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Abstract

Sleep quality and memory are both relevant topics in today's society, especially among college students.
Purpose: To determine if there is a correlation between sleep quality and short-term memory including objective and subjective measures.
Methods: This study consisted of 25 participants, 6 males and 19 females, ages ranging from 19 to 22 (20.8±0.8 years), who avoided stimulants, caffeine or other sleep altering drugs for at least eight hours. Our participants were recruited via word of mouth, poster, and discussions in classroom settings. Participants memorized a list of 30 words for two minutes and then had two minutes to recall and write as many words as pos sible. Sleep quality was measured with the Pittsburg Sleep Quality Index and then scored using the official Pittsburg Index score sheet, and perceived memory was scored at face value. An independent t-test was used to determine if there was a significant difference between genders on their sleep quality, Memory Functioning Questionnaire scores, and their ability to recall words.
Results: The test revealed no significant difference (p=0.68) between the sleep quality of males (7±3) and females (7±3). There was also no significant difference (p=0.16) between the number of words recalled by males (14±4 words) and females (11±3 words). The difference between the Memory Functioning Questionnaire scores of males (318±37) and females (282±55) was not significant (p=0.10). No significant difference (p=0.45) was found between science majors (8±4) and non-science majors (8±3) on sleep quality. Similarly, Memory Functioning Questionnaire scores were not significantly

different (p=0.73) for science majors (285±52) and non-science majors (293±55). The test for recalled words also showed no significant difference (p=0.99) between science majors (12±3 words) and non-science majors (12±3 words).

Introduction

Memory is an important aspect of academic performance, particularly with college students. One issue that many college students face is lack of sleep. According to the Center for Disease Control (CDC, 2015), "Insufficient sleep is a public health epidemic." In the years 2005-2008, 38.8 million adults under the age of 20 self-reported that they had difficulty remembering things in their daily lives. In a survey conducted in 2009, 43.7% of young adults ages 18-25 reported unintentionally falling asleep during the day at least once in the past month (Center for Disease Control, 2015). Many previous studies have sought to demonstrate the correlation between sleep and memory function. According to these previous studies, "good" sleepers perform better in prospective memory tasks (Fabbri, Tonetti, Martoni, & Natale, 2014) and gross motor tasks (Kempler & Richmond, 2012) than "bad" sleepers. In addition to adults, poor sleep can also negatively affect the memory function of children (Ashworth, Hill, Karmiloff-Smith & Dimitiriou, 2014). This indicates that sleep quality is an important factor in individuals of many age categories.

In addition to sleep quality, the amount of sleep an individual gets each night has also been found to affect performance, particularly with motor skills (Tucker & Fishbein, 2009). Sleep affects all aspects of the body; aside from helping with memory, it also helps lower oxidative stress. Sleep contributes to all organs in the body and helps rest, but mainly replenishes the hippocampus, body striatum, and prefrontal cortex. The hippocampus is the main structure in the brain where memories are stored (Ciccarelli & White 2015). Oxidative stress eats away at the nitric oxide in the brain reducing the effects of learning and memory (Liam, de Bruin, Rios, & de Bruin, 2014). When comparing good sleepers to those with primary insomnia, sleeplessness that is not attributable

to a medical, psychiatric, or environmental cause, it was found that healthy sleep helps to consolidate new memories, and that this process is impaired for procedural memories in patients with primary insomnia (Nissen et al., 2011).

Sleep quality and memory can be assessed in a number of ways. One way that sleep quality has been measured in previous research is with a Basic Mini-Motionlogger actigraph, a device worn on the wrist, that measures Sleep Onset Latency, Total Sleep Time, Wake After Sleep Onset, Sleep Efficiency, and Number of Awakenings (Fabbri, Tonetti, Martoni, & Natale, 2014). A sleep logbook and the Karolinska Sleepiness Scale have also been used by researchers to quantify total sleep time and subjective levels of general sleepiness (Kempler & Richmond, 2012). The Pittsburgh Sleep Quality Index is a subjective questionnaire that measures sleep disturbances and overall sleep quality over a one-month time period. This questionnaire is a validated, reliable, subjective assessment of sleep quality that is short and easy for participants to follow. A study conducted by Murre, Kristo, & Janssen (2014) found that sleep quality measured by the Pittsburgh Sleep Quality Questionnaire was associated with poorer autobiographical memory performance 4-6 weeks after the recorded event. It is a more feasible option compared the Basic Mini- Motionlogger actigraph because it does not require the use of a sleep lab or special hardware devices of an extended period of time.

Just as there are multiple ways to assess sleep quality, there are also several ways to assess memory function, both objectively and subjectively. With a study involving the memory of mice, a maze test was used to assess memory (Liam, de Bruin, Rios, & de Bruin, 2014). Word recall tests are often a common instrument used to objectively assess the memory function of humans. The word recall test has been utilized in a number of studies, including a study by Nestor, Akdag, O'Donnell, Niznikiewicz, Law, Shenton, & McCarley (1998) comparing schizophrenic individuals with individuals without schizophrenic symptoms. A word recall test was also used in a study by Mazzoni, Gori, Formicola, Gneri, Massetani, Murri, & Salzarulo (1999) involving older adults and sleep. Similarly, a study by Epstein, Phillips, & Johnson (1975) used a slightly

different word recall of pairs of words and specific, unique instructions. The participants of this study were high school and college students. Memory can also be measured in subjective ways. One of these assessments is the Every Day Memory Questionnaire (EMQ) which has been used to measure memory failure in adults with HIV (Heinz, Fogler, Newcomb, Trafton, & Bonn-Miller, 2014) and severe head injuries (Schwartz & McMillan, 1989). A study by Rebok, and Balcerak (1989) used a different questionnaire called the Memory Self-Efficacy Questionnaire to measure perceived memory confidence in young and old adults. Another way to subjectively measure memory is with the Memory Functioning Questionnaire (MFQ), which has been used in a study by Gilewski, Zelinski, & Schaie (1990) to assess memory complaints in adults and older adults.

The purpose of the present study is to examine the relationship between sleep quality and memory in college students. It is hypothesized that students with good sleep quality will perform better in the word recall test and report a higher perceived memory showing a positive correlation between the two variables.

Methods

Data Collection

This study sought to examine the relationship between sleep quality and short-term memory of Georgia College State University (GCSU) students. Participants were recruited from the GCSU community via flyers posted around the university at pre-approved locations. Students were excluded from this study if they had consumed alcohol, central nervous system stimulants, or caffeine eight hours before the study, or sleep aids twenty-four hours before the study. Eligible participants were scheduled to meet in a predetermined room at a specific time.

Before arriving at the study site, participants were sent an email informing them about the location and time of the study. An exclusionary checklist was also included in the email, informing the participant about what not to consume prior to the study. Before

participating in the study, the participants were given the opportunity to express any questions or concerns regarding their involvement within the study. All participants were given an informed consent document to review and sign if in agreement. Participants then received and completed three separate questionnaires. The questionnaires include the Pittsburgh Sleep Quality Index, the Memory Functioning Questionnaire (MFQ), and a demographics questionnaire.

After the completion of these questionnaires, subjects took part in a memory word recall test. During this test, the participants were shown a list of thirty words for a duration of two minutes. After two minutes, the list was taken from the participant and he or she were immediately asked to recall as many words as possible from the viewed word list by writing the remembered words on a piece of paper. The number of correctly recalled words were recorded for each participant.

Statistical Analysis

Descriptive statistics (mean + SD) will be calculated for all of the dependent variables: number of recalled words, score from MFQ, and information from the demographics questionnaire (age, gender, anticipated graduation year, current number of hours enrolled). Data was analyzed using Pearson Product Moment Correlation to detect relationships between continuous dependent variables. Statistical significance will be set at $p < 0.05$, and all analyses will be carried out using the Statistical Package for the Social Sciences version 22.0.

Results

The sample size included 25 individuals (6 males and 19 females) ranging from ages 19 to 22 (20.8±0.8 years) recruited from Georgia College. Sixty-eight percent (n=17) of subjects were science majors and 32% (n=8) of subjects were non-science majors. No participants were excluded based on the exclusionary checklist. Participants were enrolled in an average of 13.36 hours (13.36

+2.61) of academic classes.

An independent t-test was used to determine if there was a significant difference between males and females on their sleep quality, Memory Functioning Questionnaire scores, and their ability to recall words. The test revealed no significant difference (p=0.68) between the sleep quality of males (7±3) and females (7±3). There was also no significant difference (p=0.16) between the number of words recalled by males (14±4 words) and females (11±3 words). However, the difference between the Memory Functioning Questionnaire scores of males (318±37) and females (282±55) was not significant (p=0.10).

An independent t test was utilized to determine if there was a significant difference between science majors and non-science majors on their sleep quality, Memory Functioning Questionnaire scores, and their ability to recall words. No significant difference (p=0.45) was found between science majors (8±4) and non-science majors (8±3) on sleep quality. Similarly, Memory Functioning Questionnaire scores were not significantly different (p=0.73) for science majors (285±52) and non-science majors (293±55). The test for recalled words also showed no significant difference (p=0.99) between science majors (12±3 words) and non-science majors (12±3 words).

A Pearson Product Moment Correlation analysis compared sleep quality, Memory Functioning Questionnaire scores, words recalled, age, and academic hours enrolled. No correlation was found between Memory Functioning Questionnaire scores and sleep quality (**Figure 1**). Similarly, no correlation was found between the number of words recalled and sleep quality (Figure 2). The only statistically significant correlation was found between age and Memory Functioning Questionnaire scores (r=-0.41, p=0.04).

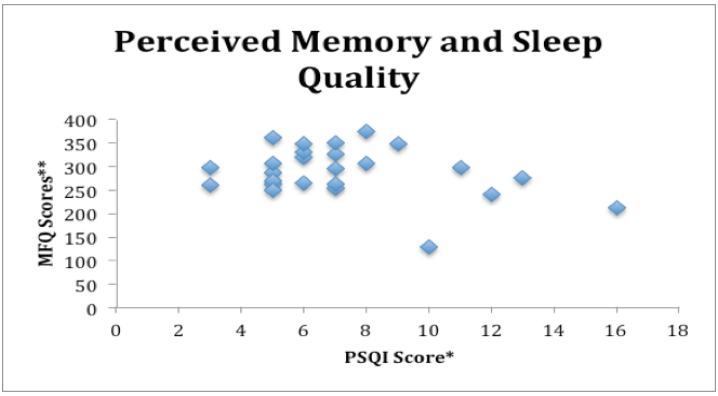

Figure 1. Correlation between perceived memory and sleep quality (N=25).

*Pittsburg Sleep Quality Questionnaire. Scores range from 0 to 21. Higher PSQI scores represent poorer sleep quality.

**Memory Function Questionnaire. Scores range from 64 to 448. Higher MFQ scores represent a better-perceived memory.

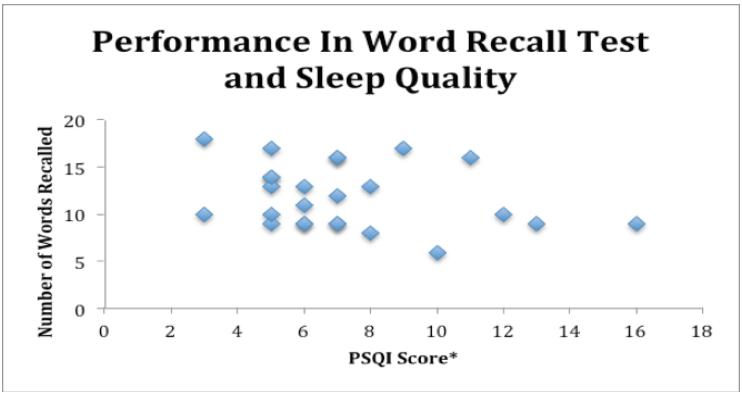

Figure 2. Correlation between word recall test performance and sleep quality (N=25).

*Pittsburg Sleep Quality Questionnaire. Scores range from 0 to 21. Higher PSQI scores represent poorer sleep quality.

Discussion

The objective of this study was to determine if there was a relationship between sleep quality and memory function. It was hypothesized that better sleep quality would be correlated with higher perceived memory and better performance on the word recall task. The research revealed that an individual's quality of sleep was not related to their perceived memory or short-term memory, thus the research investigators rejected the original research hypothesis. The results found in the present study do not coincide to a study conducted by Murre, Kristo, & Janssen (2014) found that sleep quality measured by the Pittsburgh Sleep Quality Questionnaire was associated with poorer autobiographical memory performance 4-6 weeks after the recorded event. However, this study also found no effect of sleep length on memory, which do mirror the results found in the present study. The effect size that Murre et al. (2014) study found concerning memory and sleep quality was quite small, especially given the relatively large sample size. However, many studies have shown a relationship between sleep quality and memory. One such study found that hierarchical regression analyses indicated that poor sleep quality, but not short sleep length, was associated with significantly lower recall at the longer retention periods (3046 days), but not at the shorter ones (215 days), although the difference in recall between good and poor sleepers was small (Fabbri, Tonetti, Martoni, & Natale, 2014; Ashworth, Hill, Karmiloff-Smith & Dimitiriou, 2014). This indicates that further research needs to be conducted in order to clarify the discrepancies reported on the true relationship between sleep and memory function.

The present study revealed that there was no difference between males and females regarding short-term memory and sleep quality. The results of the present study also found there was no difference between science and non-science majors in relation to short-term memory (word recall) and sleep quality. However, there was a relationship between age and perceived memory (MFQ scores), which showed that perceived memory decreased with age. The latter findings are similar to a study conducted on 230 women enrolled in the Seattle Midlife Women's Health Study, with a mean

age of 46.7 years, which found that stress, physical health, and aging were linked to most types of memory change (Mitchell & Woods, 2004). Another study, which was conducted to assess the importance of working memory and perceptual comparison speed as related to age differences in cognitive functioning, found that many of the differences in cognition appear to be mediated by age-related reductions in working memory. These reductions in working memory may in turn be mediated by age-related reductions in the speed of performing simple processing operations (Salthouse, 1991).

Although the present study showed results no significance for gender and memory function, there is evidence that females excel in certain areas of memory while males excelled in other areas. A study done between genders of three different age groups, adolescents, young adults, and older adults tested auditory memory, visual memory tasks, and lastly working memory tasks (Petermann & Lepach. 2013) The investigators reported that women had better auditory memory, which increases into young adulthood and then steeply decreased into older adulthood. Men did not perform as well in auditory memory; they seemed to slightly decrease from adolescence into young adulthood and then steeply decreased into older adulthood. Men started out better in visual memory tasks in adolescence, slightly decreased into young adulthood and then dropped into older adulthood. Women started lower on the scale, however into young adulthood men and women were almost even in score, and then both respectively drop into older adulthood. The last test was to measure working memory tasks. Men did better during adolescence, men and women were very close in adulthood, and then women declined faster into older adulthood than the men did. "Although currently conducted analyses confirmed that there were reliable differences between men and women in all memory measures, the direction of those gender-linked effects was found to be strongly depending on the type of memory measure. Furthermore, these effects slightly differed in magnitude across the age groups" (Pauls, Petermann, & Lepach, 2013). The findings of this study suggest that gender differences are subjective to the test being used and the age group performing. Further research should be conducted to elucidate the true differences between gender and

various memory function assessments.

One of the goals of the present study was to determine whether or not there was a difference in memory for science versus non-science majors. The results indicated that there was no significant difference in the memory function questionnaire or sleep quality between the two categories of academic majors. Although there was no significant difference between the different majors, more research should be done in this field to further verify the results of the present study.

A limitation of the present study was the small sample size of 25 participants. A larger sample size may have resulted in different outcomes and may have increased the likelihood of discovering significant results. Another factor that may have altered the results of the study was the questionnaire that was used to assess perceived memory. The Memory Functioning Questionnaire, which was created in 1988, was somewhat outdated and some of the questions were not age appropriate. The results of the present study indicated that perceived memory was not related to short-term memory test performance, suggesting that the Memory Functioning Questionnaire may not have been an accurate measure of perceived memory for this population. It includes questions such as, "How is your memory compared to the way it was 20 years ago?" This question was not appropriate for our participants with ages ranging from 19-22. A more age appropriate measure of memory may have been the Memory Self-Efficacy Scale, a similar measure of confidence in memory. This Likert scale has been found to be reliable and valid in a group of college students from Southeastern University (Berry, West, & Dennehey, 1989). In place of the word recall test, the Wechsler Adult Intelligence Scale-III Digit Span Forwards Test may have been a more valid and reliable measure of short-term memory, however our resources did not allow this test to be used.

In conclusion, this study found that the Memory Functioning Questionnaire and the word recall test may not be the best tools to assess the effects of sleep quality on perceived memory and short-term memory in subjects who are between the ages of 18-22. This knowledge may allow for future research to be conducted more accurately for this age group by using more age appropriate

means of testing. The present study also shows that there is a need for further research to be conducted on the relationship between sleep and memory function for college age students, as well as on the gender differences between sleep quality and memory recall performance for this age group.

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