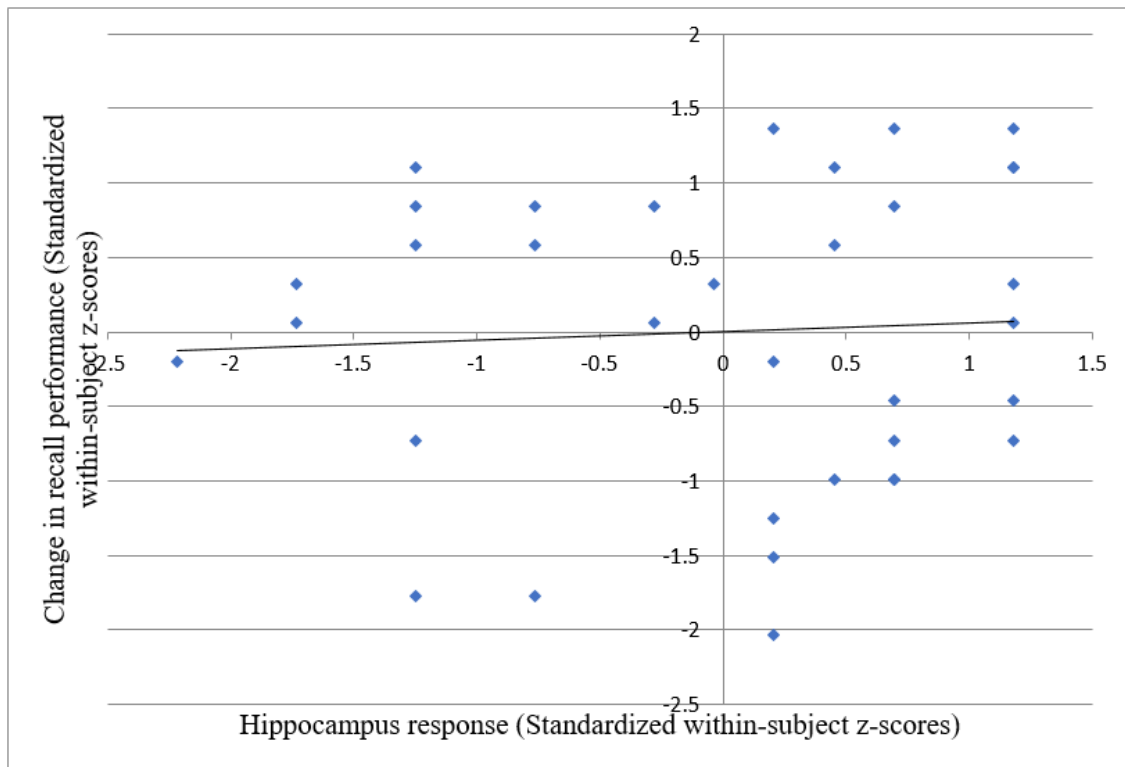


Figure 3. Scatterplot of hippocampus response and change in recall performance. Pearson's $r = .06$.

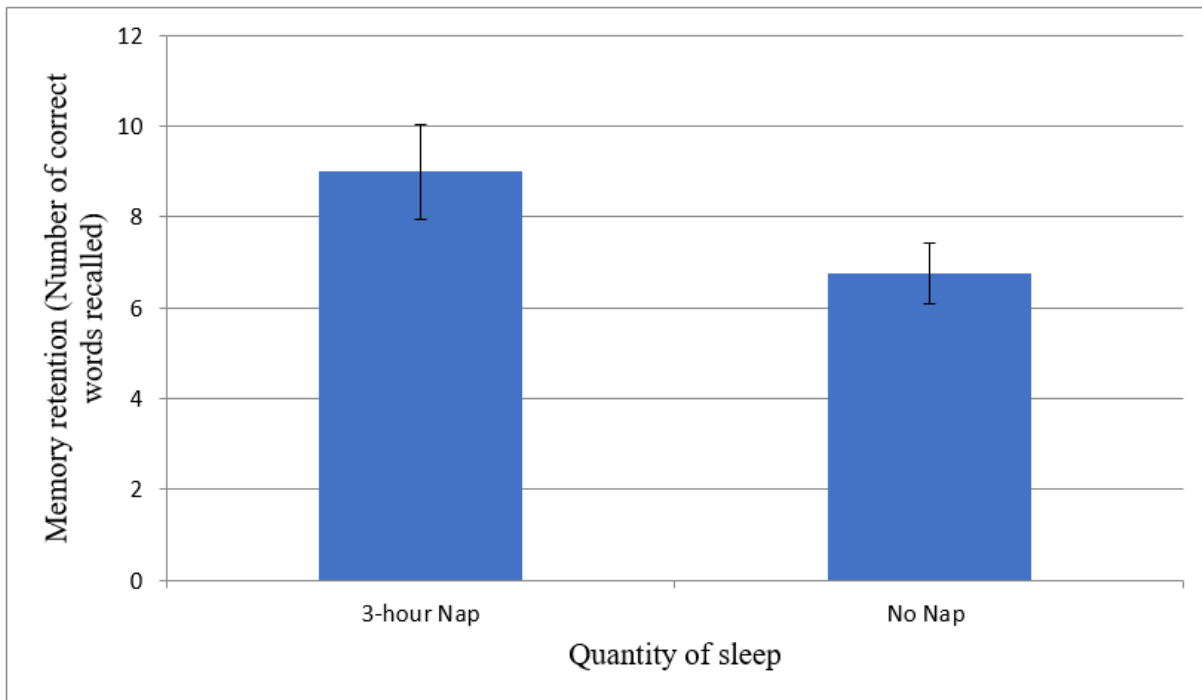


Figure 4. Bar graph of average (\pm 95% C.I.) correct words recalled between 3-hour Nap condition and No Nap condition.

mean value was 6.75 ($SD = 1.57$). This data was analyzed using an independent t-test and the results were significant, $t(46) = 3.75$, $p = .000$ for the pooled raw data (see Figure 4) and $t(46) = 4$, $p = .000$ for the pooled standardized data. This suggests that the increase in the amount of sleep resulted in a greater number of words recalled.

4. Discussion

While a positive correlation was found between memory retention and both the quality and quantity of sleep, no statistically significant relationship was found between hippocampal activity during sleep and changes in recall performance. The results of our experimental study also supported a causal role of increased sleep quantity upon improvements in memory retention.

These findings are in line with other previous studies on quality and quantity of sleep and memory retention. Potkin and Bunney (2012) found that long-term memory was improved in the group that was tested following a sleeping period as compared to the group in which sleep was omitted. Moreover, the effect of sleep on memory retention was also dependent on the quality of sleep, where recall performance has been found to be improved if people have good sleep-behaviour (Scullin, 2013).

However, in contrast to Jegou et al. (2019), whose findings suggested a positive correlation between hippocampal response during sleep and the post-pre sleep change in recall performance, our study found that the correlation was not statistically significant. This difference was possibly caused by the difference in measurement of retention, which was that some subjects only

considered the number of correctly recalled words post sleep instead of the difference between number of words recalled post sleep and pre sleep. To test the hypothesis that an increase in hippocampal response during sleep will lead to an improvement in overnight change in recall performance, the group were to measure the discrepancy by subtracting the amount of correct words recalled before sleep from the number of words after sleep. However, some subjects just used the data from after waking up, possibly leading to differences in the significance of result.

The present study only involved experimenting on college students' memory retention of random words. The study involves small sample size with limited demographic representability and limitation on the materials, as information that needs to be memorized is not always limited to randomly generated words.

Based on the group finding, the amount of sleep a person gets has a positive effect on their memory retention of information. These results have many important implications, mainly on the importance of having a balance life and a healthy sleep schedule. Students should be encouraged to have enough sleep every night to maximize study ability. The results of this study might also enhance our understanding of academic performance and its relationship with sleep disorders such as insomnia.

References

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