11-13-2014

Sleep deprivation and the negative effect it will have on the individual's cognitive function

Stephen Fisher

SLEEP DEPRIVATION AND THE NEGATIVE EFFECT IT WILL HAVE ON THE INDIVIUDALS COGNITIVE FUNCTION

by
Stephen Jon Fisher

A Thesis

Submitted to the
Department of Educational Services, Administration and Higher Education
College of Education
In partial fulfillment of the requirement
For the degree of
Masters of Arts in School Psychology
at
Rowan University
May 6, 2014

Thesis Chair: Terri Allen, Ph.D.

Abstract

Stephen Jon Fisher
SLEEP DEPRIVATION AND THE NEGATIVE AFFECT IT WILL HAVE ON THE INDIVIUDALS COGNITIVE FUNCTION
2013/14
Terri Allen, Ph.D.
Master of Arts in School Psychology

The purpose of this study was to determine if there was a correlation between sleep deprivation and an individual's cognitive function. Cognitive function was evaluated by looking at participants working memory and processing speed. To investigate this extrapolation, data was collected from undergraduate students at Rowan University. Participants were evaluated using an application called sleep time alarm clock to measure their sleep quality, and then measured by the Stroop test to determine their level of processing speed and working memory. Univariate analyses were done to determine if there was any correlational relationship between sleep deprivation and processing speed and working memory. There was no significant correlation between sleep deprivations on an individual's cognitive function. Other correlation analysis showed a significant relationship between processing speed and the condition in which participants were measures (sig. = .005). There was also a correlation between working memory and the factors of sex and sleep quality (sig. = .035) and sex and the condition in which the participants were measured (sig. = .046).

Table of Contents

Abstract	iii
List of Figures	vi
List of Tables	vii
Chapter 1: Introduction	1
Operational Definitions	1
Limitations	2
Summary	2
Chapter 2: Literature Review	3
Sleep Deprivation	3
Cognitive Function	7
Working Memory	8
Processing Speed	10
Relationship between Sleep Deprivation and Cognitive Functions of Working Memory and Processing Speed	11
Stroop Test	12
Chapter 3: Methodology	15
Participants	15
Materials	15
Design	16
Procedure	18
Chapter 4: Results	20
Descriptive Statistics: Sample Population	20

Table of Contents (Continued)

Analyses Investigation Sleep Deprivation Effects on Processing Speed 22

Analyses Investigation Sleep Deprivation Effects on Working Memory 24

Chapter 5: Discussion 28

Conclusion regarding Sleep Deprivation and Cognitive Function 28

Factors Relating to Processing Speed 28

Factors Relating to Working Memory 29

Limitations 29

Further Directions 30

References 31

List of Figures

Figure Page

Figure 1. Comparing Nonverbal Scores with Verbal Scores in Regards to Response Time in Processing Speed 23

Figure 2. Comparing Nonverbal Scored and Verbal Scores in Regards to the Sex of the Participant and their Response Times 24

Figure 3. Comparing Sleep Quality in Regards of Sex of the Participant and how Accurately 26

Figure 4. Comparing Sleep Quality in Regards to Sex of the Participant and how Accurately their Responses were 27

List of Tables

Table	Page
Table 1 Descriptive Statistics: Processing Speed	21
Table 2 Descriptive Statistics: Working Memory	22
Table 3 Variance of Scores specific to Processing Speed	23
Table 4 Variance of Scores specific to Working Memory	25

Chapter 1

Introduction

Everyone needs sleep, and we have all felt the effects of what both a lack of sleep and an excess amount of sleep. The effects can either impede or benefit our daily lives. Sleep is an important part of our cognitive function, because during sleep our brain is able to recharge and make room for new information. Our ability to pay attention is a key function of everyday life, without our attention span, information is not processed and task can be neglected or forgotten about. A lack of sleep can be seen to have a wide range of effects on a college student. The need of this research is to determine if getting a lack of sleep affects their ability to pay attention.

Sleep affects everyone, and a lack of sleep can have a big impact on a person's ability to pay attention. College students are a good group to pull data from, because they tend to pull a lot of all-nighters studying and doing homework. The present investigation studied, lack of sleep in college students and effect on working memory and processing speed. The lack of sleep a college student gets during a night of rest will have a negative effect on that person's cognitive function. This research was conducted and the conclusion was in made in light of the following operational definitions:

Operational Definitions

Processing Speed: the ability to automatically and fluently perform relatively easy or over-learned cognitive tasks, especially when high mental efficiency is required

Working Memory: the system that actively holds multiple pieces of transitory information in the mind, where they can be manipulated.

Sleep Deprivation: defined as zero to six hours of sleep a night, ranging over one night, or consecutive nights depending on the individual

College Students: Undergraduate students whom are enlisted and a residents at a college or university.

Stroop Test: the ability to demonstrate interference while performing a task, and a person reaction time to perform it; being able to differentiate when the actual color word when it appears in a different color. Also being able to determine the color of the word when it appears under a different color, eg., "**BLUE**" appears "**RED**."

Limitations

The limitations of this study include sample size, being able to effectively measure a person's sleeping patterns, and method of data collection. Being able to accurately measure a person's lack of sleep will be a limitation of the study. For someone to accurately record the amount of sleep will require them to recall what time they went to bed and what time they woke in the morning. Students may not be able to answer these questions and therefore make up the responses.

Summary

In summary, this study was designed to determine if there is negative correlation between sleep deprivation and an individual's cognitive function. This study examined processing speed and working memory as the major components of cognitive function. First, a review of previous literature will be discussed and looked at to determine if any other research has found a correlation between sleep deprivation and cognitive function. Next, the experimental design will be outlined in detail. Lastly, the research's findings will be given and an appropriate conclusion will be drawn from the results.

Chapter 2

Literature Review

Review of past literature will first present the definition of sleep. Second, the review will provide the definition of cognitive function and discuss two different domains of cognitive function. Third, the relationship between sleep deprivation and cognitive functions will be discussed and the affects that sleep deprivation has on cognitive function. Fourth, the Stroop Effect Test pertaining to cognitive function measurement will be described, along with a discussion of limitations of the current research.

Sleep Deprivation

Sleep deprivation is prevalent and has a considerable health, social, and economical impact (Giesbrecht, Smeets, & Leppink, 2009). A study done by Gruber (2013) showed that sleep deprivation (SD) affects cognition, emotional regulation, and health. Sleep deprivation can significantly impact multiple factors necessary for everyday functioning. According to Peachy & Zelman (2012) restful sleep is necessary for health, and disordered sleep is a cause, a perpetuating factor, or a consequence of most mental disorders. Previous reviews have suggested that sleep deprivation has specific effect on cognition in certain domains, particularly on tasks mediated by the prefrontal cortex (PFC) function (Lim and Dinges, 2010). Recognizing where sleep deprivation affects an individual helps to better understand what it is that is being affected. Psychopathology could result from or be exacerbated by insufficient sleep and consequent fatigue and sleepiness (Sadeh, Raviv, & Gruber, 2000). Over the years there has been numerous studies investigating the overlap between sleep disturbances and psychopathology (Koffel, 2011).

Other studies have presented questions of whether sleep loss adversely affects metacognition for more complicated cognitive tasks and for tasks using memory integration and discrimination (Blagrove & Akelhurst, 2000). Decision-making is a cognitive function that takes place in the prefrontal cortex, and takes help from a person's working memory. Schnyer, Zeithamova, & Williams (2009) determined that neural consequences of sleep deprivation during decision-making will provide critical information about the brain's ability to adapt to mental fatigue as well as revealing important biomarkers of significant cognitive impairment. Early investigations of sleep deprivation arose mainly from an interest in the influence of fatigue on performance (Malmo & Surwillo, 1960). Sleep deprivation is important to understand because of the impact it has on our cognitive function and it is the first step to finding a way to overcome it. Even one sleepless night was found to cause a decline in vigilance, to the extent that participants were unable to maintain satisfactory speed and accuracy performance levels (Jugovac & Cavallero, 2011). It is important to make sure that we are getting a good quality of sleep at night so that an individual does not become sleep deprived.

Normal duration of sleep in Western societies is estimated as 7– 8 hours per night (Willert, Thulstrup, Hertz, & Bonde, 2010). Sleep deprivation leads to deficits in perceptual comparison and mental addition, but subjective confidence in responses closely tracks performance, and the subjective "certain" confidence level remains valid (Baranski & Pigeau,1997; Baranski, Pigeau, & Angus, 1994).

Sleep deprivation is becoming more relevant for both scholars and practitioners due to the fact that individuals are working more and are putting more work hours into the day, and sleep deprivation is factor that could affect their performances (Welsh, Ellis, Christian, & Mai, 2014). A study done by Fisk, Mongromery, & Murphy (2009) showed aspects of executive functioning, measures of day-time sleepiness and physiological arousal, aspects of psychological affect and everyday memory functioning. Sleep is a crucial part of everyday functioning. During sleeping is when our brain is able to “recharge” and take a break from constantly processing data. Sleep deprivation can have a major impact on an individual’s daily function and performance on their cognitive performance. The National Sleep Foundation (2005) did a poll that estimated 29% of adults feel tired at least 3 days a week. Also 11% of those same adults indicated that sleepiness seriously impacts their daily activity.

According to Bub, Buckhalt, El-Sheikh (2011) there are two conditions that help to explain different aspects of sleep, sleepiness and sleep/wake problems. A review done by Harrison and Horne (2000) that examine the effects of sleep deprivation on behavior and psychological performance have concentrated on measures deemed sensitive to "sleepiness" favoring more basic skills, such as vigilance, reaction time, and aspects of memory. Sleepiness is concerned with the consequences of sleep problems for daytime functioning, whereas Sleep/Wake Problems relate to behaviors associated with the process of going to bed and sleep, with sleeping itself, and with waking up (Bub, Buckhalt, El-Sheikh, 2011). Gruber (2013) refers to sleepiness as the effects that sleep deprivation has on daily functioning, in particular, the feeling an individual has when they did not get a sufficient amount of sleep the night prior. The aspect of sleep/wake problems refers to the actual process of sleep, and anything that may cause a problem during a sleep cycle that could impact an individual's quality of sleep. Previous studies have shown indirect evidence from neuroimaging studies that support the hypothesis of; sleep deprivation is likely to decrease the efficiency of top-down inhibition circuitry (Minkel et al. 2012). The cognitive ability to think from a broad range all the way down to very specific details is revealed to be effected by sleep deprivation.

Sleep is recognized as a fundamental human need (Maslow, 1943), and poor quality of sleep has been associated with a number of adverse health outcomes. Healthy participants who slept only 5 hours per night for 1 week experienced a progressive worsening in mood (Dinges et al., 1997). Other studies showed conflicting findings with the previous research that sleep deprivation increases negative mood (Talbot, Harvery, Kaplan, McGlinchey, & Dahl, 2010).

Sleep is regulated by two distinct physiological processes that interact to govern sleep timing and composition (Moore, 1999). Sleep timing refers to the amount of time, whereas composition refers to the actual process of sleep and awakening. According to Lee the neural heat-regulating centers were near the so-called sleep center in the hypothalamus and said, "It is quite possible that activity in the former irradiates to the latter and assists in producing feelings of lassitude, inattentiveness and drowsiness" (pg 724).

Other definitions describe how sleep deprivation affects a person's daily function. Sleep deprivation is assumed to have a negative effect on an individual. According to Matella & Marotta (2013) sleep loss increases sleepiness and impairs cognitive performance. Short sleep duration induces sleepiness in children, leading to externalizing behaviors, irritability, and short attention span (Gruber, 2013). Sleep deprivation can also have a negative effect on a person cognitive performance. During periods of sleep deprivation, the hippocampus (the brain's memory-encoding center) fails to engage normally when required to perform tasks, such as verbal learning or visual memory (Drummond et al., 2000). Sleep is also critical to the consolidation of memory (Stickgold & Walker, 2005).

Cognitive failures associated with sleep deprivation are of great importance, because individual's real world failures due to sleep deprivation have real-world consequences that are often catastrophic (Dinges, 1995). Much of the literature focuses on the effects of sleep deprivation on basic attentional processes and complex, real-world tasks. Decision-making, which generally falls under the domain of executive functions, engages a number of cognitive operations that have been examined under conditions of sleep deprivation, including working memory (Williamson, Feyer, Mattick, Friswell, & Finlay-Brown, 2000).

Cognitive Function

Cognitive processes, such as processing speed, attention, and concentration-refers to a person's higher order executive functions or episodic memory (Nebes, Buysse, Halligan, Houck, & Monk, 2009; Schmutte, Harris, Levin, Zweig, Katz, & Lipton, 2007). Cognitive functioning is any type of executive function that takes place in the frontal lobe of the brain. Executive function is our higher cognitive function that our brains preform daily and that is necessary for everyday function.

An individual must be able to pay attention to a situation and process that information into working memory. During working memory it is determined if the information is important enough to be stored into long-term memory or if it is going to be discarded. Cognitive function involves a combination of working memory and processing speed working together to perform a task.

Working Memory

Working memory is one of the most influential theoretical constructs in cognitive psychology (Lervåg & Hulme, 2013). Working Memory (WM) is defined as the temporary encoding, maintenance and manipulation of information in short term registers (Baddeley, 2000), and it is critical for virtually all cognitive functions and activities of daily living, such as planning, conversation, and problem solving. In working memory information that is processed during an individual's attention is stored temporarily. In working memory information that was processed is either transferred into long-term memory or erased from memory. When information is converted and stored into long-term memory it can now be recalled for tasks such as problem solving. Working memory gives an individual the ability to keep and manipulate a limited amount of information over a short period of time, specifically while solving a problem (Goldstein et. al., 2014).

Research by Oberauer, Süß, Wilhelm, and Sander (2008), on working-memory capacity (WMC) examines the individual's ability to keep several chunks of information simultaneously so as to be available for direct access. Working memory capacity is the amount of information that can be processed efficiently in working memory. According to Meier & Kane (2013) working memory capacity, as measured by complex span tasks, predicts success in complex intellectual activities such as learning computer languages, multitasking, and solving novel problems. Results from a study by Peich, Husain, & Bays (2013) indicate that the precision with which visual features can be maintained in memory declines with aging. This shows that working memory has a certain capacity, and dependent upon the age is how much capacity is in working memory.

The rate at which the brain processes cognitive information is intricately related to working memory (Nebes et al., 2000). In order for information to be processed efficiently there needs to be a balance between the rate at which the incoming information can be processed and the rate at which irrelevant information is displaced or decays. Working memory has a limited capacity that provides enough storage to manipulate information for complex cognitive tasks, such as ones that involve learning and reasoning (Goldstein et. al., 2014). Information that passes through working memory is either quickly used or stored in long-term memory for later use. There is not always enough storage in working memory to collect a lot of information, the more capacity an individual has the more information they are able to store and in turn help them complete the task at hand.

Working Memory refers to the individual's capability of processing and maintaining information, as opposed to short-term memory that can only store information. Vergauwe, Camos, & Barrouillet (2014) proposed working memory as becoming increasingly more important in psychology. Several lines of research support the notion that individual differences in performance on working memory tasks are driven by differences in the ability to retrieve information from short-term memory (Rose, 2013). Working memory is involved in both high-level cognition and also in low-level basic processes, often considered as automatic. Our ability to be able to quickly respond to a situation, without hesitation, comes from our working memory ability and the information that has been deemed as important enough to be stored for future usage.

Processing Speed

The Processing Speed Theory as proposed by Salthouse (1996) proposes that the speed at which information is processed influences the quality and quantity of memory performance. A person's processing speed can be described as their response time (RT) when confronted with information. The faster a person's response time is, the faster they are able to process the information and quickly answer the question. Speed of processing has been extensively studied because it appears to play a central role in the effects of age on cognition (Hartley, 2013).

The relationship between cognitive aging and processing speed is often referred to as the processing speed hypothesis and implies a meditational model such that age has an indirect effect on cognitive functioning through its direct effect on processing speed, which in turn has a direct effect on cognition (Robitaille et al., 2103). Processing speed can be related to general task-related operations and how quickly an individual is able to respond. An individual who is having trouble processing information quickly could be suffering from a neurological problem. Information could be getting cut off, or being diminished in another way. The response time of an individual is dependent open the information being quickly retrieved from memory and then used appropriately for the task at hand. The Stroop test is a(n) effective assessment when looking to test processing speed. Individuals that struggle concentrating, will not be able to recall information as quickly and their response time will lengthen. A method to improve processing speed is

Speed of processing training; it is an approach that has resulted in improvements in both cognitive and everyday functional abilities (Edwards, Haley, Lister, O'Brien, & Ruva, 2013).

Processing speed is the measure of cognitive efficiency or cognitive proficiency (ETFO 2014). A person's ability to quickly process information determines whether their processing speed is quick or slow. Recalling information from memory automatically determines the processing speed of that individual. Tasks that are practiced more, or information that has been engraved in memory, will increase the processing speed of that individual.

Relationship between Sleep Deprivation and Cognitive Functions of Working Memory and Processing Speed

Former studies suggested that the cognitive deficits are often seen on tests that place demands on attention, information processing speed, and short-term or working memory (Schucard, J., Wing, Safford, & Schucard, D., 2011). A study done by Sutter, Zollig, Allemand, & Martin (2012) states that there is a positive correlation between sleep quality and cognitive functions in relation to processing speed, executive functions, and long-term memory. Processing speed and executive may contribute differentially to age-related changes in different aspects of memory (Lee et al., 2012). This study looks to determine if there is any type of correlation between sleep deprivation, working memory, and processing speed.

According to Abel & Bäuml (2013) recent studies have suggested a link between sleep and memory consolidation, indicating that sleep in comparison to wakefulness stabilizes memories. Previous research has suggested that cognitive processes such as inhibition, executive attention and control, processing speed, and differences in capacity of storage are responsible for individual differences in working memory (Villegra, Gothë, Oberauer, & Kliegel, 2013).

An individual's performance, which develops during a period of work, is accentuated by the loss of one night's sleep (Pepler, 1958). The more sleep that an individual gets the more able they will be to complete strenuous tasks that require higher cognitive functioning. If there is a positive correlation, then it can be assumed that there is an inverse correlation with sleep deprivation and the affect it has on cognitive function. In previous studies there have been little findings in determining if there is any type of relationship between sleep deprivation and cognitive function. That is exactly what this study hopes to determine. A good measure of a person working memory and processing speed is the cognitive Stoop test.

Stroop Test

The Stroop (Stroop, 1935) is a frequently used neuropsychological test, with poor performance typically interpreted as indicative of disinhibition and frontal lobe damage. The Stroop test measures an individual's basic attention, working memory, and processing speed. According to Heffin, Laluz, Jang, Ketelle, Miller, & Kramer (2011) correlation with other neuropsychological tests have found that the Stroop shares a large amount of variance (e.g., correlation of .95) with that of different measures of processing speed.

The test typically consists of three conditions: a color naming condition for which individuals are asked to name patches of colors on a page as quickly as possible, a color reading condition for which individuals are asked to read color names on a page as quickly as possible (congruent) and a color-word interference condition that contains color names written in incongruent colors (Heffin et. al., 2011). During the congruent trials the words will match the color (e.g., *BLUE* in blue color). As for the incongruent trials the world will conflict with the color (e.g., *BLUE* written in red color). For the purpose of this study there are two conditions we are going to focus on, the color reading condition and the color-word interference condition. The longer it takes to name the colors on the color-word interference condition and the rise in the number of errors that are committed can be referred to as "the Stroop effect" (Heffin, et. al., 2011), or Interference (Meier & Kane, 2013). According to a study by Cohen, Dunbar, Batch, & Braver (1997) Stroop interference effects are asymmetrical (i.e., that words usually interfere with colors, but not the reverse). Which is one of the conditions used by the Stroop test in this study.

The Stroop test is set up proportionally (75% incongruent vs. 25% congruent) and randomizes itself between the two. Stroop measures how fast an individual can get through the test and how many errors they commit during. RT is typically longer in the incongruent rather then in the control condition (Roelofs, 2010).

The Stroop Test is a good test of a person's working memory capacity, it causes the individual to be able to filter between necessary information and interference information, and then be able to respond in a timely manner Individuals with lower-working memory capacity will commit more errors on tasks that put a premium on actively maintain accessibility to novel task goals against a strong but inappropriate habitual response (Meier & Kane 2013). Individuals with higher working memory capacity experience less color-word interference. Processing speed determines the individual's response time and how quickly an individual is able to access the information in working memory and then use it to quickly answer each question. Low working memory capacity subjects were less accurate than high working memory capacity subjects on incongruent Stroop color-word trials with a high proportion of congruent trials (Burnham, Sabia, Langan, 2013).

Chapter 3

Methodology

Participants

The participants in this study were undergraduate psychology students at Rowan University. They were recruited using the online Psychology Subject Pool website, this allowed participants to sign up for both parts of this study. A total of 32 participants signed up and participated in both parts of the study. Participants that were considered ineligible for the study included participants that did not own a smart cellphone device, and only completed part one of the study. The majority of participants were male (N=21) and very few females (N=11).

The participants were separated on what condition was used to measure for cognitive function, 22 participants that were measured using the non-verbal Stroop test and 10 participants that were measured by using the verbal Stroop test. The participants were also grouped into either "sleep deprived" (N=14) or "good sleep" (N=18) when determining sleep quality.

Materials

The application used in this study is called Sleep Time Alarm Clock (STAC), developed by Azumio Inc. This application allows participants to monitor their sleep quality throughout the night. Sleep time asks participants to set their alarm for thirty minutes after they want to wake up (e.g. if they want to way up at, 7:00am they would set their alarm for 7:30am) because the application monitors their movement throughout the night it is able to tell when the participant is either in: light sleep, deep sleep, or awake. The application will wake up the participant at their desired time, when the application thinks that the participant is in their lightest stage of sleep. Sleep time knows what stage of sleep the participant is in and will wake them up during the stage of lightest sleep, instead of pulling them out of what could be the deep sleep stage.

The conditions that were used to measure the participant's cognitive function (processing speed and working memory) were two forms of the Stroop Test; Stroop Test Online developed the first and Eric H. Chudler developed the second. These tests demonstrate the participant's ability to avoid interference and their reaction time during a task. Two Stroop tests were used, because on the last day of testing the first Stroop test's website crashed and an alternative condition was needed. In the first Stroop tests five colors were used (*BLACK, BLUE, GREEN, YELLOW, & RED*), and there were twenty total questions (five congruent and fifteen incongruent). Participants asked to choose which color ink the word that flashed on the screen was written in, the test calculated how fast they were able to answer and how many they got wrong. The second Stroop test used eight colors (*BLUE, BROWN, GREEN, ORANGE, PINK, RED, YELLOW, & WHITE*), and there was a total of forty questions (twenty congruent and 20 incongruent). Participants had to verbally read out loud the colors on the screen, and click the finish button to determine how quickly they were able to read the words.

Design

This study looked at the correlation between sleep deprivation and the affect it had on the participants cognitive functioning. Sleep deprivation was determined by the sleep time alarm clock application, a participant was determined to be sleep deprived with an average hour of sleep less than 6.5 hours. The sleep time alarm clock was able to determine the participants sleep duration and quality throughout the night by tracking their movements while they slept. The application use something called the accelerometer on their smart phone and is able to sense their movements. The movements of the participants determine what phase of sleep they are in, whether it is light sleep, deep sleep, or awake.

The sleep time alarm clock monitors their movements and determines how long the participant is in each stage of sleep for. The application is able to determine the duration of sleep a participant gets and how effective that night's sleep was for them. The data was collected for each participant and their average duration of sleep and efficiency of sleep was calculated.

There will be two different Stroop test measures used, a non-verbal and a verbal form of the Stroop test. The non-verbal Stroop test will be given on a computer and participants will be given directions on how the test is to be completed. During this test participants will be asked a total of twenty questions (5 congruent vs. 15 incongruent), and there were five options to choose from (*BLACK, BLUE, GREEN, YELLOW, RED*). Participants will need quickly and accurately decide what the color of ink the word was written in.

The second Stroop test verbally measures the participants processing and working memory abilities. This test is comprised of two parts, each part containing twenty questions (twenty congruent vs. twenty incongruent). During the first part a display of words will be shown on the screen and participants will be asked to read aloud (left to right) the color of the word (e.g. *RED* written in red ink). The number of wrong answers that the participant gives and how quickly they were able to respond will be calculated and recorded. In the second part of the Stroop test, again of display of twenty words will be shown but this time participants will be ask to identify and respond to the color ink the word is written in (e.g. *RED* written in blue ink). Again the number of wrong answers given and how quickly they were able to respond will be calculated and recorded. When the data collected from the Stroop tests is analyzed, a conclusion and interpretation of the data will result.

Procedures

First, a group of participants was created. Using the Rowan University online subject pool, students were given the opportunity to sign up and participate in both parts of the study. Students that only completed part one of the study were eliminated from the pool of participants.

Participants will be asked download an application sleep time alarm clock on their smart (STAC) cell phone. An explanation of the application will be given to them, and directions on how to use it. STAC will monitor their sleep throughout the night and determine their duration of sleep and how efficient their sleep was. Participants will be instructed to use the application for five out of seven days, because the application only can hold five days' worth of data and also to give them an extra day in case they were to forget to set their alarm one night. After a week of using the STAC participants will be asked to come back in so that the data may be collected and recorded from the application and then complete the cognitive test.

The first twenty-two participants completed the non-verbal condition of the Stroop test. In this version participants were asked to sit at a computer and read the on screen directions. There were twenty questions, the directions were to look for the color the word is written in and respond with that color as their answer. At the end of the test, average response time and number of errors were displayed and then recorded for each participant.

Due to an unforeseen complication the last ten participants had to complete an alternate Stroop test condition. This test was broken into two parts, the first part required participants to verbally read off a list of twenty words the color that was shown. The second part was where the Stroop interference would come in. Participants were asked to again verbally read off a list of words, but this time respond with the color that the word was written in (e.g. *RED* written in blue ink). At the end of each part the response times were given, the numbers of errors were recorded as the participant read aloud their responses.

The data collected from both STAC and the Stroop test were analyzed to investigate whether correlations exist between a sleep deprivation and the cognitive function of an individual. Analyses were also conducted to determine if the condition of the Stroop test (non-verbal vs. verbal) had any relation with the processing speed of the participant. Explanations and interpretations were made from the results of the data that was collected.

Chapter 4

Results

Before the result can be presented an understanding of represented values used for the analyses and interpretation of data is needed. When looking at the data "good sleep" is an average nights rest of over 6.5 hours of sleep, anything under that number is classified as "sleep deprived". Also, the conditions were either non-verbal response, or a verbal response.

Descriptive Statistics: Sample Population

Descriptive statistics were conducted on the entire body of data collected. There are two tables to help show overall representation of the sample in this study. The results in Table 1 are a descriptive statistics pertaining only to the processing speed of the participants in this study, and Table 2 is a descriptive statistics pertaining to the working memory of the participants of this study. To summarize processing speed, the mean Average Nonverbal Scores among the participants was 29.332 seconds RT (SD = 6.64) and the mean Average Verbal Score among this sample population was 41.728 seconds RT (SD = 7.77). In the nonverbal condition participants with good sleep had an average scores RT of 28.953 seconds (SD = 7.85) and participants who were sleep deprived had an average RT of 29.996 seconds (SD = 4.10). For the verbal condition the participants average RT when they received a good night's sleep was 39.645 seconds (SD = 6.01) and participants who were sleep deprived had a RT time of 43.117 seconds (SD = 9.01).

To summarize working memory, the mean Average Nonverbal Scores among this sample population was 94.55% correct responses (SD = 7.55) and the mean Average Verbal Scores among this sample population was 97.25% correct responses

(SD = 4.92). In the nonverbal condition participants with good sleep had an average scores of 97.14% of correct responses (SD = 5.45) and participants who were sleep deprived had an average score of 90.00 % of correct responses (SD = 8.86). For the verbal condition the participants average RT when they received a good night's sleep was 98.13% of correct responses (SD = 3.75) and participants who were sleep deprived had a RT time of 96.67% of correct responses (SD = 5.85).

Table 1

Descriptive Statistics: Processing Speed

Processing Speed/Measure	N	Mean	SD
Nonverbal			
Sleep Deprived	8	29.996	4.10
Good Sleep	14	28.953	7.85
Verbal			
Sleep Deprived	6	43.117	9.01
Good Sleep	4	39.645	6.01
Average Nonverbal Score	22	29.332	6.64
Average Verbal Score	10	41.728	7.77

Note. Scores for processing speed are calculated in seconds.

Table 2

Descriptive Statistics: Working Memory

Working Memory/Measure	N	Mean	SD
Nonverbal			
Sleep Deprived	8	90.00	8.86
Good Sleep	14	97.14	5.45
Verbal			
Sleep Deprived	6	96.67	5.85
Good Sleep	4	98.13	3.75
Average Nonverbal Score	22	94.55	7.55
Average Verbal Score	10	97.25	4.92

Note. Scores for working memory are calculated in percentage of correct responses.

Analyses Investigation Sleep Deprivation Affects on Processing Speed

The following statistical processes were conducted to investigate participants processing speed and how it was affected in the study. The correlation between processing speed and the quality of sleep participants obtained was not statistically significant, $r(32) = +1.509$, $p = .231$. The correlation between processing speed and the sex of the participant was not statistically significant, $r(32) = +.335$, $p = .568$. A univariate analysis of variance (general linear model) was calculated to assess whether processing speed was affected by the condition in which the participant was measured by. The findings were significant, $F(1,32) = 9.728$, $p = .005$.

Table 3

Variance of Scores specific to Processing Speed

	df	SS	MS	F	p
Conditions	1	526.878	526.878	9.728	.005**
Sleep	1	81.749	81.749	1.509	.231
Sex	1	18.120	18.120	.335	.568
Condition*Sleep	1	19.355	19.355	.357	.556
Condition*Sex	1	51.955	51.955	.959	.337
Sleep*Sex	1	14.764	14.764	.273	.606
Condition*Sleep*Sex	1	76.305	76.305	1.409	.247
Error	24	1299.823	1299.823		
Corrected Total	31	2524.807			

Note. **Finding is significant at $p < 0.05$.

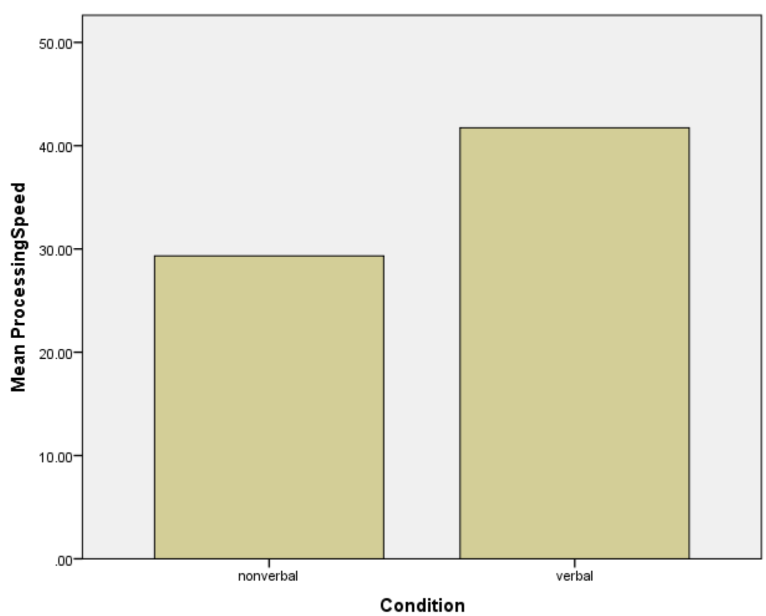

Figure 1 Comparing nonverbal scores with verbal scores in regards to response time in processing speed.
Note. *** Finding is significant at $p< .005$

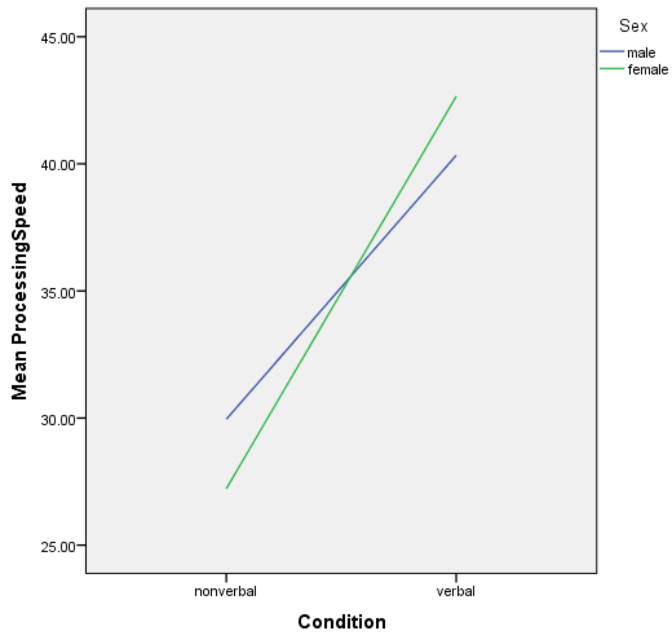

Figure 2 Comparing nonverbal scored and verbal scores in regards to the sex of the participant and their response times.
Note. *** Finding is significant at p< .005

Analyses Investigation Sleep Deprivation Affects on Working Memory

The following statistical processes were conducted to investigate participants processing speed and how it was affected in the study. The correlation between working memory and the quality of sleep participants obtained was not statistically significant, r(31) = +3.862, p = .061. The correlation between working memory and the condition in which the participants were measured was not statistically significant, r(31) = +2.681, p = .115. The correlation between working memory and the sex of the participant was not statistically significant, r(31) = +.326, p = .573. A univariate analysis of variance (general linear model) was calculated to assess whether working memory was affected by the condition in which the participant was measured by and the sex of the participant. The findings were significant, F(1,31) = 4.442, p = .046. A univariate analysis of variance (general linear model) was calculated to assess whether working memory was affected by the quality of sleep the participant obtained and the sex of the participant. The findings were significant, $F(1,31) = 5.008$, $p = .035$

Table 4

Variance of Scores specific to Working Memory

	df	SS	MS	F	p
Conditions	1	105.044	105.044	2.681	.115
Sleep	1	151.295	151.295	3.862	.061
Sex	1	12.770	12.770	.326	.573
Condition*Sleep	1	174.029	174.029	4.442	.046**
Condition*Sex	1	39.048	39.048	.997	.328
Sleep*Sex	1	196.205	196.205	5.008	.035**
Condition*Sleep*Sex	1	.398	.398	.100	.921
Error	24	940.298	39.179		
Corrected Total	31	1463.867			

Note. **Findings are significant at $p < 0.05$.

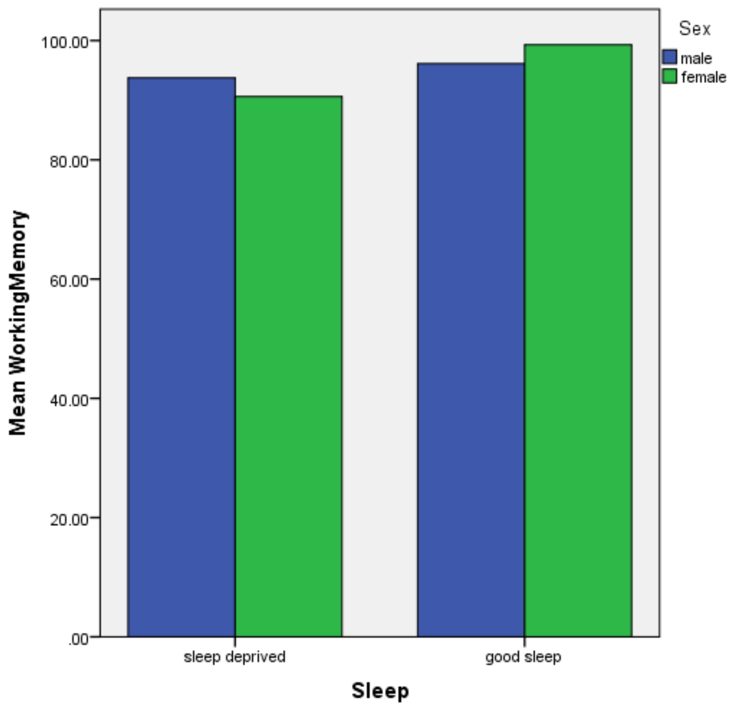

Figure 3. Comparing sleep quality in regards of sex of the participant and how accurately their responses were.
Note. *** Finding is significant at p< .005

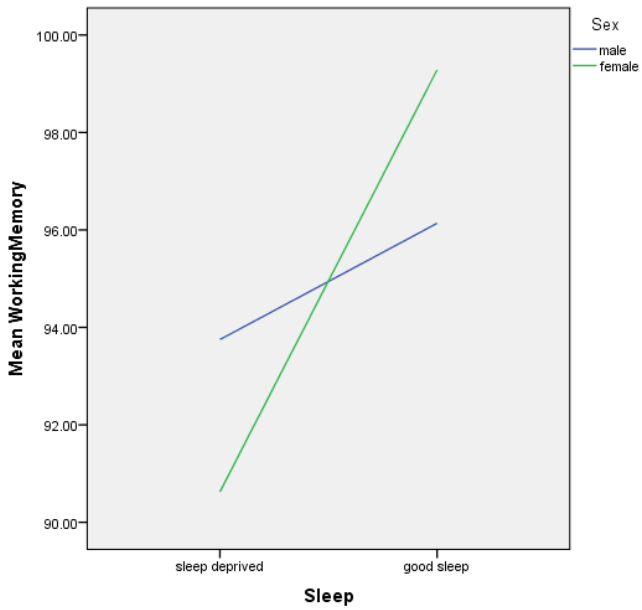

Figure 4. Comparing sleep quality in regards to sex of the participant and how accurately their responses were.
Note. *** Finding is significant at $p < .005$

Chapter 5

Discussion

Conclusion regarding Sleep Deprivation and Cognitive Function

The findings from this study revealed significant information about the same population that was targeted in this research. However, not all of the results were of significance (p = .05). This study did not find a significant relationship between sleep deprivation and an individual's cognitive function; processing speed and working memory; processing speed and working memory. Sleep was only an influential factor when it pertained to sex of the individual and working memory. During analysis of the results there were significant findings for factors relating to both processing speed and working memory.

In contrast to Matella & Marotta (2013) Sleep quality did not have a impact on the individual's cognitive function. These results showed no evidence that less sleep an individual receives the negative impact it would have on their cognitive functioning. There was no support that there was any type of correlation between sleep deprivation and an individual's cognitive functioning.

Factors Relating to Working Memory

After analyzing the results there were two significant results relating to working memory. There were significant correlations for working memory and the factors of the sex of the participant and the quality of sleep they received (sig.= .035). These results show us that females who are sleep deprived tend to make more errors then males who are sleep deprived. Figure 3 shows a difference between male vs. female schools for errors committed. Working memory also had a significant correlation between the factors of the sex of the participant and the condition they were measured by (sig.= .046). Working memory seems to be mostly affected by the sex of the participant, this does not give us an accurate enough view of the correlation between working memory and sleep. The sex of the participants is not a sufficient enough factor to accurately determine if there is a significant correlation between working memories and sleep deprivation.

Factors Relating to Processing Speed

During the analysis of the results a significant correlation between processing speed and the condition was found (sig.= .005). The conditions were how the participants were measured using the Stroop test, either with the non-verbal version or the verbal version of the test. When participants have to verbally respond it take them longer then it would to click a button on the keyboard. The articulation that is required when verbally responding takes longer to process the right words that need to be used while responding. Processing speed is a good factor when trying to determine an individual's cognitive function, in this study there was no significant correlation between processing speeds and sleep deprivation.

Limitations

The main limitation in this study is the limited amount of students that were part of the population. The participants that were recruited from the Rowan subject pool, any student that was able to log onto the online system, was only a handful of the total number of undergraduate students at Rowan. During parts one and two of the study, there was only limited amount of time given to meet with the participants. Meaning that there was only so many students that could participate in the study, because there were only certain hours of availability to meet with the participants.

This study has very little demographic information to provide. This does not allow for a better understand of the population group. Understand the diversity of sample population in this study could help to better understand the results of the population.

Further Directions

Expanding the field to all undergraduate students and not just the select handful that can use the Rowan online system can increase the limited population that was used. Expand the field and allow more than just a select number of students to participate. The more students in the population the better results that can be found. A large subject pool to obtain participants from it allows for more of a diverse group of participants.

Time is always the most important part of any study, and for this study there was very limited time. For better results and to open up the population to more participant further studies should plan for multiple weeks of research. The more weeks the more time that can be given to recruit participants, and the more participants there are the more data that can be drawn. A more diverse population can help to better understand how certain cultures sleep can be either effective or ineffective.

References

Abel, M. & Bauml, K. H. (2013). Sleep Can Eliminate List- Method Directed Forgetting. *Experimental Psycholog: Learning, Memory, and Cognition, 39*(3), 946-952.

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? Trends in Cognitive Sciences, 4, 417–423.

Baranski, I. V., & Pigeau, R. A. (1997). Self-monitoring cognitive performance during sleep deprivation: Effects of modafinil, d-amphetamine and placebo. *Journal of Sleep Research, 6,* 84-91

Blagrove, M., & Akehurst, L. (2000). Effects of Sleep Loss on Confidence-Accuracy Relationships for Reasoning and Eyewitness Memory. *Journal of Experimental Psychology, 6*(1), 59-73.

Bub, K. L., Buckhalt, J. A., & El-Sheik, M. (2011). Children's Sleep and Cognitive Performances: Across-Domain Analysis of Change over time. *Developmental Psychology, 47*(6), 1504-1514.

Burnham, B.R., Sabia, M., & Langan, C. (2014). Components of Working Memory and Visual Selective Attention. *Journal of Experimental Psychology, 40* (1), 391-403.

Cohen, J. D., Dunbar, K. O., Batch, D. M., & Braver, T. S. (1997). Issues concerning relative speed of processing hypotheses, schizophrenic performance deficits, and prefrontal function: Comment on Schooler et al. (1997). Journal of Experimental Psychology: General, 126, 37-41.

Dinges, D. F., Pack, F., Williams, K., Gillen, K. A., Powell, J. W., Ott, G. E., . . . Pack, A. I. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4–5 hours per night. *Sleep, 20,* 267–267.

Drummond, S., Brown, G., Gillin, J., Stricker, J., Wong, E., & Buxton, R. (2000). Altered brain response to verbal learning following sleep deprivation. *Nature, 403,* 655 657.

Edwards, J. D., Haley, C. B., Lister, J. J., O'Brien, J. L. & Ruva, C. L. (2013). An Examination of Mediators of the Transfer of Cognitive Speed of Processing] Training to Everyday Functional Performance. *Psychology and Aging, 28*(2), 314 321.

Fisk, J.E., Mongormery, C., & Murphy, P.N. (2009). The Association Between the Negative Effects Attributed to Ecstasy Use and Measure of Cognition and Mood Among Users. *Experimental and Clinical Psychopharmacology, 17*(5), 326-336.

Giesbrecht, T., Smeets, T., & Leppink, J. (2013). Acute Dissociation After 1 Night of Sleep Loss. *Psychology of Consciousness: Theory, Research, and Practice, 1* (S), 150-159.

Goldstein, G., Allen, D. N., Thaler, N. S., Luther, J. F., Panchalingam, K., & Pettegrew, J. W. (2014, February 24). Developmental Aspects and Neurobiological Correlates of Working and Associative Memory. Neuropsychology

Gruber, R. (2013). Making Room for Sleep: The Relevance of Sleep to Psychology and the Rationale for Development of Preventative Sleep Education Programs for Children and Adolescents in the Community. *Canadian Psychology / Psychological Canadience, 54*(1), 62-71.

Harrison, Y., & Horne, J.A. (2000). The Impact of Sleep Deprivation on Decision Making. *Journal of Experimental Psychology: Applied, 6*(3), 236-249.

Hartey, A.A. (2013). Age and Method Variance in Measures of Speed and Working Memory *Psychology and Age, 28*(2), 522-528.

Hefin, L.H., Laluz, V., Jang, J., Ketelle, R., Miller, B.L., & Kramer, J.H. (2011). Let's Inhibit Out Excitement: *The Relationships Between Stroop, Behavioral Disinhinbition, and Frontal Lobes. Neuropsychology, 25* (5), 655-665

Jugovac, D.; & Cavallero, C. (2011). Twenty-four hours of total sleep deprivation selectively impairs attentional networks. *Experimental Psychology, 59*(3), 115-123.

Koffel, E.(2011). Further validation of the Iowa Sleep Disturbances Inventory. *Psychological Assessment, 23*(3), 587-598

Lee, D H. K. (1950). Physiology as a guide to combating tropical stress. New *England Journal of Medicine*, 243, 723-730.

Lee, T., Crawford, J.D., Henry, J.D., Trollor, J.N., Kochain, N.A., Wright, M.J., …Sachdev, P.S. (2012). Mediating Effects of Processing Speed and Executive Function in Age-Related Differences in Episodic Memory Performance : *A Cross Validation Study. Neuropsychology, 26* (6), 776-784.

Lervåg, M.M. & Hulme, C. (2013). Is Working Memory Training Effective? A Meta Analytic Review. *Developmental Psychology, 49*(2). 270-291.

Lim, J., & Dinges, D.F. (2010). A Meta-Analysis of the Impact of Short-Term Sleep Deprivation on Cognitive Variables. *Psychological Bulletin, 136*(3), 375-389.

Malmo, R.B., & Surwillo, W.W. (1960). Sleep Deprivation: *Changes in Performance and Physiological Indicants of Activation*. *Psychological Monographs, 74*(15).

Martella, D. & Marotta, A. (2013). Inhibition of Return, but Not Facilitation, Disappears Under Vigilance Decrease Due to Sleep Deprivation. *Experimental Psychology,* 1-11.

Maslow, A. (1943). A theory of human motivation. *Psychological Review, 50,* 370–396. Maddox, W.T., Zeithamova, D., & Schnyer, D.M. (2009). Dissociable Processes in Classification: Implications from Sleep Deprivation. *Military Psychology, 21*, S55-S61.

Meier, M. E. & Kane, M. J. (2013). Working Memory Capacity and Stroop Interference: Global Versus Local Indices of Executive Control. *Experimental Psychology: Learning, Memory, and Cognition, 39*(3), 748-759.

Minkel, J.D., Banks, S., Hataik, O. Moreta, M.C., Jones, C.W., McGlinchey, E.L., Simpson, N.S., & Dinges, D.F. (2012). Sleep Deprivation and Stressors: Evidence for Elevated Negative Affect in Response to Mild Stressors when Sleep Deprived. *Emotion, 12*(5), 1015-1020.

Moore, R. Y. (1999). A clock for the ages. *Science, 284,* 2102–2103.

National Sleep Foundation. (2005). *Sleep in America poll*. Washington, DC: Author

Nebes, R. D., Buysse, D. J., Halligan, E. M., Houck, P. R., & Monk, T. H. (2009). Self reported sleep quality predicts poor cognitive performance in healthy older adults. *The Journals of Gerontology, Series B: Psycho- logical Sciences and Social Sciences, 64,* 180 –187.

Nebes, R. D., Butters, M. A., Mulsant, B. H., Pollock, B. G., Zmuda, M. D., Houck, P. R., & Reynolds, C. F. (2000). Decreased working memory and processing speed mediate cognitive impairment in geriatric depression. Psychological Medicine, 30, 679–691

Oberauer, K., Süß, H.-M., Wilhelm, O., & Sander, N. (2008). Individual differences in working memory capacity and reasoning ability. In A. R. A. Conway, C. Jarrold, M. J. Kane, A. Miyake, & J. N. Towse (Eds.), *Variation in working memory* (pp. 49–75). New York, NY: Oxford University Press.

Peachey, J. T., & Zelman, D. C. (2012). Sleep education in clinical psychology training programs. *Training and Education in Professional Psychology, 6*(1), 18-27.

Peich, M.C., Husain, M., & Bays, P.M. (2013). Age-Related Decline of Precision and Binding in Visual Working Memory. *Psychology and Aging, 28* (3), 729-743.

Pepler, R.D. (1958). Warmth and lack of Sleep: Accuracy or Activity Reduced. Phillips, L.H., Smith, L., Gilhooly. (2002). The Effects of Adult Again and Induced Positive and Negative Mood on Planning. *Emotion, 2*(3), 263-272.

Roelofs, A. (2010). Attention and Facilitation: *Converging Information Versus Inadvertent Reading in Stroop Task Performance. Journal of Experimental Psychology, 36* (2), 411-422.

Robitaille, A., Piccinin, A. M., Muniz-Terrera, G., Hoffman, L., Johansson, B., Deeg, D. J. H., Aartsen, M. J., Comijs, H. C., & Hofer, S. M. (2013, August 19). Longitudinal Mediation of Processing Speed on Age-Related Change in Memory and Fluid Intelligence. *Psychology and Aging*.

Rodriquez-Villegra, O. A., Gother, K., Oberauer, K., & Kliegel, R. (2013). Working Memory Capacity in a Go/No-Go Task: Age Differences in Interference, Processing Speed, and Attentional Control. *Developmental Psychology, 49*, (9) 1683-1696.

Rose, N.S. (2013). Individual Differences in Working Memory, Secondary Memory, and Fluid Intelligence: *Evidence From the Levels-of-Processing Span Task*. *Canadian Journal of Experimental Psychology, 67*(4), 260-270.

Sadeh, A., Raviv, A,. & Gruber, R. (2000). Sleep patterns and sleep disruptions in school- age children. *Developmental Psychology, 36*(3), 291-301.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Bulletin, 103,* 403–428

Schmidt, R.E., & Van der Linden, M. (2009). The Aftermath of Rash Action: Sleep Interfering Counterfactual Thoughts and Emotions. *Emotions, 9*(4), 540-553.

Schmutte, T., Harris, S., Levin, R., Zweig, R., Katz, M., & Lipton, R. (2007). The relation between cognitive functioning and self-reported sleep complaints in non demented older adults: *Results from the Bronx Aging Study*. *Behavioral Sleep Medicine, 5*, 39–56.

Schnyer, D.M., Zeithamova, D., & Williams, V. (2009). Decision-Making Under Conditions of Sleep Deprivation: *Cognitive and Neural Consequences. Military Psychology, 21* (1), S36-S45.

Shucard. J.L., Wing, H.L., Safford, A.S., & Shucard, D.W. (2011). The Relationship Between Processing Speed and Working Memory Demand in Systemic Lupus Erythematous: *Evidence From a Visual N-Back Task. Neuropsychology, 25* (1), 45-52.

Stickgold, R., & Walker, M. P. (2005). Sleep and memory: The ongoing debate. *Sleep, 28,* 1225-1227.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662

Sutter, C., Zollig, J., Allemand, M., & Martin, M. (2012). Sleep Quality and Cognitive Function in Healthy Old Age: The Moderating Role of Subclinical Depression. *Neuropsychology, 26*(6), 768-775.

Talbot, L. S., Harvery, A. G., Kaplan, K. A., McGlinchey, E. L. & Dahl, R. E. (2010). Sleep Deprivation in Adolescents and Adults: Changes in Affect. *Emotion,* (10), 831-841.

Vergauwe, E., Camos, V., & Barrouillet, P. (2014). The Impact of Storage on Processing: *How Is Information Maintained in Working Memory? Journal of Experimental Psychology.*

Welsh, D. T., Ellis, A. P. J., Christian, M. S., & Mai, K. M. (2014). Building a Self Regulatory Model of Sleep Deprivation and Deception*: The Role of Caffeine and Social Influence. Journal of Applied Psychology.*

Willert, M.V., Thulstrup, A.M., & Bonde, J.P. (2010). Sleep and Cognitive Failures Improved by a Three-Month Stress Management Intervention. *International Journal of Stress Management, 17*(3), 193-213.

Williamson, A. M., Feyer, A., Mattick, R. P., Friswell, R., & Finlay-Brown, S. (2000). Developing measures of fatigue using an alcohol comparison to validate the effects of fatigue on performance. *Accident Analysis and Prevention, 33*, 313 326.