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Effect of Sleep on Vigilance, Short-Term Memory, and Learning in College Students

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This is to certify that the doctoral dissertation by

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Walden University
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Abstract

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MA, The City College of New York, 2007

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

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Abstract

Despite years of research supporting a link between sleep and cognitive functioning, little research has focused on the effect of sleep on cognitive factors in the college population. According to the trace reactivation hypothesis, sleep plays a crucial role in memory consolidation and learning. Cognitivism further indicates that the processing of information is limited when sleep is restricted. The purpose of this quantitative study was to examine the effect of sleep on vigilance, short-term memory, and learning; an additional goal was to test whether these variables influence grade point average (GPA). Sleep and GPA data were collected using self-report questionnaires. Vigilance was measured using the Digit Vigilance Test (DVT). Short-term memory and learning were measured using subtests of the Wide Range Assessment of Memory and Learning, 2nd Edition (WRAML 2). Data were collected from 20 undergraduate students to detect an effect size of .90 with a power of at least .80, one tailed $p < .05$. Test assumptions were satisfied prior to analysis using SPSS. Independent samples *t* tests were used to compare the difference between adequate and inadequate sleep on measures of vigilance, short-term memory, and learning. Results indicated that inadequate sleep had a significant effect on short-term memory and learning but not on vigilance. A multiple linear regression analysis revealed that sleep, vigilance, short-term memory, and learning were not significant predictors of GPA. The small sample size may have limited the study conclusion. This study may help students, educators, and school administrators to improve academic performance as well as develop effective learning strategies.

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Dedication

This dissertation is lovingly dedicated to my parents. This is for my mom, Helima Uddin, whose support, words of encouragement, and push for perseverance got me through the challenges and obstacles faced throughout the entire doctoral program. In fact, it was my mom who gave me the courage to pursue a PhD degree. This accomplishment is in memory of my dad, Askir Uddin, whose belief in diligence and pursuit of academic excellence inspired me to stay driven in accomplishing this goal. I could not be more blessed in life than to have such wonderful parents.

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Chapter 1: Introduction to the Study

Introduction

In today's fast-paced society, sleep deficiency has become a widespread problem affecting quality of life for many Americans. Reportedly, about 50 to 70 million adults in the United States experience sleep problems that adversely affect their health and longevity (McKnight-Eily et al., 2009). Like food, sleep is a basic biological need that the body requires to function and survive (Gilbert & Weaver, 2010). Hence, sleep is a vital function of life. Despite the understanding of the significance and processes of sleep that has been supported by research over the years, there is yet much to be explored about the many roles of sleep in human functioning.

Researchers argued that sleep is one of the most important yet least understood functions of the brain (Hayaishi, 2011; Wright, Hull, Hughes, Ronda, & Czeisler, 2006). Scientists have been attempting to find answers to questions about sleep such as why it is important, why it is needed, and how it is regulated. Although over 100 sleep disorders have been described over the years, the etiology of many of these disorders is still unclear (Hayaishi, 2011). What is clear about sleep disorders is that they are linked to cognitive impairments such as poor memory and learning as a result of sleep disruptions and poor sleep (Beebe, Di Francesco, Tlustos, McNally, & Holland, 2009; Hagewoud et al., 2010a; Nakao, 2006).

According to Wulff, Gatti, Wettstein, and Foster (2010), there has been a long history of research suggesting an association between sleep disruption and mental health. Researchers have argued that insufficient sleep is associated with low mood and affect

(Wulff et al., 2010). It has been reported that sleep problems are common in patients with Alzheimer's disease (AD) or Parkinson's disease (PD), and that more than 80% of patients with depression or schizophrenia report sleep complaints (Wulff et al., 2010). Furthermore, sleep deficiency has been linked to cognitive impairment, emotional impairment, a poor immune system, metabolic problems, and higher risks of cancer and heart disease (Wulff et al., 2010).

Although there are many debates about the need for sleep in the scientific community, no one really knows why humans sleep. Scholars have proposed a number of hypotheses in an attempt to explain the function of sleep. One theory is the restorative theory of sleep, which proposes that the body repairs itself from everyday wear and tear and restores biological processes during sleep. Research supporting this theory shows an increase in sleep after a period of sleep deprivation or strenuous physical activities (Browman, 1980; Robles & Carroll, 2011). Additionally, the energy conservation hypothesis suggests that brain thermoregulation, detoxification, and tissue restoration take place during sleep (Maquet, 2001). Each of these theories provides valid arguments regarding the function of sleep. Both indicate that sleep functions to restore and energize the body from everyday usage. Another possible argument to support these theories is the need for rest after mental/physical exercise (Courtney, Francis, & Paxton, 2010; De Lange et al., 2009; Ioana Cristina & Mungiu, 2009).

Wright et al. (2006) argued that *sleep homeostasis*, the need for sleep, builds up with the duration of wakefulness. In other words, the longer a person stays awake, the sleepier they become with the passing of time. Wulff et al. (2010) described sleep as a complex state resulting from an interaction between the circadian rhythm and a sleep-wake homeostatic build-up of sleep pressure. Therefore, sleep is inevitable. Scholars agreed that a person may voluntarily put off sleep only for so long before the onset of involuntary sleep (Crowley, 2011; Ferrara & De Gennaro, 2011; Rempe, Best, & Terman, 2010).

Research suggests that humans maintain alert wakefulness for about 15 to 17 hours and that extending it beyond this time impairs brain functions that include vigilance, short-term and long-term memory, executive functions, and learning (Hagewoud, 2010a; Wright et al., 2006).

Studies on sleep deprivation have focused on the need for sleep to maintain normal levels of cognitive ability and physical activity, including implications for physical and psychological health. Many researchers have suggested that sleep deprivation increases both physical and mental health risks, as well as accident-related injuries that result in immediate death (Clinkinbeard, Simi, Evans, & Anderson, 2011; Gregory, 2008). The quantity and quality of sleep affect daily physical and cognitive functioning. Experts have suggested that insufficient sleep reduces the quality of physical and cognitive performance. Prolonged sleep loss has been implicated in chronic fatigue syndrome (CFS), which impairs the capacity to fulfill daily activities (Ioana Cristina & Mungiu, 2009). Thus, sleep management is important for health and safety.

Research has shown that sleep is associated with optimal performance of essential cognitive functions related to academic and social success in higher education (Gilbert & Weaver, 2010). Therefore, ramifications of sleep deprivation are crippling the educational process and getting in the way of academic and career success. Thus, inadequate sleep is widely recognized as a major public health issue. As a result, sleep research has gained a lot of attention over the years with growing concerns in the health and education fields. Although substantial research conducted over the years has focused on the impact of sleep on areas of human functioning such as vigilance, short-term memory, and learning, the relationship between these areas is still poorly understood.

Background

For centuries, scientists have been fascinated by the complexities of the human mind. Although Hergenhahn (2009) documented that psychology established itself as a distinctive field of study in the early 1900s, many scholars have referred to an origin of psychology long before this time. Inquiries into mind-body phenomena are evidenced in works of many early Greek philosophers, who not only influenced the later contributions to many different areas of psychology, but also created a foundation for this field of study. Phenomena of the human mind that continue to intrigue researchers are learning, memory, and vigilance, as well as how the biological function of sleep relates to cognitive processes (Crowley, 2011).

The mind and cognitive processes have been examined in many fields in an effort to gain greater insight through different perspectives. One such field in which scholars are interested in uncovering the relationship between sleep and cognitive processes has been sleep research. Researchers have attempted to explore the vital role of sleep in human functioning by examining the consequences of sleep deprivation and making inferences about how sleep affects mental state and cognitive functions (Clinkinbeard et al., 2011; Mograss, Guillem, Brazzini-Poisson, & Godbout, 2009).

Although complex phenomena such as sleep, learning, memory, and attention remain poorly understood, researchers over the decades have indicated crucial roles that they play in human functioning. As a result, the relationship between such phenomena has received wide recognition in the scientific community. It has been widely evidenced that sleep deprivation (full/partial) impacts learning, memory, and attention. Studies have suggested that both the quantity and quality of sleep have a profound effect on learning, memory, and attention (Astill, Van der Heijden, Van IJzendoorn, & Van Someren, 2012). For instance, a person deprived of sleep may have difficulty focusing his or her attention to information presented and may not learn it well because it may not be stably processed into memory.

Numerous studies have suggested that memory is consolidated during sleep, a process in which memory becomes stable (Fenn & Hambrick, 2012; Holz et al., 2012; Wiedemann, 2009). Sleep research has implied that different stages of sleep are responsible for strengthening learning and memory. Additionally, nonrestorative sleep impairs ability to focus and concentrate during the learning and memory process.

Research examining brain functions has revealed that the association between sleep-wakefulness and internal circadian timing is very important in reinforcing cognitive performance (Nakao, 2006; Wright et al., 2006). It has been established that the quality of sleep plays a role in other brain functions such as vigilance, short-term memory, and learning (Nakao, 2006). Studies that limited sleep to 6 hours or less per night reported that vigilance performance decreased and sleepiness increased on subsequent waking hours (Wright et al., 2006). Similarly, research showed that memory traces were found first in slow wave sleep during non-rapid eye movement sleep and then later in rapid eye movement sleep (Nakao, 2006; Wright et al., 2006).

To better understand cognitive functioning and other physiological processes associated with it, scientists have turned their attention to the field of cognitive science. Cognitive science is a fairly recent field that has bloomed over the past 50 years as researchers have attempted to explain states of consciousness that include attention, memory, and learning, as well as sleep, an altered state of consciousness (Vaitl et al., 2013). Given that sleep is considered an altered state of consciousness by many scholars, it can be argued that studying this phenomenon provides researchers with useful insights concerning the implications of sleep for cognition. Hence, examining the role of sleep and how the human body functions after sleep deprivation has provided scientists with important insights about sleep and functions linked to this phenomenon (Hayaishi, 2011).

Consciousness is a complex phenomenon that is poorly understood despite years of research. There is much yet to be learned about cognitive processes and states of consciousness in human functioning (Cavanna, Shah, Eddy, Williams, & Rickards, 2011). Though the effects of sleep on short-term memory retention capacity and the learning slope have received a great deal of focus in the past, very few studies on this topic have focused on the college population group. Furthermore, there is a limited amount of data on the role of sleep in vigilance during learning in the traditional classroom setting.

It is general knowledge that most college students deprive themselves of sleep to meet the many demands of everyday student life (Anderson, 2010; Gomes, Tavares, & de Azevedo, 2011; Srivastava, Tamir, McGonigal, John, & Gross, 2009). For instance, student life demands not only attending classes, but also balancing time for assignments and studying while making time for other duties. Balancing time and managing a healthy sleep schedule become two of the most difficult tasks for many undergraduate freshman students (Lev Ari & Shulman, 2012). During the first year of college, students are expected to keep up with coursework at a faster rate than they are used to while adapting to their new lifestyle (Welle & Graf, 2011). Although many adapt to their new lifestyle, sleep deficiency and daytime sleepiness are not uncommon for students (Lev Ari & Shulman). Consequently, attention and concentration are poor during classroom lectures, information presented is poorly processed to short-term memory, and learning is not effective (Anderson, 2010; Hagewoud et al., 2010b; Lim & Dinges, 2010; Valdez, Reilly, & Waterhouse, 2008). Accordingly, many students struggle to meet their academic goals and suffer financially (Okpala, Hopson, & Okpala, 2011; Toby, 2010).

There are many different theories of learning. Each theory has been developed in an attempt to provide a general explanation of the learning process. Learning theorists have generally attempted to provide a conceptual framework of acquired knowledge, how it is processed, and the amount retained from different theoretical perspectives (Watrin & Darwich, 2012). The learning theory applied in a setting is determined by the type of learner(s) and the model that describes them. Additionally, people have unique styles of learning and learn at different rates. Several variables, both extrinsic and intrinsic to the learner, can interfere with the learning process and produce different learning responses (Wright et al., 2006).

Cognitivism is a relatively recent learning theory that focuses on mental processes (Yilmaz, 2011). Its proponents attempt to explain cognitive activities occurring during learning. Hence, cognitivism provides a theoretical foundation for vigilance, short-term memory, and learning, as all these factors require information processing and are cognitive functions. Cognitivists are scientists who are concerned with information processing into schema and determining the learning experience rather than simply observing behavioral changes. In other words, cognitivists focus on the learning process behind a behavior. Mental processes can be impaired by physiological insufficiency of sleep, which acts on various areas of the brain (Marzano, Ferrara, Curcio, & De Gennaro, 2010; Tartar, 2006).

There is little research evidence indicating the implications of sleep for lecture learning in the undergraduate full-time college population group. Researchers have established a link between sleep and brain functions like vigilance, short-term memory, and learning (Beebe et al., 2009; Hagewoud et al., 2010a; Nakao, 2006; Wright et al., 2006). Scholars have agreed that learning outcomes are associated with sleep among college students (Gilbert & Weaver, 2010; Gomes et al., 2011; Vail-Smith et al., 2013). However, there is no current research supporting the effect of sleep on lecture learning based on vigilance and short-term memory performance.

Statement of the Problem

Although there is some controversy over how much sleep is necessary, experts have advised that 7 to 9 hours of sleep per night are necessary for optimal functioning in adults (American Psychological Association [APA], 2013; National Sleep Foundation [NSF], 2009). Research has reported that sleep deprivation (inadequate amount of total sleep) and nonrestorative sleep (poor sleep quality) have become an epidemic in American society (APA, 2013; McKnight-Eily et al., 2009; NSF, 2009). Sleep deprivation and poor sleep quality have become major barriers to learning affecting college students (Gilbert & Weaver, 2010; Gomes et al., 2011). Evidence has suggested that sleep is necessary for key cognitive functions related to academic success in college students (Gilbert & Weaver, 2010). Inadequate sleep has been implicated in lower performance on course evaluations due to poor attention and short-term memory processes that interfere with learning. Recent research has revealed that sleep deprivation significantly impairs attention, memory, and subsequently learning (Anguera, Reuter-Lorenz, Willingham, & Seidler, 2010; Hagewoud et al., 2010b; Mograss et al., 2009).

Recent research has suggested a strong association between the total amount of sleep, sleep quality, and academic achievement among undergraduate college students (Gilbert & Weaver, 2010; Gomes et al., 2011). Though college students are prone to the same risks accompanying poor sleep as the general population, the lifestyle and campus culture add a unique set of challenges that place this group at greater risk for depression, anxiety, stress, risky behaviors, poor lifestyle choices, and negative impacts on general well-being (Field, Diego, Pelaez, Deeds, & Delgado, 2012; Forquer, Camden, Gabriau, & Johnson, 2008; Vail-Smith et al., 2009). Research findings have indicated that improving sleep quantity and quality leads not only to overall health benefits, but also to improved academic performance (Gilbert & Weaver, 2010; Gomes et al., 2011; Field et al., 2012; Vail-Smith et al., 2009). Therefore, there has been an increased effort to implement effective instructional designs in education and to improve academic success rates.

It is widely known that when memory and attention processes are hindered, learning may be ineffective (Finn & Roediger, 2013; Jang, Schunn & Nokes, 2011). Understanding the learning process is useful in the educational setting in regard to implementing and improving instructional designs. Information processing and memory storage are important factors to consider in learning. Studies have suggested that learning is stronger when new information is processed from short-term memory to long-term memory (Astill et al., 2012). Similarly, learning is more effective through auditory and visual encoding of information (Barrett & Livesey, 2010; Fougnie & Marois, 2011). Therefore, loss of information presented impacts the learning process.

Furthermore, it is well known that sleep consolidates memory and subsequently enhances learning (Johnson & Hasher, 1987; Neubauer, 2009). There are many different types of memory that are differentiated with specific learning tasks. For instance, memory is typically described as declarative or procedural. *Declarative memory* is fact-based information and is further divided into *spatial-temporal context* (*episodic memory*) and *facts* (*sematic memory*; Johnson & Hasher, 1987; Neubauer, 2009). *Procedural memory* involves processing of actions, skills, and habits that do not require conscious recollection (Johnson & Hasher, 1987; Neubauer, 2009).

Generally, experts agree that memory occurs in phases of encoding, storing, and recall that are affected differently by different sleep phenomena such as sleep deprivation, slow wave sleep, and rapid eye movement sleep (Horton & Mills, 1984; Le Pelley & McLaren, 2001; Neubauer, 2009). Wickelgren (1981) distinguished between the memory phases of learning, storage (consolidation), and retrieval (recall or recognition). Neuroimaging studies have shown that sleep deprivation produces abnormal hippocampal functioning, which arguably explains impaired performance on certain learning tasks (Neubauer, 2009).

According to Horton and Mills (1984), making a distinction between short-term memory and long-term memory is a useful way of organizing memory and the learning process. Researchers have postulated that learning is an indicator for rehearsal and recall from short-term memory (Horton & Mills, 1984; Johnson & Hasher, 1987; Le Pelley & McLaren, 2001; Wickelgren, 1981). Wickelgren (1981) argued that repetition makes memory traces stronger and that the way in which information is coded determines the strength of learning. Additionally, storage of information and the time lapse in retrieving it results in how well it is learned (Johnson & Hasher, 1987; Wickelgren, 1981).

Research has suggested that sleep deprivation results in poor cognitive functioning due to ineffective transfer of information in the brain. Sleep deprivation has been linked with modifications of neurotransmitter receptor function in areas of the brain and in the hippocampus, which have been implicated in learning and memory (Longordo, Kopp, & Luthi, 2009). That is, when memory is accurately encoded and stored, it can be used for later recall and learning. Hence, sleep also plays an important role in neural firing and interchange of information in brain areas responsible for attention, memory, and learning (Astill et al., 2012; Maquet, 2001; Peyrache, Khamassi, Benchenane, Wiener, & Battaglia, 2009; Shen, Kudrimoti, McNaughton, & Barnes, 1998).

Purpose of the Study

The purpose of this quantitative study was to examine the effect of sleep on vigilance, short-term memory, and learning, and to determine whether these variables predict GPA. An independent samples *t* test was conducted to look at the effect of sleep on vigilance, short-term memory, and learning. A multiple linear regression model was used to determine whether the variables of sleep, vigilance, short-term memory, and learning predicted the dependent variable of GPA. Martella, Marotta, Fuentes, and Casagrande (2014) defined *vigilance* as sustained activation of the neural network over a period of time to maximize task performance. Vigilance in this study was measured with attention and alertness (Brown, Collier, & Night, 2013; Metin et al., 2013; Roberts, Milich, & Fillmore, 2012). Ricker and Cowan (2014) defined *short-term memory* as “memory traces that can be immediately accessed and used to perform a cognitive task” (p. 417). The objective of this study was to determine whether sleep deprivation affects performance on vigilance tasks as well as the ability to process information to short-term memory for later recall and learning.

Research Questions and Hypotheses

The research questions and hypotheses listed below were derived from the review of existing literature in the areas of sleep, vigilance, memory, and learning. A more detailed discussion is provided in Chapter 3.

Research Question 1. Does inadequate sleep affect vigilance task performance in undergraduate college students?

Null Hypothesis ($H_0$1). Inadequate sleep, as determined by self-report, does not affect vigilance task performance, as assessed by the Digit Vigilance Test (DVT) in undergraduate college students.

Alternative Hypothesis (H_a1). Inadequate sleep, as determined by self-report, does affect vigilance task performance, as assessed by the Digit Vigilance Test (DVT) in undergraduate college students.

Research Question 2. Does inadequate sleep affect short-term memory in undergraduate college students?

Null Hypothesis ($H_0$2). Inadequate sleep, as determined by self-report, does not affect short-term memory, as assessed by the Working Memory Index (WMI) of the Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2) in undergraduate college students.

Alternative Hypothesis (H_a2). Inadequate sleep, as determined by self-report, does affect short-term memory, as assessed by the Working Memory Index (WMI) of the Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2) in undergraduate college students.

Research Question 3. Does inadequate sleep affect lecture learning in undergraduate college students?

Null Hypothesis ($H_0$3). Inadequate sleep, as determined by self-report, does not affect learning, as assessed by the Verbal Memory Index (VMI) of the Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2) in undergraduate college students.

Alternative Hypothesis (H_a3). Inadequate sleep, as determined by self-report, does affect learning, as assessed by the Verbal Memory Index (VMI) of the Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2) in undergraduate college students.

Research Question 4. Do sleep, vigilance, short-term memory, and learning predict a student's grade point average (GPA)?

Null Hypothesis ($H_0$4). Sleep, vigilance, short-term memory, and learning do not predict a student's grade point average (GPA).

Alternative Hypothesis (H_a4). Sleep, vigilance, short-term memory, and learning do predict a student's grade point average (GPA).

Theoretical Constructs

In order to better understand the relationship among sleep, vigilance (attention), short-term memory, and learning, different theoretical models are discussed to provide an explanatory examination of established learning and sleep theories. A theoretical model that provides a good foundation for the study of learning as well as attention and memory is cognitivism. A theoretical model that provides good insight into the link between sleep and memory (which is key in learning) is the trace reactivation hypothesis. Together, these models fill in gaps by linking sleep, vigilance, short-term memory, and learning.

Cognitivism

Yilmaz (2011) argued that learning is described using different conceptual frameworks, cognitivism being one of the theories of learning (Kelly, 2011; Watrin & Darwich, 2012). Scholars have argued that cognitivism was established between the 1960s and 1970s in an attempt to understand the human mind and learning (Ibáñez & Cosmelli, 2008; Kelly, 2011; Watrin & Darwich, 2012). Additionally, past literature has suggested that learning is a mental process that influences behavioral responses (Watrin & Darwich, 2012). Hence, to understand behaviors within an environmental context (i.e., education), emphasis should be placed on the individual. Therefore, cognitivists are more concerned with the mental process of the behavior than with the behavior itself. Furthermore, cognitivism was born as a reaction to behaviorist theory in a theoretical attempt to explain and understand the process of learning (Ibáñez & Cosmelli, 2008). More specifically, scientists were interested in finding a more fitting information processing model.

Cognitivism describes mental functions such as thought, perception, memory, and learning using the information processing model (Ibáñez & Cosmelli, 2008). In other words, the human mind/cognitive process is described by analogy to a computer. However, Ibáñez and Cosmelli (2008) argued that humans are rationally and logically guided. Learning involves making associations, which are established through contiguity and repetition (Watrin & Darwich, 2012). Over the years, studies in intentionality, intersubjectivity, and natural cognition have provided a better understanding of how the mind works and captured more specific abilities of human cognition (Ibáñez & Cosmelli, 2008). Hence, cognitivism serves as a framework for examining the complexities of the mind and how people learn with emphasis on attention/vigilance and memory.

Trace Reactivation Hypothesis

It is widely known that sleep plays an important role in memory consolidation. Numerous studies have shown the neural mechanisms that affect brain functioning, cognition, and behavior when sleep is restricted. Arguably, sleep aids in the memory consolidation process through reactivation of traces of neuronal activity that are encoded during the prior waking period (Astill et al., 2012; Maquet, 2001; Peyrache et al., 2009;

Shen et al., 1998). Hence, the trace reactivation hypothesis proposes that traces of information encoded during the waking state are reactivated by neural firing during sleep. According to this hypothesis, reactivation aids in the transfer of the information from short-term memory to long-term memory (Astill et al., 2012).

Operational Definitions

Digit Vigilance Test (DVT): A tool used to assess psychomotor speed, visual-motor tracking, and visual attention while reducing the influence of attentional components such as selectivity and processing capacity (Lewis, 1995).

Grade point average (GPA): A numerical value used to rank students on academic performance.

Learning: A process in which new information is acquired (Anguera et al., 2010). Learning was measured using the VMI of the WRAML 2 to estimate learning and recall of information (Sheslow & Adams, 2003).

Inadequate sleep/insufficient sleep: Lack of sleep that is sometimes self-imposed (Marzano et al., 2010; Söderström, Jeding, Ekstedt, Perski, & Åkerstedt, 2012). Subjective self-report was used in accounting for the total number of hours slept per night. Past research indicated that less than 4 hours of sleep is inadequate for optimal cognitive functions. Therefore, in this study, I considered less than 4 hours of sleep to be insufficient sleep compared to 6 hours or more of sleep.

Short-term memory: The ability to hold information for a short period of time. Information is encoded and transferred from sensory memory (paying attention) to short-term memory, where it can be retrieved actively (immediately/without delay; Fenn & Hambrick, 2012). Short-term memory speed and accuracy permit an estimation of the memory trace in storage and its retrieval and are associated with attentional focus (Wickelgren, 1981). The WMI of the WRAML2 was used to measure memory trace for information retained in short-term memory.

Story Memory: A subtest of VMI in the WRAML2 that measures how well the meaning and content of a story are preserved.

Symbolic working memory (SWM): A subtest of the WMI in the WRAML2 that is used to assess how well a person actively operates on and retains symbolic information prior to recall.

Total sleep time (TST): The total amount of sleep (Carney, Berry & Geyer, 2012). Total sleep time was obtained using self-report.

Verbal Memory Index (VMI): Consists of Story Memory and Verbal Learning, which measure learning and recall of information (Sheslow & Adams, 2003).

Verbal Learning (VL): A subtest of the VMI in the WRAML2 that assesses how well information that was initially unrelated is learned for recall with repetition.

Verbal Working Memory (VWM): A subtest of the WMI in the WAML2 that is used to assess the ability to reorganize and manipulate information held as memory trace on working memory tasks.

Vigilance: Alertness to surrounding environment (Jung et al., 2011). Vigilance is measured using the DVT, which assesses alertness and attention to tasks (Lewis, 1995).

Wide Range Assessment of Memory and Learning, Second Edition (WRAML2): The WRAML 2 is a carefully standardized and reliable psychometric measure used for evaluating memory and learning (Sheslow & Adams, 2003). It contains the VMI and WMI.

Working Memory Index (WMI): An optional index of the WRAML2 that consists of two subtests, the VWM and SWM. Together, these two subtests provide an estimate of how well the respondent retained information in short-term memory.

Nature of the Study

Although past studies have examined the effect of sleep on vigilance, memory, and learning, very few have explored these variables in a single study. Additionally, there have been no studies examining the implications of sleep for lecture learning that have included consideration of vigilance and short-term memory in the undergraduate college student population group. There is also a lack in recent literature in support of a direct association between total sleep time and learning. Thus, this study was conducted in an attempt to make a connection between sleep deficiency and learning. Despite past research suggesting that sleep has aversive/negative cognitive effects, very little research has focused on the college population group in examining specific cognitive factors. Thus, the current investigation was intended to bridge a gap in the literature by illustrating the influence of sleep on vigilance, short-term memory, and learning. Additionally, data supporting a link between sleep and specific cognitive functions (e.g., vigilance, short-term memory, and learning) were presented in this study.

This study determined whether sleep has an impact on vigilance, short-term memory, and learning in the college population. Data were collected from undergraduate students. Sleep was analyzed as adequate (6 or more hours) and inadequate (less than 6 hours) of sleep. These parameters were chosen based on past evidence substantiating that 7 to 9 hours of sleep are necessary for optimal cognitive functions (APA, 2013; McKnight-Eily et al., 2009). Data analysis included an independent samples *t* test analysis to compare the differences in performance between the adequate sleep and inadequate sleep groups on measures of vigilance, short-term memory, and learning, where sleep was the independent variable and vigilance, short-term memory, and learning were the dependent variables. A multiple linear regression model was used to predict GPA by sleep, vigilance, short-term memory, and learning, where GPA was the dependent variable and sleep, vigilance, short-term memory and learning were the independent variables.

This quantitative study explored the effect of sleep on vigilance, short-term memory, and learning in undergraduate college students. A sample of 20 undergraduate college students was obtained from the Metropolitan New York City area via flyer distribution, postings, and emails. Data were obtained using a sleep questionnaire, a basic demographic questionnaire, DVT, and WMI and VMI of the WRAML 2. Hours slept and GPA data were based on self-reports on the questionnaires. Vigilance was measured using the DVT, short-term memory was measured using the WMI of the WRAML 2, and learning was measured using the VMI of the WRAML 2. The first three research hypotheses examined whether amount of sleep affects vigilance, short-term memory, and learning separately. The fourth hypothesis examined whether these variables predicted GPA. Independent samples *t* tests were used to compare the sleep group means for the first three hypotheses, and a multiple linear regression analysis was conducted to determine whether sleep, vigilance, short-term memory, and learning predicted GPA.

This study has implications for social change in that it contributes to the scientific field by presenting findings and expanding the body of literature on the effect of sleep on cognitive functioning. This study contributes to sleep, health, and educational research, specifically in the areas of learning, memory, and attention. The findings highlight the potential adverse effects of inadequate sleep on academic life, cognitive functioning, and general health. The study may also educate and empower members of the target group, helping them to be better informed concerning the risks of sleep deprivation and how it impacts them. The results of this study may lead to more focus on the topic and may invite other researchers to conduct further studies to address issues that were not addressed in this study.

Assumptions and Limitations

Several theoretical assumptions have been made in the past about learning. For the current study, I assumed that learning is a result of biopsychosocial factors. That is, biological mechanisms such as sleep functions prepare the brain for the information encoding and storage process that is presented as auditory or visual stimuli in the external environment, which influences the rate and quantity of learning. In other words, the assumption is that physiological functions such as sleep are associated with cognitive functioning. Inferences from the data analysis provided insight into the mind–body interaction. Furthermore, I assumed that sleep influences attention and memory, which are important in novel learning.

Researchers have made strong arguments that despite unique human experiences, theoretical assumptions made regarding the learning process are similar in given conditions. Many facts about biological operations have been evidenced in science. One is impairments in cognitive functions due to sleep deprivation. Though different people respond to situations differently, people respond to basic needs in common ways. For instance, all organisms eat to satisfy hunger. Similarly, sleep is necessary to function to recharge the brain and body. People can only go on for so long without sleep; it is inevitable and almost involuntary after a long interval of wakefulness. The longer a person is in a waking state, the greater the sleep need becomes. Thus, I presumed that I would see some impairments in cognitive functions with less than 6 hours of reported sleep.

This study was confined to the college population group. Findings on the effects of inadequate sleep on vigilance, short-term memory, and learning may not be reflective of the general population. The inclusion criteria were undergraduate college students between the ages of 18 and 39. The exclusion criteria were those who smoked; had been diagnosed with a sleep disorder, attention disorder, or psychomotor movement disorder; or had experienced a recent trauma to the head.

The use of specific age criteria resulted in young adults (aged 18 to 39 years) comprising the sample, which did not represent all college students. Older students were excluded, as insomnia is prevalent among that age group. This research also excluded graduate students who were more advanced in their education as well as coping with college life. Thus, the study might not provide insights into the effects of sleep deprivation on lecture learning capacities for students older than 39 years or in a graduate program. The study included young adults from a New York City private college, and therefore the findings do not represent student life demands in other states, cities, or countries. The selection criteria limited the variability of student lifestyles represented in the sample; lifestyle factors may influence sleep habits and/or learning techniques. Additionally, the study was conducted using a relatively small sample of the overall target population due to difficulty in recruiting students from the study site. A larger sample might have yielded different findings. Despite the limitations, it may be possible to generalize some of the findings to the undergraduate college student population. There were no researcher or data analysis biases noted that might have influenced study outcomes.

Significance of Study

This study may contribute to positive social change by indicating the importance of sleep in the academic setting. Through this study, I aim to contribute to sleep research in an effort to raise awareness of the negative implications of sleep deprivation. The study findings may encourage higher education teachers and staff to hold more realistic expectations of students, thereby enhancing the learning experience and students' academic performance.

Summary

This chapter has provided an introduction to the study along with background information to offer greater clarity concerning the topic. An overview of the effects of sleep on attention, memory, and learning has been provided to introduce readers to pertinent problems and major findings in relevant fields. The chapter has also presented the nature of study, a statement of the problem, research questions and hypotheses, and theoretical constructs to ground the study. Further, this chapter has highlighted the goals of the study, its significance, and its limitations.

Chapter 2 contained a review of the existing literature and current findings. The chapter began with a description of sleep and theoretical explanations. Physiological and neurological functions of sleep were examined to highlight biological mechanisms that may alter cognitive functions. The chapter progressed into showing literature support for cognitive functions such as attention and short-term memory, and their relation to learning. The trace reactivation hypothesis was discussed to ground the theoretical explanation for the role of sleep in memory consolidation and the impact sleep has on attention and learning. Cognitivism was further discussed as a learning theory and served as one of the theoretical frameworks for this dissertation. Cognitivism and the trace reactivation hypothesis guided the research questions and confirmed the theoretical constructs. Past and current literature on sleep research are introduced to highlight how sleep impacts cognitive processes such as attention, memory, and vigilance. The chapter concluded with implications of past research in relation to the current study. A discussion on the limitations of past literature were discussed as well.

Chapter 3 presente the methodology used to conduct this study. The chapter detailed the procedures and instruments used. A description of the data analysis was presented. The chapter also included the ethical considerations that were made for the study. Research questions and hypotheses were restated to outline the major focus of the study. The sample population group, sample size, effect size, and statistical power used in the study were justified in the chapter. Further, data collection methods were presented to fully describe how the study was conducted.

Chapter 4 presented the results of the study. The chapter included a description of the study participants and research questions. Statistical analysis of the demographic data and descriptive data were presented in the beginning of the chapter. An explanation of data cleaning for missing data and outliers was discussed prior to data analysis. Assumptions for each statistical test used to test the hypotheses were discussed to justify their usefulness in providing a meaningful interpretation of the data. Results of the data analysis using the SPSS software were presented for each research question and indicated whether the null hypotheses were significant or not. Tables and figures were presented along with the results per research question to provide a visual illustration of the findings.

Lastly, Chapter 5 presented a discussion of the study. The chapter included study highlights explaining possible factors that may have influenced the findings. An interpretation of the results were provided. The chapter also discussed whether the results were supported by the theoretical framework used to ground the study. Additional, implications for social change, limitations of the study, and recommendations for future research were provided.

Chapter 2: Literature Review

Introduction

Although past studies have examined the relation among sleep, vigilance, memory, and learning, very few have explored these phenomena in a single study. The purpose of this chapter was to review and present the existing literature on sleep, vigilance, memory, and learning. Additionally, GPA was considered in determining whether sleep, vigilance, short-term memory, and learning influenced a sample of academic performance. In this chapter, I described the link among sleep, vigilance performance, short-term memory, and the learning process within the traditional lecture learning context. In doing so, I examined some of the most crucial elements (e.g., sleep, vigilance, and memory) of the learning process in a traditional setting. I began by reviewing the current literature on sleep. Some of the issues presented in past studies were presented here to avoid errors and improve the quality of the study. Additionally, I presented the literature on neurological and physiological mechanisms of sleep. I then examined the impact of sleep on vigilance performance and described how insufficient sleep may result in reduced attention. Next, I examined how the processing of new information were presented to short-term memory. The literature on learning and theories of learning (i.e., cognitivism) were also presented. Following that, some of the current literature available on issues in traditional college learning were presented. Implications of past research for the present research were reviewed in the next section. Lastly, literature relating to differing methodologies were reviewed for a comparison. Thus, this chapter presented empirical data that support the efficacy of learning with consideration to how sleep may affect vigilance and short-term memory.

Literature Search

My aim in the literature review was to discuss the most current peer-reviewed literature on the role of sleep in learning and to demonstrate how sleep may affect vigilance performance and short-term memory processing, which are vital to learning. However, older articles had to be included to support theories of sleep, attention, and learning. Additionally, older articles had to be used as supporting evidence because updated data were not available in some cases. For some of the supporting evidence, especially when it came to true experimental physiological data on sleep, much older or original studies were referenced.

The Walden University Library database was used to obtain literature for the study. Various databases were used to identify articles for the literature review. An initial search was conducted by selecting articles by topic, the psychology field database, and then PsycARTICLES. The search was expanded to Academic Search Complete, CINAHL Plus with Full Text, Cochrane Database of Systematic Reviews, eBook Collection (EBSCOhost), Education Research Complete, ERIC, Health and Psychosocial Instruments, MEDLINE with Full Text, PsycBOOKS, PsycCRITIQUES, PsycEXTRA, PsycINFO, SocINDEX with Full Text, and Humanities Source databases due to the limitation in search results. The search was further expanded to the Thoreau multiple databases.

Search terms included the following, either alone or in combination: *sleep, sleep deprivation, insufficient sleep, sleep disorder, sleep data, sleep time, data, sleep poll, sleep stages, NREM, REM, brain mechanism, sleep architecture, suprachiasmatic nucleus, attention, vigilance, learning, learning model, memory, short-term memory, short-term memory, mental fatigue, health, physical exercise, functioning, theory, restorative, restoration, conservation, energy, significance, education, college students, cognitivism, trace reactivation hypothesis*, and *reactivation*. The general search was limited to: full text; scholarly (peer-reviewed) journals; publication year from 2008-2012 and 2009-2013. Later, the search included a search for journal articles from 2013 and beyond. However, publication limiters had to be removed when search results were not producing much articles.

Specific limiters were selected when the search yielded a large number of results to narrow the results down to more relevant articles. The PsycARTICLES database was used in the initial searches with the following general limiters: full text, scholarly (peer-reviewed) journals, and publication year from 2008-2012. The initial literature search included the search terms *sleep, vigilance, short-term memory, learning*, and *college students* without any limiters due to the use of multiple terms in one single search, but it yielded no results. However, the terms *sleep, vigilance,* and *learning* produced 10 results without limiters and one result with the general limiters mentioned above. When the key term *sleep* was entered alone with the above limiters, it yielded 3,445 results. Setting the age limiter to young adulthood (18-29 years of age) produced 854 results, 81 results when narrowed down to *sleep deprivation* (81 results), with only six results found for *performance* and six results found for *vigilance*. When the key term *vigilance* was entered alone with the general limiters above, it produced 51 results, five results when limited to *attention*, and only two results when the term *sleep* was added. The key term *short-term memory* alone with the same general limiters produced 438 results, 16 results with *attention*, nine results with *cognitive ability*, and three results when the term *sleep* was added. The term *learning* entered alone with the general limiters included resulted in 4,021 results, 79 results when limited to *memory*, and four results when further limited to *cognitive ability*. The terms *learning* and *sleep* with the general limiters produced 14 results and only one result when further limited to *cognitive processes*; there were no results when the term *college students* was added to this search. Thus, the search had to be expanded using more general terms with a broader scope for each topic individually, in combination with other terms, and using a variation of multiple databases to come up with relevant articles.

Role of Sleep

Hayaishi (2011) argued that sleep is probably one of the most crucial yet least understood biological mechanisms of the brain. Despite over two centuries of studies investing the phenomena of sleep, there are still many questions about sleep and the variables affecting it (Hayaishi, 2011; Wright et al., 2006). More importantly, there is still much that scholars do not know about sleep and many variables linked to it to explore. At the same time, those in the field of sleep research have made some progress by discovering more than 107 different sleep disorders since the 1800s (Hayaishi, 2011).

Much of the existing knowledge on sleep has come from examining the effect it has when there is a lack of it. Most of the literature on the significance of sleep reveals the unhealthy side effects of poor or inadequate sleep. It has been well documented that sleep serves a primary function for survival (Gregory, 2008; Hayaishi, 2011; Ohayon, Guilleminault, & Chokroverty, 2010; Robles & Carroll, 2011). Studies have revealed that the need to sleep increases with prolonged sleep deprivation, suggesting a biological drive for sleep (Miccoli, Versace, Koterle, & Cavallero, 2008; Pa Van Dongen, Rogers, & Dinges, 2003; Rempe et al., 2009). For instance, many report excessive sleepiness after a night of inadequate or poor sleep (Rempe et al., 2010).

Scientists have long studied the mechanisms of sleep, different states in the sleep cycle, and sleep patterns. Studies have shown that sleep correlates strongly to activities during the waking state (Rempe et al., 2010; Sakurai, Mieda, & Tsujino, 2010). More specifically, humans require a healthy dose of sleep to function optimally during their waking state. While there is no benchmark number, studies have shown that about 8 hours of sleep is considered a healthy dose for human adults, and the number varies among individuals (APA, 2013; NSF, 2009; Ohayon et al., 2010).

Sleepiness and prolonged sleep deprivation increase sleep propensity and sleep onset (Sargent, Darwent, Ferguson, Kennaway, & Roach, 2012). Sleepiness is a response to the homeostatic drive, which attempts to make up for wakefulness (Couyoumdjian et al., 2010; Sakurai et al., 2010; Sargent et al., 2012; Todd, Gibson, Shaw, & Blumberg, 2010). Although sleep deprivation has been shown to impair performance, different individuals respond to it differently. Thus, it is imperative to understand the cognitive process of learning, which has been linked to related factors such as information processing into short-term memory and vigilance (Roberts et al., 2012; Willmott, Ponsford, Hocking, & Schönberger, 2009). Similarly, it is essential to examine the effect of sleep on the learning process to establish more successful goals in the educational system.

The Centers for Disease Control and Prevention (CDC, 2008) analyzed the Behavioral Risk Factor Surveillance System (BRFSS) from all 50 states to examine the prevalence of inadequate sleep or rest among U.S. adults. The findings revealed that 11.1% of 403,981 respondents reported experiencing insufficient sleep or rest daily in the past 30 days, females (12.4%) were more likely than males (9.9%) to report insufficient sleep, and non-Hispanic Blacks (13.3%) were more likely than other racial/ethnic groups to report insufficient sleep (APA, 2013; NSF, 2013; McKnight-Eily et al., 2009; Swanson et al., 2011). Inadequate sleep has also been linked to feeling fatigued during the daytime and being unable to perform daily activities (Querstret & Cropley, 2012). The data collected on sleep problems only account for the number of cases reported. Hence, the actual statistics of people suffering from inadequate or poor sleep are unknown.

Neurological Basis

Researchers have substantiated that structures of the brain regulate the intrinsic rhythms of sleep and wake cycles. It has been long identified that the preoptic area (POA) of the hypothalamus is the regulating center for sleep and body temperature (Todd et al., 2010). Discoveries in brain anatomy have demonstrated brain structures and their functional roles. However, the molecular mechanisms of the sleep-wake cycle remain less understood. Recent experimental research has made some progress in this area, with studies still underway (Golombek & Cardinali, 2008).

Recent findings are now indicating that the neurotransmitters that regulate sleep-wake states are identified as prostaglandins (PG) D_2 (Zhi-Li, Urade, & Hayaishi, 2011). Similarly, Huang, Urade, and Hayaishi (2011) found that adenosine maintains a homeostatic sleep/wake cycle. In other words, adenosine neurons act as a sleep-wake regulator. The brainstem, reticular formation, basal forebrain, areas of the hypothalamus, and the preoptic area have also been identified to be rich with neurons that induce sleep (Couyoumdjian et al., 2010; Todd et al., 2010). Thus, wakefulness appears to be the product of the arousal systems in the brain.

The reticular activating system is an area that plays a role in maintaining arousal and consciousness among other major functions such as awareness, attention, cardiac reflexes, and sleep (Dijk et al., 2012). Production of orexins in the lateral hypothalamus area (LHA) was initially recognized as the regulator of feeding behaviors (Sakurai et al., 2010). However, recent findings suggest that the neurons also play a critical role in the regulation and maintenance of sleep/wake states (Sakurai et al., 2010).

The suprachiasmatic nucleus (SCN) of the hypothalamus is identified as the intrinsic biological clock that regulates the sleep-wake cycle and entrains it to approximately 24 hours (Evans, Elliott, & Gorman, 2010; Rempe et al., 2010; Sakurai et al., 2010). The light-dark cycle is incorporated by hypocretin neurons and acts as a conductor of extrinsic cues for the SCN pacemaker (Evans et al., 2010). The SCN also controls the pineal gland, which secretes and releases melatonin, a hormone that increases in dim/dark light and induces sleep (Evans et al., 2010). This explains the increase in sleep propensity during nighttime and dim light. Studies find that the light perceived by the retina converts energy to the occipital region of the brain, where the release of melatonin is inhibited, delaying or putting off sleep (Rea & Figueiro, 2011).

Physiological Basis

The physiological architectures of sleep describe the specific characteristics of the stages of sleep and wakefulness. Sleep generally occurs in a sequence of five stages. The first four stages are referred as *nonrapid eye movement* (NREM), and the last stage is referred to as *rapid eye movement* (REM; Evans et al., 2010; Ferrara & De Gennaro, 2011; Vassalli & Dijk, 2009). Marzano et al. (2010) reported that despite contrary beliefs, REM sleep and NREM share similar homeostatic processes in sleep deprivation states. Vassalli and Dijk (2009) argued that wakefulness increases sleep propensity. Hence, the longer a person remains awake, the greater his or her drive/need to sleep becomes.

Therefore, sleep duration and intensity increase subsequent wakefulness (Vassalli & Dijk, 2009).

As early as the 1800s, experiments were being conducted to understand the physiological nature of sleep. For instance, Patrick and Gilbert (1896) did case studies in which they recorded physiological responses to sleep deprivation. They were among the first to demonstrate some of the side effects of sleep, insomnia, and the body's response to sleep interruptions. Among many findings, they found that in one of their case studies, the subject began having visual hallucinations after 50 hours of being awake. Research in the two centuries that followed not only confirmed Patrick's and Gilbert's findings, but also advanced the field, and this body of research continues to grow.

Major findings in sleep research over the past two decades have revealed that sleep plays a crucial role in memory, learning, and attention, among other critical cognitive functions. Recent studies have found that successive nights of sleep restriction result in a gradually accumulating decline in cognitive functions and increased daytime sleepiness (Rempe et al., 2010; Wright et al., 2006).

Not getting a full night's sleep leaves one feeling tired and fatigued throughout the day, variables that have been implicated in interference with vigilance, short-term memory, and learning processes in various studies. Inadequate sleep delays the body's reaction time for task performance and impairs cognitive processes (Miccoli et al., 2008).

After a prolonged state of sleep deprivation, the body attempts to make up the sleep loss in the following nights with even as little as 2 to 3 hours per night (Rempe et al., 2010). Additionally, inadequate or poor sleep has been shown to cause excessive daytime sleepiness, which sometimes results in afternoon naps or microsleeps, which act in a manner similar to naps (Rempe et al., 2010). Groeger, Burns, and Dijk (2011) conducted a study on the effect of executive load on short-term memory after morning or afternoon naps and found that participants performed better on simple tasks than they did on more complicated tasks after afternoon naps. This evidence suggested that it takes individuals taking afternoon naps longer to return to their normal mental workload state to perform more complex cognitive tasks. Such cognitive tasks also require sustained attention to response tasks, as reflected in error rates on vigilance to stimuli, which is impaired by excessive daytime sleepiness (Van Schie et al., 2012).

Vigilance

Vigilance is an important aspect of attention that promotes learning. Sleep insufficiency has been shown to impair multitasking capacities (Haavisto et al., 2010). Jugovac and Cavallero (2012) argued that a large body of evidence indicates a decline in vigilance marked by sleep deprivation. Additionally, sleep deprivation has been linked to poor reaction times and reduced accuracy rates on vigilance tasks (Jugovac & Cavallero, 2012). Martella et al. (2014) argued that people can shift attention from one task to another; however, accuracy and reaction time are dependent on other factors.

Haavisto et al. (2010) argued that the vigilance rate is critical in multitasking roles that are hindered by sleep restriction. Kronholm et al. (2011) conducted a study examining the impact of self-reported duration of sleep on psychomotor reaction time, which is associated with vigilance, and results indicated increased health risks and impaired functional abilities with insufficient sleep. Additionally, sleep loss has been shown to progressively impair both the degree and duration of vigilance tasks (Haavisto et al., 2010).

Jung, Ronda, Czeisler, and Wright (2011) did a reaction time study comparing the difference between auditory and visual attention sustainability during a 40-hour period of sleep deprivation. The study concluded that auditory vigilance was generally faster and less variable than visual vigilance, a larger difference was noted during sleep deprivation, and pattern of change was similar among sensory-motor responses. Furthermore, auditory vigilance is involved in higher mental abilities and can be used as a mental fatigue measurement (Tyagi, Shen, Shao, & Li, 2009).

Studies showed that alertness declined in short-term and long-term sleep deprivation conditions (Kilpeläinen, Huttunen, Lohi, & Lyytinen, 2010). Research revealed that attention to tasks decreased with prolonged sleep deprivation (Kilpeläinen et al., 2010). Furthermore, the task to maintain alertness is affected by environmental conditions (Kilpeläinen et al., 2010). For instance, a person may lose focus more easily in a boring environment due to lack of interest or inactivity.

Attention

According to Martella et al. (2014), attention is a set of independent neural networks that perform specific calculations in selecting objects and locations, solving conflicts in target selection when competing distractors are present, or achieving and maintaining alertness. Attention shifts can occur automatically or voluntarily (Martella et al., 2014). That is, the relevancy and saliency of information plays a role in capturing attention.

Past research has demonstrated that sustaining attention is arguably one of the most important factors in cognitive processing of information (Brown et al., 2013; Roberts et al., 2012). Research in the past has indicated that lack of attention resulted in poor information processing, impulsive responses, and/or inaccuracy in responses which traded off for speed (Metin et al., 2013). Additionally, there is a possibility of less willingness or motivation in processing information before responding to tasks (Bechtoldt, De Dreu, Nijstad, & Choi, 2010; Metin et al., 2013).

Lim and Dinges (2010) argued that a lot of focus has centered around the effects of sleep deprivation on basic attentional processes and more complex real world tasks. There has been a growing interest in attentional sustainability problems. Although most experts generally agree that sleep deprivation effects cognitive functioning, the extent of the consequences is not yet clearly defined (Lim & Dinges). Jugovac and Cavallero (2012) did an experiment examining attentional deficits after a period of 24 hours of total sleep deprivation and found an overall decrease in reaction times and accuracy in response.

Studies suggested that short term memory impairments are frequently observed in individuals who experience attention problems (Fassbender et al., 2011; Martin, 2009). Dowd and Mitroff (2013) argued that attention is filtered through a selection process that is influenced by either “bottom-up” cues “(e.g., when attention is captured by an item’s physical distinctiveness)” and “top-down” cues “(e.g., when attention is directed toward a task-relevant location)” (p. 1786). Researchers suggested that working memory cues guide the *bottom-up* and *top-down* process (Dowd & Mitroff, 2013).

Short-Term Memory

According to Melby-Lervåg and Hulme (2013), short-term memory is also known as the concept of working memory, “one of the most influential theoretical constructs in cognitive psychology” that measures the “capacity and a wide variety of real world skills” (p. 270). Short-term memory provides temporary storage of information necessary for cognitive tasks (Baddeley & Hitch, 1994). Additionally, short-term memory tasks involve maintaining information active in memory while simultaneously performing other activities (Butler & Weywadt, 2011). Therefore, short-term memory is strongly linked to attention (Dowd & Mitroff, 2013).

Researchers argued that people with high short-term memory capacity perform better on tasks requiring the inhibition of distracting information (Meier & Kane, 2013; Melby-Lervåg & Hulme, 2013). Evidence suggested that short-term memory predicts success in complex intellectual activities, multitasking, solving novel problems, and learning (Meier & Kane, 2013).

Literature in the past suggested that learning of new information is process and initially stored to the short-term memory for later recall (Corbin & Marquer, 2013). If the information presented is effectively processed through sensory mechanisms, the more likely it is to retain the information for a short period of time until it is processed to long-term memory storage (Rose & Craik, 2012). Literature consistently showed that sleep is crucial in strengthening memory and transferring new information from short-term memory to long term memory (Fenn & Hambrick, 2012; Rose & Craik, 2012). This implied that when an individual is restricted to sleep, memory of information during the waking hours may not get consolidated (Fenn & Hambrick, 2012).

Trace Reactivation Hypothesis

Acquisition of memory trace and learning during sleep has been evidenced in various parts of the brain, primarily the hippocampus. Investigations show that patterns of neuronal activities are recorded in the hippocampus and neocortex regions of the brain during the waking state are reactivated during subsequent slow-wave sleep (Shen et al., 1998). Recent findings indicated that the hippocampus and neocortex exchange information during slow-wave sleep that show a change in memory traces, favoring memory consolidation (Peyrache et al., 2009). Sleep has also been implicated in the plastic cerebral changes that cause memory and learning (Maquet, 2001). The trace reactivation hypothesis was used as a theoretical construct in this study because it provides a physiological explanation of memory and learning during sleep.

Learning

Cognitive strategies rely on the hippocampus for flexibility in integrating novel information (Hagewoud et al., 2010b). According to Yilmaz (2011), theories of learning can be categorized into behaviorism, cognitivism, and constructivism. Among the three, cognitivism is a relatively a recent theory of learning theory that provides a theoretical basis to classroom instruction and illustrate teaching techniques (Yilmaz, 2011).

Cognitivism

Thomas Kuhn’s theory of scientific progress and change paved the way for other scientists and the scientific community to follow and understand the existence of school of thoughts. Kuhn’s viewpoint served as a foundation for the practice of science that produced information in a progressive way that brought about shifts in theories.

According to Kuhn, normal science occured when research is based on past scientific achievements that the scientific community acknowledges as a foundation for future accomplishments. It is assumed that the world consisted of knowable truths that were estimated through systematic procedures of science, and is considered normal science (Kuhn, 2002). Progress is the result of solving problems defined by a paradigm in the scientific community. Thus, Kuhn’s description of normal science is worth noting in the rise of the cognitive revolution and the formulation of learning theories, particularly cognitivism. Cognitivism supports theories of attention, memory, and learning.

In the late twentieth century, increased efforts to understand the cognitive process brought about the cognitive revolution and gave rise to cognitivism, causing the decline of behaviorism and behavioral analysis (Kretchmar, 2008; Watrin & Darwich 2012). The cognitive revolution like any other paradigm was due to the progress and change as a process of normal science, a movement that started cognitive science in the modern context of interdisciplinary fields and has been dominating the educational scene for the last several decades with many advances in cognitive neuroscience. Cognitivism, a theory of learning, takes into consideration a multitude of mental process including memory and attention, as well as intrinsic and extrinsic variables such as physiological states of consciousness and environmental settings.

According to Kelly (2011), studies of learning often face difficulty with the lack of knowledge differentiating between the learning construct and behaviors that point to more fundamental processes. Arguably, cognitive science provides a learning analysis that is grounded in empirical evidence. Though in the early stages, literature focusing on cognitive science have made some important breakthroughs in defining the learning process, existing evidence suggests that general abilities essential to learning are linked to specific brain functions (Kelly, 2011).

Studies focusing on attention and memory show important implications of these factors on learning (Vassalli & Dijk, 2009). Additionally, emerging data suggests that the quality of learning may be related to the effect of sleep on attention processes and consolidation of memory (Fenn & Hambrick, 2012; Lee, Kim & Suh, 2003; Payne, 2011; Peters, Ray, Smith & Smith, 2008; Vassalli & Dijk, 2009).

Issues in Traditional College Learning

Student concentration and maintaining attention during lectures has been a challenge for lecturers. Young, Robinson, and Alberts (2009) reported that student attention drops somewhere between 10 and 30 minutes into a lecture, which arguably has consequences on the learning outcome. Literature consistently supports that sleep deprivation impairs vigilance performance. Gilbert and Weaver (2010) found a significant correlation between sleep quality and lower academic performance among college students.

Zawadzki, Graham and Gerin (2013) argued that there are underlying mechanisms interfering with sleep and performance in college students. Zawadzki, Graham and Gerin observed that there is a link between loneliness and depressed mood, which resulted in poor sleep. The results of their [Zawadzki, Graham and Gerin] investigation showed that rumination and trait anxiety fully facilitated the relationship between loneliness and depressed mood as well as poor sleep quality. Findings from the study discussed suggests that college students who feel lonely are more likely to have depressed mood and experience poor sleep quality as well as quantity. As a result, these students are at higher health risks and will have a more difficult time concentrating during lecture classes.

Implications of Past Research on Present Research

It is well documented that cognitive functions such as learning, short-term memory, and vigilance are impaired by insufficient sleep (Fenn & Hambrick, 2012; Lee et al., 2003; Payne, 2011; Peters et al., 2008; Vassalli & Dijk, 2009). Many researchers argued that less than 6 hours of sleep is insufficient for optimal cognitive functioning and memory (Mograss et al., 2009; Ohayon et al., 2010). Additionally, past researches found a strong link between poor sleep and lowered performances in cognitive tasks requiring vigilance, short-term memory, and learning (Hagewoud et al., 2010; Tyagi et al., 2009; Wright et al., 2006).

Past studies have indicated that sleep has an effect on attention and cognitive tasks but the impact of insufficient sleep on stress levels during daytime functioning and visual and auditory vigilance during lectures has not been well explored. Research showed that poor sleep reduces attention and memory that is crucial to cognitive performance and learning of new information (Hagewoud et al., 2010; Wright et al., 2006). In addition, Young et al. (2009) found that attention drops 10 to 30 minutes into lecture, suggesting that vigilance decreases with time. Thus, the purpose of this study is to understand how insufficient sleep may impair learning in traditional lecture classroom by examining vigilance task performance, short-term memory, and learning.

Wright et al. (2006) did a study in which they found that poor sleep significantly impaired learning. This suggested that sleep deprivation may be directly related to learning. In addition, insufficient sleep reduces vigilance because a proper alignment between the sleep-wake cycle and internal circadian rhythm is crucial for cognitive performance (Wright et al., 2006). Vigilance to learning cues presented such as visual and auditory reduce after some time elapses (Young et al., 2009). Hence, the ability to sustain attention in lectures reduces over time. Additionally, excessive daytime sleepiness impairs vigilance and the ability to sustain attention to response tasks (Van Schie et al., 2012). Jmaiswal & Mallick (2009) argued that sleep deprivation reduces the ability to learn new tasks or information because poor sleep influences memory and attention.

Taylor, Vatthauer, Bramoweth, Ruggero, and Roane (2013) conducted a study investigating the predictability of academic performance using sleep along with common non-sleep predictors of academic performance are included. Their study hypothesized that a low amount of total sleep time would increase sleep latency, later bedtimes, later wake times, and decreased academic performance. Findings from their study revealed that the most significant predictors of academic performance were high school GPA, standardized test scores, total sleep time, sleep inconsistency, and perceived stress. The results of their study suggested that sleep is an important predictor of academic performance.

Furthermore, there is a strong relationship between sleep, performance, and health (Roth, 2009). Inadequate sleep is linked with the many demands and stressors of everyday life as well as to diseases and disorders, both physical and psychological (Lee et al., 2003; Minkel et al., 2012). Nonetheless, the consequences of prolonged sleep deprivation to health or cognitive functions are detrimental. Our body needs sleep at some point, whether it is voluntary or involuntary. We can delay sleep for a period of time until we fall asleep involuntarily.

Literature Relating to Differing Methodologies

Abel and Bäuml (2013) did a quantitative study examining the link between sleep and memory consolidation using a 2 x 3 design with between participant factors: cue (remember and forget) and condition (12 hr wake, 12 hr sleep, short delay). In their study, Abel and Bäuml had 192 students participated and were equally distributed across conditions with no regard to age, IQ, or ratings on the Epworth Sleepiness Scale. Abel and Bäuml used Item material comprised of two lists, each containing 16 concrete nouns. They found that pre-cued items declined as more items from the list are recalled for the first half of 16-item list.

Summary

This chapter reviewed literature in the areas of sleep, vigilance, short-term memory, and learning. Major themes in literature was the role of sleep in attention, memory, learning and academic performance. National statistics presenting sleep as a problem to the American society as a whole was introduced to show the large impact it has epidemically. Literature on different areas of sleep was presented to provide greater insight and better understanding of the nature of sleep. Furthermore, existing literature on vigilance, short-term memory, and learning were highlighted in this chapter along with reference to their link to one another. Current study aims at filling the gap in literature by exploring the variables sleep, vigilance, short-term memory, and learning using the college student population that needs much research focus.

The literature relating to the study variables and gaps in literature were presented here. The next chapter will summarize the methodology of this study. The chapter began by discussing the purpose of the research, variables in the study, and a rationale for the study design and parameters used. Chapter 3 also described the study setting and sample used. A step-by-step description of the procedures used is detailed in the next chapter. Chapter 3 also provides a description of the instruments used in data collection, along with the reliability and validity of the standardized tools. The data analyses is presented in chapter 3, which highlights the research questions and the hypotheses and the statistical methods used to test these hypothesis. The following chapter also discusses the ethical considerations made in this study and how ethical issues were addressed.

Chapter 3: Research Method

Introduction

In this chapter, the quantitative research framework for the study of the impact of sleep on vigilance, short-term memory, and learning are discussed. The rationale for choosing a quantitative design are presented. Additionally, this chapter covers the methodology used for the study, including a description of the setting, sample, procedure, participants, selection criteria, and ethical issues. Furthermore, this chapter includes an explanation of the instruments used and how the data were analyzed. The validity, reliability, and norm of the tools used are also discussed in this chapter. All in all, the goal of this chapter was to provide a good description of the methods used for this study so that it may be replicated in the future.

Purpose of the Study

The purpose of this quantitative study was to examine the effect of sleep on vigilance and short-term memory, as well as whether these variables predict GPA. This study was conducted in an attempt to address the learning process in terms of sustained vigilance and short-term memory during a lecture. There is very little current research focusing on the implications of sleep and cognitive functions among the college population group.

Therefore, this study examined sleep in terms of adequate (6 hours or more) and inadequate (less than 6 hours) sleep. Parameters for adequate and inadequate sleep were chosen based on research support for the amount of sleep needed for unaffected cognitive processing. Although the exact number of hours of sleep needed cannot be identified due to individual differences and capacities, researchers have suggested that 7 to 8 hours of sleep per day is considered an adequate amount for healthy functioning (APA, 2013; Clinkinbeard et al., 2011; Gregory, 2008; Kronholm et al., 2009; McKnight-Eily et al., 2009). Furthermore, sleep need data based on laboratory measurements have shown that a minimum of 6 to 8 hours of total sleep per day reduces risks for medical problems and early death (Gregory, 2008). Similarly, the CDC (2013) reported that though individual sleep need varies, the recommended amount of sleep for adults is 7 to 8 hours a day. Blagrove, Alexander, and Horne (1995) argued that long-term sleep restriction to 5 hours per night results in cognitive deficits. Additionally, Tewari, Soliz, Billota, Garg, and Sin (2011) reported that “total sleep duration of 5 hours/night over 1 week shows both decrease in speed and the beginning of accuracy failure” (p. 13).

Research Design and Approach

This study was intended to explore the effect of sleep on vigilance, short-term memory, and learning. The goal of this study was to examine how sleep influences vigilance, short-term memory, and learning, and whether these variables influence academic performance as sampled by GPA. Sleep was analyzed in two groups: those who reported getting adequate (6 hours or more) sleep and those who reported getting inadequate (less than 6 hours) sleep. The two sleep groups were compared on measures of vigilance, short-term memory, and learning using assessment tools, where sleep was the independent variable and vigilance, short-term memory, and learning were the dependent variables. An independent samples *t* test was used to compare the means of the sleep groups for the vigilance, short-term memory, and learning measures. Additionally, test variables sleep, vigilance, short-term memory, and learning were used as predictors of GPA, where GPA was the dependent variable. A multiple linear regression analysis was conducted to examine whether the four independent variables sleep, vigilance, short-term memory, and learning predicted the dependent variable, GPA.

Setting and Sample

The target population group was undergraduate college students between the ages of 18 and 39. The sample was obtained from a 4-year private college located in the Metropolitan New York area. The main campus is situated in Dobbs Ferry, with additional locations in Manhattan, Bronx, and Yorktown Heights. The institution consists of over 90 undergraduate and graduate programs within its five schools (Business, Education, Health and Natural Sciences, Liberal Arts, Social and Behavioral Sciences). For the Fall 2014 semester, total undergraduate enrollment was 7,939.

A sample of this population was obtained to provide a useful representation of the population because collecting data from the entire student population might not have been feasible (Lee Abbot, 2013; Thompson, 2012). Sample size was determined using a predetermined table based on the alpha level, effect size, and statistical power in order to detect a statistically significant relationship between sleep, vigilance, short-term memory, and learning (Thompson, 2012). Determining the appropriate statistical power, sample size, alpha level, and effect size is crucial in detecting a real effect within a population (Burkholder, n.d.; Gravetter & Wallnau, 2010).

The alpha level is the very unlikely probability of making a wrong decision if the null hypothesis is true, known as a *Type I error* (Gravetter & Wallnau, 2010). Conventionally, an alpha level of .05 is used in most research to avoid rejecting a null hypothesis when it is true (Burkholder, n.d.; Gravetter & Wallnau, 2010). An alpha level of .05 means that there will be a 5% chance of arriving at the wrong conclusion and a 95% chance of being correct. Thus, an alpha level of .05 with a confidence interval of 95% was considered for the statistical analyses.

The effect size described the observed effect between the variables being examined in this study (Fritz, Morris, & Richler, 2012; Kelley & Preacher, 201). Thus, the effect size helped in determining the statistical significance in hypothesis testing and interpreting the quantitative description of the strength of an effect. According to Fritz et al. (2012), effect sizes observed previously can be used to calculate power and estimate appropriate sample sizes. There is little literature to guide the section of effect size. A large effect size of .90 was considered for the sample size used in data collection.

Statistical power is the probability that a statistical test will detect a real effect in hypothesis testing (Burkholder, n.d.; Gravetter & Wallnau, 2010). In other words, the statistical power in this study identifies the likelihood of an effect if one really does exist. Burkholder (n.d.) stipulated that the commonly accepted value for power is .80 (80%).

This means that I can expect to find a real difference in the study 80% of the time for the sample size regardless of how many times I repeat this study.

Therefore, to detect an effect size of .90 with a power of at least .80, the study would require about 20 participants for a one tailed test at $p < .05$. The sample selected for this study represents the undergraduate college student population group between the ages of 18 and 39 years for the New York City Metropolitan area (Fritz et al., 2012; Gravetter & Wallnau, 2010; Kelley & Preacher, 2012; Lim & Dinges, 2010).

Participants

Participants were recruited via flyers (see Appendix A) posted throughout campuses, distributed through departmental e-mails, and handed out in classes of instructors who agreed to help with flyer distribution. The flyer included a description of the study's purpose along with inclusion/exclusion criteria. The inclusion and exclusion criteria (also discussed below) informed potential participants about eligibility requirements. Participants received a five dollar gift card as compensation for participating in the study.

Inclusion criteria. The inclusion criteria specified that participants must be undergraduate students between the ages of 18 and 39 years. Lam et al. (2013) stated, "Longitudinal follow up studies of brain development have shown evidence of significant neurological changes as a function of age" (p. 62). Researchers have generally accepted that memory declines with age (Morack, Ram, Fauth, & Gerstorf, 2013). Therefore, the age range was limited to students between the ages of 18 and 39 to minimize distortions in the results.

Exclusion criteria. Those who smoked; had been diagnosed with a sleep disorder, attention disorder, memory disorder, or psychomotor movement disorder; or had experienced a recent trauma to the head were excluded from the sample. Interested candidates who met the exclusion criteria were not considered for this study because the exclusion factors mentioned above could have resulted in misleading study findings, as any of them can influence the variables under study.

Procedure

Institutional Review Board (IRB) approval from the institute on record and the recruitment site institute was obtained prior to participant recruitment and data collection. The Participants were recruited via flyer postings on campuses, handouts in classes of instructors who agreed to help with recruiting, and departmental emails. The flyer is in Appendix A. Permission to post flyers on campuses was obtained. Initially, it was proposed that 90 participants would be recruited for the study. However, the sample size was later reduced to 20 undergraduate students and a five dollar gift card to Dunkin' Donuts was also offered to all participants due to difficulty in getting students to participate despite recruitment efforts. The gift card was given to participants at the beginning of the in-person data collection session, before collecting data.

Participants who met the inclusion criteria but not the exclusion criteria initiated contact with me via an email address that was provided in the study flyers. Responses to interested participants included a brief description of the study and the procedures involved to better inform students' participation decisions. Interested volunteers were also requested in the response email to schedule a brief (5 to 10-minute) phone call for screening and data collection session scheduling. Screening calls and data collection sessions were scheduled based on the students' availability.

The screening call entailed going over the inclusion/exclusion criteria to confirm eligibility. No personally identifiable information was obtained during the phone call except the student's name and age. Students who were eligible were informed about expectations and requirements for participating. Students who agreed to participate voluntarily after being well informed were asked to schedule an individual in-person session, during which participants filled out the questionnaires and took assessment tests administered by me. Participants were also informed about a free smartphone app called SleepBot that can be used to measure and log sleep hours. Reminder calls were made at least 24 hours prior to the scheduled data collection session to confirm the appointment. The phone screening transcript is in Appendix B.

The designated data collection site was located in the Social and Behavioral Sciences lab at the Bronx campus. However, I met with students at other locations in instances when a student was unable to commute to the Bronx campus. Individual data collection sessions were scheduled. The data collected included the signed informed consent and responses to a basic demographic questionnaire, a sleep questionnaire, the

DVT, and four subtests of the WRAML2. The data collection session took no more than an hour, and there was no follow-up required.

Participants were given both verbal and written informed consent before data collection. The informed consent included a brief introduction to the study and descriptions of the procedures used, anticipated risks/benefits, the participation incentive, and privacy/confidentiality (see Appendix C). Participants were offered the opportunity to ask questions before signing the informed consent. A copy of the informed consent was given to participants at the end of the data collection session for their records.

During the data collection session, participants completed a basic demographic questionnaire that included items on age, gender, study major, year in college, enrollment status, GPA, total number of credits for the term, and employment status (see Appendix D). The purpose of collecting basic demographic data was to reference the characteristics of the population group being used in the study. The demographic data questionnaire took about 1 to 2 minutes to complete.

I administered the DVT and WRAML2 subtests to the participants. Test security was maintained throughout the session. The introductory section of the test was not used because age, gender, education, and occupation were obtained using the demographic data questionnaire. The DVT was completed in less than 10 minutes by all participants. Each of the four subtests from the WRAML2 took about 10 to 15 minutes to complete. The introductory section of the WRAML2, which asked for the test date and the participant’s date of birth, was used to calculate the test age year, month, and day for valid test administration. The participant's date of birth was not obtained in the demographic data questionnaire.

Lastly, participants completed the sleep questionnaire, which took less than a minute. These self-report data were used to determine the amount of sleep the participant got on the night before the data collection session. The sleep questionnaire included a question about the number of hours of sleep for the night before and whether or not the smartphone app had been used (see Appendix E).

At the end of the data collection session, participants were informed that data collection was complete and were notified that they would not be contacted for any follow-up. Participants were informed that although the test scores would be used for data analysis in the study to address the research questions and would be published, confidentiality would be maintained.

Data were analyzed in two sleep groups. Those who reported getting 6 hours or more of sleep on the sleep questionnaire were placed in the adequate sleep group. Those who reported getting less than 6 hours of sleep on the sleep questionnaire were placed in the inadequate sleep group. Sleep groups were assigned after all the data were collected and for the purpose of analyses in comparing the two sleep groups on measures of vigilance, short-term memory, and learning. I kept the study invitation open for an additional 3 weeks after getting a sample of 20 participants. However, no new participants came forward. Therefore, recruitment was closed, and the exiting data from the 20 participants were analyzed.

Instrumentation

The instruments used for this study are discussed below. The instruments were standardized tests on normative samples, except for the sleep questionnaire.

Sleep Questionnaire

The sleep questionnaire consisted of three open-ended questions. Participants were instructed to answer these questions for the night before the test. The questions asked were "How many hours of sleep did you get last night?" "Did you use the smartphone app, SleepBot?" and "If yes, what was the recorded sleep length?" The reported number of hours slept was used to determine whether the participant should be in the adequate (6 hours or more) sleep or inadequate (less than 6 hours) sleep group.

Digit Vigilance Test (DVT)

The DVT was designed to assess psychomotor speed, visual-motor tracking, and visual attention while reducing the influence of attentional components such as selectivity and processing capacity (Lewis, 1995). The DVT measures vigilance during quick visual scanning and selection of target items. It also focuses on alertness and attention tasks. Respondents were instructed to find and cross out all the sixes that appeared randomly within 59 rows of single digits on two separate pages as fast as they could (Lewis). Respondents were timed on the task and asked not to cross out other digits or miss any of the target digits. Scores for total time, errors of commission, errors of omission, and total errors were calculated. The raw scores were converted to scaled scores, which were then converted to T-scores (Lewis).

Although the author of this test and the administration manual did not describe the samples used for test validation and norming, it was normed on two adult samples, ages 20 to 80 (Heaton, Grant, & Matthews, 1991, as cited in Lewis, 1995) and 17 to 79 years (Lewis, Kelland, & Kupke, 1990, as cited in Lewis), in other references. The administration manual reported an unpublished study with test-retest reliability coefficients of .91 for total time, .80 for page 1 time, .66 for total errors, and .61 for page 1 errors within a 1-week interval (n = 40; Lewis). Additionally, alternative forms of reliability (n = 20) coefficients reported were .90 for Total Time and .93 for Page 1 Time (Lewis). Some validity studies were reported in the user's manual. An analysis of construct validity with a sample of 202 normal volunteers yielded a two-factor solution and accounted for 65% of the total test variance, where the first factor represented speed of information processing and the second factor represented simpler motor functions (Lewis). All in all, research reported in the manual indicated that DVT was a reliable measure and demonstrated satisfactory validity.

Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2)

The WRAML 2 is a carefully standardized and reliable psychometric measure used for evaluating memory and learning (Sheslow & Adams, 2003). The normative sample for the WRAML 2 was constructed using a national stratified sampling technique by controlling for age, sex, race, region, and education (Sheslow & Adams). The WRAML 2 is normed for children, adolescents, and adults, ages 5-90 years (Sheslow & Adams).

This instrument is composed of six core subtests (Story Memory, Verbal Learning, Design Memory, Picture Memory, Finger Windows, and Number/Letter) that yield three indexes (Verbal Memory Index, Visual Memory Index, and Attention/Concentration Index) to form the General Memory Index (Sheslow & Adams, 2003). Additional optional subtests include Sentence Memory, Sound Symbol, Verbal Working Memory, and Symbolic Memory (Sheslow & Adams).

The WRAML 2 showed excellent reliability from Rasch statistics ranging from .85 to .94 on the core subtests and a very good internal consistency, with Cronbach's alpha coefficients ranging from .82 to .96 on the core index scores, and from .71 to .95 across the six core subtests (Sheslow & Adams, 2003). External validity was examined by comparing scores with other memory and learning measures such as the Wechsler Memory Scale-III (WMS-III) and the California Verbal Learning Test-II (CVLT-II). Although the correlations between the WRAML 2 subtests and the WMS-III were adequate, the .60 correlation between the WRAML 2 General Memory index score and the WMS-III General Memory index score was the most notable (Sheslow & Adams). Similar findings were noted with the CVLT-II (Sheslow & Adams). The WRAML 2 is also noted to have moderate correlations with general intelligence measures, such as the Wechsler Adult Intelligence Scale-III and the Wechsler Intelligence Scale for Children-III.

Sheslow & Adams (2003) argued that the WRAML 2 is a flexible instrument because a selection of subtests can be used instead of the full battery. Additionally, qualitative classification ranges have been created for both standard and scaled scores in which scores of 129 or above is Very Superior, 120-129 is Superior, 110-119 is High Average, 90-109 is Average, 80-89 is Low Average, 70-79 is Borderline, and scores below 70 is Impaired (Sheslow & Adams).

Working Memory Index (WMI). The WMI is an optional subtest that consists of two subtests, the Verbal Working Memory and Symbolic Working Memory. Together, these two subtests provided an estimate of how well the respondent retained information in short-term memory. On the Verbal Working Memory subtest, the respondent was asked to listen to a list of words then recall them immediately afterwards. The Verbal Working Memory subtest assesses the ability to reorganize and manipulate information held as memory trace on working memory tasks. The Symbolic Working Memory required respondent to utilize more difficult listening and working memory skills that were important in finding appropriate learning strategy and executive skills. Symbolic Working Memory relies more heavily on more route sequential recall of symbols in a specific order. The Symbolic Working Memory subtest assessed how well a participant actively operated on and retained symbolic information (e.g., numbers, letters) prior to recall. Important features of the tasks involved in this subtest are memory and attention.

Verbal Memory Index (VMI). The VMI has two subtests, a Story Memory and Verbal Learning that measure learning and recall of information (Sheslow & Adams, 2003). More specifically, the VMI was designed to measure everyday tasks like recall of stories, conversations, or information presented in a lecture, as well as following directions and recalling a list of items from a list (Sheslow & Adams). Story Memory required participants to listen to stories then paraphrasing or repeating verbatim, which measured how well the meaning and content of the story was preserved. The Verbal Learning required listening to a list of words across 4 trials and recalling them, which evaluated active learning and recall ability. This subtest assessed how well information that was initially unrelated was learned for recall with repetition.

Analysis

The data in this study was analyzed using descriptive statistics, independent samples t-tests, and a multiple linear regression models using the SPSS software. The five variables under study were sleep, vigilance, short-term memory, learning, and GPA. Sleep was analyzed in two groups, adequate (6 or more hours) sleep and inadequate (less than 6 hours) sleep, and was the independent variable. Both groups were compared on measures of the dependent variables vigilance, short-term memory, and learning using standardized instruments. Sleep, vigilance, short-term memory, and learning were used as predictors of GPA. Prior to analysis, data cleaning included checking for missing data and outliers, and checking for test assumptions that were presented in the results. Details are presented below. The research questions and hypotheses are listed again for review.

Research Question 1. Does inadequate sleep affect vigilance task performance in undergraduate college students?

Null Hypothesis ($H_0$1). Inadequate sleep, as determined by self-report, does not affect vigilance task performance, as assessed by the Digit Vigilance Test (DVT) in undergraduate college students.

Alternative Hypothesis (H_a1). Inadequate sleep, as determined by self-report, does affect vigilance task performance, as assessed by the Digit Vigilance Test (DVT) in undergraduate college students.

Analysis. An independent samples t-test was used to determine if there was a statistically significant difference between the two group means on the DVT.

Research Question 2. Does inadequate sleep affect short-term memory in undergraduate college students?

Null Hypothesis ($H_0$2). Inadequate sleep, as determined by self-report, does not affect short-term memory, as assessed by the Working Memory Index (WMI) of the Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2) in undergraduate college students.

Alternative Hypothesis (H_a2). Inadequate sleep, as determined by self-report, does affect short-term memory, as assessed by the Working Memory Index (WMI) of the Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2) in undergraduate college students.

Analysis. An independent samples t-test was used to determine if there was a statistically significant difference between the two group means on the WMI.

Research Question 3. Does inadequate sleep affect lecture learning in undergraduate college students?

Null Hypothesis ($H_0$3). Inadequate sleep, as determined by self-report, does not affect learning, as assessed by the Verbal Memory Index (VMI) of the Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2) in undergraduate college students.

Alternative Hypothesis (H_a3). Inadequate sleep, as determined by self-report, does affect learning, as assessed by the Verbal Memory Index (VMI) of the Wide Range Assessment of Memory and Learning, Second Edition (WRAML 2) in undergraduate college students.

Analysis. An independent samples t-test was used to determine if there was a statistically significant difference between the two group means on the VMI.

Research Question 4. Does sleep, vigilance, short-term memory, and learning predict a student's Grade Point Average (GPA)?

Null Hypothesis ($H_0$4). Sleep, vigilance, short-term memory, and learning does not predict a student's Grade Point Average (GPA).

Alternative Hypothesis (H_a4). Sleep, vigilance, short-term memory, and learning does predict a student's Grade Point Average (GPA).

Analysis. A multiple linear regression model was used to examine if sleep, vigilance, short-term memory, and learning were predictors of GPA.

Ethical Considerations

Careful considerations were given to protect the rights of the participants in this study. According to Gable (2009), the ethics code compliments provisions of the law that is consistent with the ethical principles. Thus, ethical principles were stressed here to emphasize the legal rights of human participants in addition to fair treatment. IRB approvals were obtained from Walden University (approval # 01-14-15-0176558, expires January 13, 2016) and the community research partner (Protocol # 15-4). The community partner's IRB approval letter is in Appendix F.

Both verbal and written informed consent was provided to participants to ensure clarity of information and prevent misconceptions. The informed consent included a brief background information on the study, procedures used, voluntary nature of the study, risks/benefits, participation incentive, and privacy/confidentiality. Participants were given opportunities to ask questions and were provided with my contact information for later questions. The original signed copy of the informed consent was be obtained by me and a Xerox copy was given to the participant for his or her record.

Although I did not anticipate any risks for participating in this research, participation in this type of a study involves some risk of the minor discomforts that can be encountered in daily life from sitting in one place for a prolonged period of time, such as such as fatigue. Participation in this study did not pose a risk to the participant's safety or wellbeing. Participants received a five dollar gift card as compensation. The direct benefits to the participants in this research was getting educated on the topic, learning about current research, how researches are conducted and learning about strategies that can help with academic success. This study may benefit the target population group by informing them about the implications of sleep deprivation and the impact it may have on academic success. This study will contribute to social change in areas of sleep, health, and educational research by highlighting the effect of sleep on cognitive functioning. This study intends to raise awareness to the impact of sleep on daytime functioning. Having a better insight to the implications of sleep on cognitive performance may potentially play a role in greater academic success and improving the quality of life.

Participation in this research was voluntary. Participants were informed of their right to withdraw from the research at any time without any penalty to them or their academic standing, record, or relationship with the college/university.

Participants were treated with confidentiality. Data was collected by me using a paper-and-pencil format. All personal information was kept private that only I have access to. Necessary precautions to protect data were taken. Each participant's data was kept in an individual file folder and was stored securely in a locked drawer at a private location that is only accessible to the researcher. Data will be kept for up to 5 years, after which data will be shredded and disposed securely. Use of any information that might make it possible to identify a participant was avoided.

Lastly, this study will not employ deception nor is it necessary. Participants will be kept well informed throughout the data collection process.

Summary

As discussed in the previous chapter, the amount of sleep a person gets plays an important role in cognitive and brain functions like vigilance, short-term memory, and learning. Despite centuries of research in sleep, vigilance, memory, and learning, scholars argued that there is yet so much more to learn about them. Examining the effect of sleep on vigilance, short-term memory, and learning provided more insight to the relationship and significance in the real world setting. Finding a relationship between these factors will provide educators and school administrators with important insights on establishing curriculums and planning instructional learning so that attention may be sustained. This would not only benefit students in their academic goals but also help with adjusting to college life.

There is very little current research examining the effects of sleep on these cognitive factors amongst the undergraduate matriculated college student population. Therefore, focus on this issue and the relationship between these factors for this population group is much needed. The study hopes to contribute the scientific community, educational setting, and those affected by it on taking precautions in making improvements in sleep habits and lifestyles that will improve the overall health and human performances.

Chapter 4 summarized the data analysis results. The chapter included an overview of the chapter in the introduction section, followed by a description of the demographic characteristics, data management and descriptive analysis of the test variables. Statistical analysis was presented to show whether assumptions of the tests were met and then the results of the statistical tests were provided for each hypothesis.

Chapter 4: Results

Introduction

The purpose of the current study was to quantitatively examine the effects of sleep on vigilance, short-term memory, and learning. This study further examined whether the variables sleep, vigilance, short-term memory, and learning predicted the reported GPA. There were four research questions in this study.

The first research question was “Does inadequate sleep affect vigilance task performance in undergraduate college students?” The null hypothesis stated that inadequate sleep, as determined by self-report, does not affect vigilance task performance, as assessed by the DVT, in undergraduate college students. The alternative hypothesis stated that inadequate sleep, as determined by self-report, does affect vigilance task performance, as assessed by the DVT in undergraduate college students. An independent samples *t* test was used to compare the inadequate and adequate sleep group means on the DVT.

The second research question was “Does inadequate sleep affect short-term memory in undergraduate college students?” The null hypothesis stated that inadequate sleep, as determined by self-report, does not affect short-term memory, as assessed by the WMI of the WRAML 2 in undergraduate college students. The alternative hypothesis stated that inadequate sleep, as determined by self-report, does affect short-term memory, as assessed by the WMI of the WRAML 2 in undergraduate college students. An independent samples *t* test was used to compare the inadequate and adequate sleep group means on the WMI.

The third research question was "Does inadequate sleep affect lecture learning in undergraduate college students?" The null hypothesis stated that inadequate sleep, as determined by self-report, does not affect learning, as assessed by the VMI of the WRAML 2 in undergraduate college students. The alternative hypothesis stated that inadequate sleep, as determined by self-report, does affect learning, as assessed by the VMI of the WRAML 2 in undergraduate college students. An independent samples *t* test was used to compare the inadequate and adequate sleep group means on the VMI.

The fourth and final research question was "Do sleep, vigilance, short-term memory, and learning predict a student's grade point average (GPA)?" The null hypothesis stated that sleep, vigilance, short-term memory, and learning do not predict a student's GPA. The alternative hypothesis stated that sleep, vigilance, short-term memory, and learning do predict a student's GPA. A multiple linear regression analysis was performed to determine whether the variables sleep, vigilance, short-term memory, and learning were related to the reported GPA.

This chapter presents the results of data analyses. A description of the participants sampled in this study is provided, along with the descriptive and statistical analysis of the data. Prior to analysis of the data, assumptions of tests were examined to show that the data were not treated skeptically and that the test results were not biased. Results of data were presented for each of the research questions and hypotheses, along with tables and figures illustrating findings.

Demographic Characteristics

Over a 4 month period, 20 undergraduate students from a private college within the New York City Metropolitan area were recruited via flyer distribution, postings, and emails. Inclusion criteria required students to be enrolled in an undergraduate course of study and to be between the ages of 18 and 39 years. To reduce misleading results, the exclusion criteria specified that those who smoked; had been diagnosed with a sleep disorder, attention disorder, memory disorder, or psychomotor movement disorder; or had experienced a recent trauma to the head were not eligible to participate in the study. Informed consent was obtained from all 20 participants before data collection.

The age of the participants ranged from 18 (10%) to 33 (10%). Of the 20 participants, 9 participants were male (45%) and 11 were female (55%). All 20 (100%) of the participants reported being enrolled as undergraduate students. More than half (55%) of the participants reported being in their fourth year in college, and a quarter (25%) of them were in their first year of college. Although students from any particular program were not targeted during recruitment, a quarter (25%) of the participants were psychology majors. The demographic characteristics of the study sample are presented in Table 1 below.

Table 1

Demographic Characteristics of Study Sample (N = 20)

Characteristic	*n*	Percent
Age		
18	2	10.0
19	2	10.0
20	2	10.0
21	1	5.0
22	2	10.0
23	3	15.0
24	1	5.0
26	1	5.0
29	2	10.0
31	2	10.0
33	2	10.0
Gender		
Male	9	45.0
Female	11	55.0
Undergraduate enrollment status	20	100.0
Major of study		
Psychology	5	25.0
Behavioral health	2	10.0
Health science	3	15.0
Occupational therapy	3	15.0
Computer arts	2	10.0
Cyber security	1	5.0
Exercise science	1	5.0
Criminal justice	1	5.0
Pre-veterinary medicine	1	5.0
Fashion merchandising	1	5.0
Year in college		
First year	5	25.0
Second year	1	5.0
Third year	3	15.0
Fourth year	11	55.0

Note. N = Total sample; *n* = subsample.

Descriptive Statistics

The number of hours slept the night before the data collection session and the GPA were based on self-reports. Measure of vigilance, short-term memory, and learning were assessed using standardized tests, the DVT and WRAML2 subtests of the WMI and the VMI, respectively. All 20 of the participants completed the questionnaires and the standardized tests and subtests with no missing data or outliers. Therefore, the sample and data used did not bias the results.

As noted in Table 2, the lowest reported GPA was 2.2, and the highest reported GPA was 4.0. More than half of the participants reported getting 6 or more sleep hours (55%). All 20 of the participants reported that they did not use the sleep recording software SleepBot.

Table 2

Frequencies and Percentile of Study Sample (N = 20)

Variable	*n*	Percent
GPA		
2.2	1	5.0
2.7	1	5.0
2.8	5	25.0
2.9	1	5.0
3.0	2	10.0
3.1	2	10.0
3.2	1	5.0
3.6	1	5.0
3.7	1	5.0
3.8	3	15.0
4.0	2	10.0

Sleep hours		
4.0	3	15.0
4.5	1	5.0
5.0	5	25.0
6.0	2	10.0
6.5	2	10.0
7.0	3	15.0
8.0	1	5.0
8.5	1	5.0
9.0	1	5.0
10.0	1	5.0
Sleep recording software	20	100.0

Note. *N* = Total sample; *n* = subsample.

Table 3 summarizes the overall mean for each of the independent and dependent variables in the study. Sleep Hours was an independent variable in the study. While, GPA, DVT, and the WRAML2 indexes and their subtests were the dependent variables that were being affected by the amount of sleep. The overall mean for the number of hours slept on the night before the data collection was 6.15. The average GPA reported was 3.16. The average measure of vigilance performance using the DVT Total Time was 12.70. The average measure of short-term memory on the WMI was 15.80 and 15.00 on the measure of learning on VMI of the WRAML2. Scores on the WMI subtests Story and VL ranged from 3 to 11 (M = 7.15, SD = 2.54) and 5 to 16 (M = 7.85, SD = 2.87) respectively. Similarly, scores on the VMI subtests VWM and SWM ranged from 2 to 19 (M = 8.40, SD = 3.89) and 5 to 14 (M = 8.40, SD = 2.93) respectively.

Table 3

Mean for Independent and Dependent Variables of Study Sample (N = 20)

Variable	*M*	*SD*
Sleep hours	6.150	1.7404
GPA	3.195	.5135
DVT total time	12.70	1.780
WRAML2 WMI	15.80	5.238
WRAML2 Story subtest	7.15	2.540
WRAML2 VL subtest	7.85	2.870
WRAML2 VMI	15.00	4.645
WRAML2 VWM subtest	8.40	3.885
WRAML2 SWM subtest	8.40	2.927

Note. *M* = Mean; *SD* = standard deviation; GPA = grade point average; DVT = Digit Vigilance Test; WMI = Working Memory Index; VL = Verbal Learning; VMI = Verbal Memory Index; VWM = Verbal Working Memory; SWM = Symbolic Working Memory.

Research Questions

Statistical Analysis

A visual inspection of the data using boxplots for each of the first three hypotheses showed that there were no significant outliers in either of the two independent sleep groups. The independent samples *t* test assumptions for normality and homogeneity of variances were assessed using the Shapiro-Wilk test and the Levene's *F* test, respectively. Results of these tests are presented under each hypothesis testing. Thus, the results of the three independent samples *t* tests were not biased.

An analysis of standard residuals was carried out for the multiple linear regression model, which indicated that there were no outliers in the data (Std. Residual Min = -1.36, Std. Residual Max = 1.38). The collinearity assumption of the multiple linear regression analysis was satisfied by indicating that multicollinearity was not a concern (Sleep Hours, Tolerance = .54, VIF = 1.85; DVT, Tolerance = .84, VIF = 1.19; WMI, Tolerance = .50, VIF = 2.0; VMI, Tolerance = .53, VIF = 1.90), which suggested that the independent variables were not highly correlated. The independent errors assumption was met (Durbin-Watson value = 1.66), which suggested that the residuals are independent. Figure 1 depicted the histogram and scatterplot of standardized residuals that satisfied the assumptions of normality, linearity and homoscedasticity. The assumption of non-zero variances was also met (GPA, Variance = .26; Sleep Hours, Variance = .26; DVT, Variance = 3.17; WMI, Variance = 27.43; VMI, Variance = 21.58). Thus, the results of the multiple linear regression analysis were not biased.

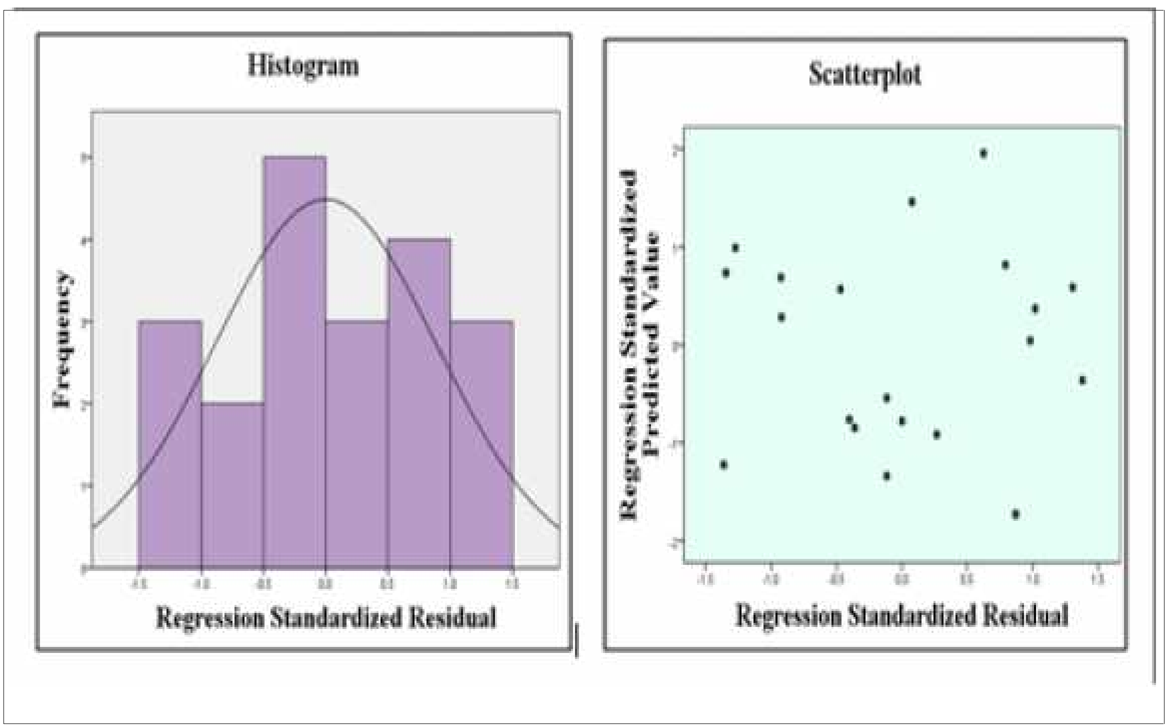

Figure 1. Histogram and scatterplot of the multiple linear regression analysis illustrating normality, linearity, and homoscedasticity assumptions with standardized residuals and standardized predicted values for GPA by sleep hours, vigilance, short-term memory, and learning.

Hypothesis 1

The first hypothesis assumed that inadequate sleep does not affect vigilance task performance, as assessed by the DVT, in undergraduate college students. An independent samples *t* test was conducted to see if the inadequate sleep group mean was significantly different from the adequate sleep group mean on the vigilance measure, DVT. The scores on the DVT scores were approximately normally distributed for the adequate (p = .285) and inadequate (p = .327) sleep groups. The assumption of homogeneity of variances was satisfied, $F(18) = .52$, $p = .480$.

As seen in Table 4, students who reported getting inadequate sleep (n = 9) scored lower on the DVT (M = 12.00, SD = 1.41) for the measure of vigilance compared to those who reported getting adequate sleep (n = 11) on the DVT (M = 13.27, SD = 1.90). However, the group difference was not statistically significant, $t(18) = 1.66$, $p = .114$, one-tailed. Therefore, the null hypothesis was maintained and it was accepted that inadequate sleep does not affect vigilance task performance, as assessed by the DVT, in undergraduate college students. The difference in the means was 1.27 with a 95% confidence interval of -.34 to 2.88. The results of the independent samples t-test are presented in Table 5.

Table 4

Mean of Sleep Hours in the Adequate and Inadequate Sleep Groups Associated With DVT (Vigilance)

Adequate sleep (n = 11)	Inadequate sleep (n = 9)

Variable	*M*	*SD*	*M*	*SD*
DVT	13.27	1.90	12.00	1.41

Note. *N* = sample size; *n* = subsample; *M* = mean; *SD* = standard deviation; DVT = Digit Vigilance Test.

Table 5

Independent Sample t Test Comparing DVT (Vigilance) Scores for the Adequate and Inadequate Sleep Groups

				95% confidence interval	
Variable	*t*(18)	*P*	Cohen's *d*	Lower	Upper
DVT	1.66	.114	.78	-.335	2.88

Note. DVT = Digit Vigilance Test.

Hypothesis 2

Hypothesis 2 assumed that inadequate sleep does not affect short-term memory, as assessed by the WMI of the WRAML2, in undergraduate college students. An independent samples *t* test was conducted to examine if the inadequate sleep group mean was significantly different from the adequate sleep group mean on the short-term memory measure, WMI. The data was normally distributed for both, the adequate (p = .150) and inadequate (p = .838) sleep groups. Additionally, the skewness and kurtosis for the adequate and inadequate sleep groups on the WMI indicated that the data was symmetrical and peaked relative to normal distribution (see Table 6). The homogeneity of variances was significant, $F(18) = 3.55$, $p = .076$. Figure 2 depicts the mean difference of the WMI scores for the two sleep groups.

Table 6

Skewness and Kurtosis for the Reported Sleep Hours in the Adequate and Inadequate Sleep Groups Associated With WMI (Short-Term Memory)

	Adequate sleep (*n* = 11)		Inadequate sleep (*n* = 9)	
Variable	Skew	Kurtosis	Skew	Kurtosis
WMI	-.28	-1.70	.19	-.72

Note. n = Subsample; *M* = mean; *SD* = standard deviation; WMI = Working Memory Index.

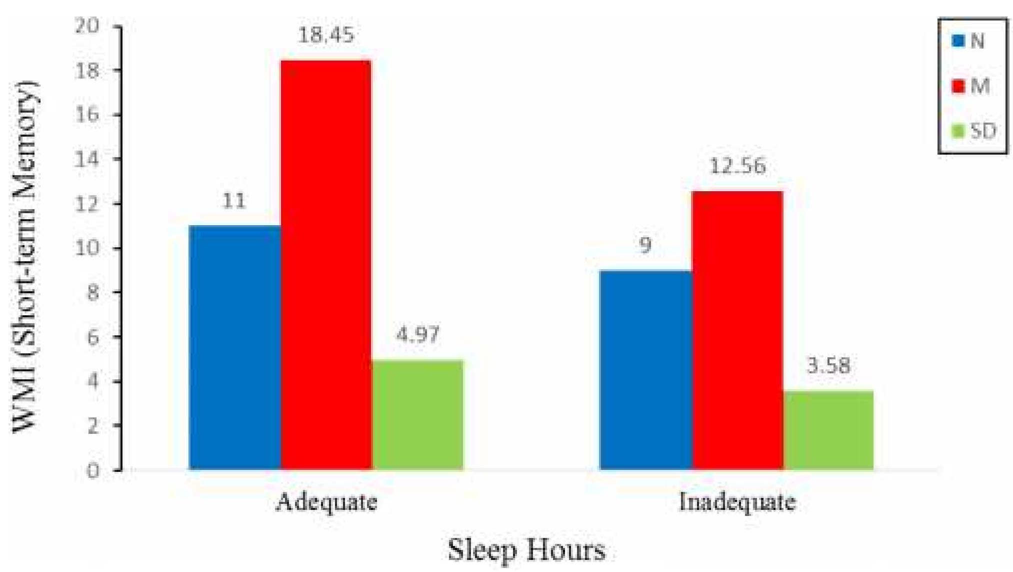

Figure 2. Comparison of the adequate and inadequate sleep group mean associated with WMI (short-term memory).

As can be seen in Figure 2, students who reported getting inadequate sleep (*n* = 9) scored lower on the WMI (*M* = 12.56, *SD* = 3.58) for the measure of short-term memory compared to those who reported getting adequate sleep (n = 11), on the WMI (M = 18.45, SD = 4.97), $t(18) = 2.98$, p = .008, one-tailed. Thus, the null hypothesis was rejected, suggesting that inadequate sleep does affect short-term memory, as assessed by the WMI of the WRAML2, in undergraduate college students. The effect size was estimated at 1.40 using a Cohen's *d*, which is a large effect. This suggests that the magnitude of group difference is significant. The statistical analysis conducted show that the group difference of the means was 5.90 with a 95% confidence interval of 1.74 to 10.06. The results of the independent samples *t* test are presented in Table 7.

Table 7

Independent Sample t Test Comparing the Adequate and Inadequate Sleep Groups on the WMI (Short-Term Memory) Measure

				95% confidence interval	
Variable	*t*(18)	*P*	Cohen's *d*	Lower	Upper
WMI	2.98	.008	1.40	1.74	10.06

Note. WMI = Working Memory Index; $^{**}p \leq .05$.

Hypothesis 3

Hypothesis 3 assumed that inadequate sleep does not affect learning, as assessed by the VMI of the WRAML2, in undergraduate college students. An independent samples *t* test was conducted to see if the inadequate sleep group mean was significantly different from the adequate sleep group mean on the learning measure, VMI. The scores on the VMI scores were approximately normally distributed for the adequate (p = .433) and inadequate (p = .614) sleep groups. Skewness and Kurtosis for the adequate and inadequate sleep groups on the VMI indicated that the data was symmetrical and peaked relative to normal distribution (see Table 8). The homogeneity of variances was significant, $F(18) = 6.42$, $p = .021$.

Table 8

Skewness and Kurtosis for the Reported Sleep Hours in the Adequate and Inadequate Sleep Groups Associated With VMI (Learning)

	Adequate sleep (n = 11)		Inadequate sleep (n = 9)	
Variable	Skew	Kurtosis	Skew	Kurtosis
VMI	-.10	-1.29	.08	-.50

Note. n = subsample; M = mean; SD = standard deviation; WMI = Working Memory Index.

Students who reported getting inadequate sleep (n = 9) scored lower on the VMI (M = 12.22, SD = 2.22) for the measure of learning, compared to those who reported getting adequate sleep (n = 11), on the VMI (M = 17.27, SD = 4.94), $t(14.46) = 3.04$, p = .009, one-tailed. Thus, the null hypothesis was rejected, suggesting that inadequate sleep, as determined by self-report, does affect learning, as assessed by the VMI of the WRAML2, in undergraduate college students. The effect size was estimated at 1.60 using a Cohen's d, which is a large effect. The magnitude of difference in the means was 5.05 with a 95% confidence interval of 1.49 to 8.61. The results of the independent samples t-test are presented in Table 9. Figure 3 depicts mean scores on the VMI for both sleep groups.

Table 9

Independent Sample t Test Comparing VMI (Learning) Scores for the Adequate and Inadequate Sleep Groups

				95% confidence interval	
Variable	*t*(14.46)	*P*	Cohen's *d*	Lower	Upper
VMI	3.04	.009	1.60	1.49	8.61

Note. WMI = Working Memory Index.

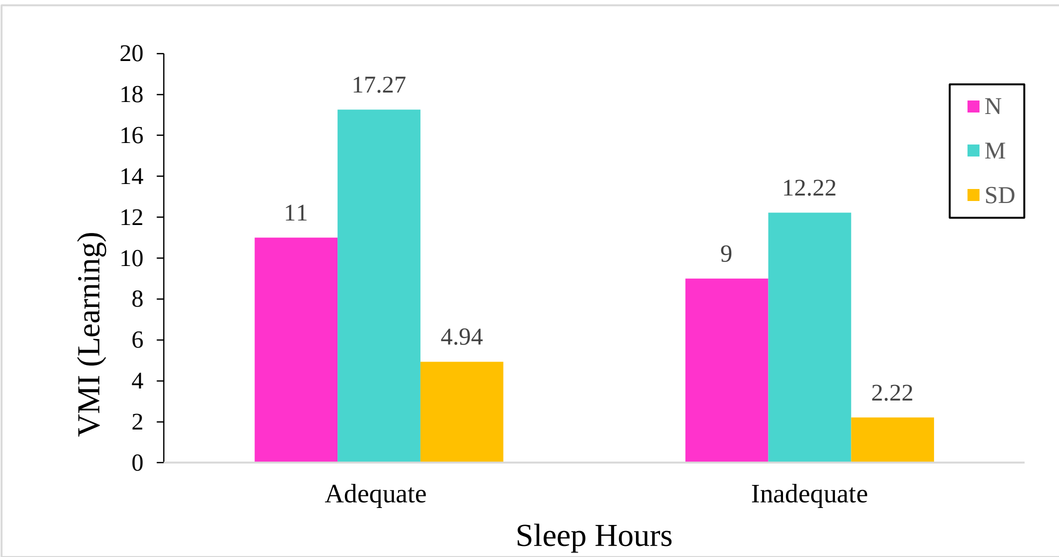

Figure 3. Mean VMI (learning) scores for adequate and inadequate sleep groups.

Hypothesis 4

The fourth hypothesis examined whether sleep, vigilance, short-term memory, and learning, predicted students' reported GPA. A multiple linear regression analysis was conducted to test if sleep, vigilance, short-term memory, and learning were predictors of the reported GPA. The result of the multiple linear regression model was not significant, *F*(4, 15) = 1.30, $p < .32$, $R^2 = .26$. This suggested that sleep, vigilance, short-term memory, and learning account for 26% of the variance in reports of GPA. None of the individual predictors were significant coefficients in the regression model. Thus, failing to reject the null hypothesis. The data analysis suggested that sleep hours, vigilance, short-term memory, and learning did not predict GPA. The results of the multiple regression are presented in Table 10.

Table 10

Results for the Multiple Linear Regression With Sleep Hours, Vigilance, Short-Term Memory, and Learning Predicting GPA

Model	B	*SE*	*β*	t	*p*
Sleep hours	.057	.076	.192	.750	.465
DVT total time	.004	.066	.015	.067	.947
WMI	.053	.029	.537	1.788	.094
VMI	-.031	.034	-.279	-.918	.373

Note. $F(4,15) = 1.30$, $p = .316$; $R^2 = .26$; adjusted $R^2 = .06$.

Summary

The statistical analyses of the results were significant for hypotheses 2 and 3 using an independent sample *t* test, but not for hypothesis 1. Additionally, the statistical analysis for hypothesis 4 using a multiple linear regression was not significant. Assessment scores on the WMI and VMI of the WRAML2 measuring short-term memory and learning respectively, were lower for the inadequate sleep group compared to the adequate sleep group. The group differences were for these two hypotheses were statistically significant and rejected the null hypotheses. Therefore, it was suggested that the amount of sleep hours does affect short-term memory and learning in undergraduate college students. On the contrary, results for hypothesis 1 accepted the null, which suggested that although the adequate and inadequate group means differed on vigilance tasks, the difference was not significant. Hence, the amount of sleep hours did not affect vigilance performance in undergraduate college students. Similarly, results for Hypothesis 4 also accepted the null, implying that sleep, vigilance, short-term memory, and learning were not significant predictors of students' GPA.

Chapter 5 summarized the key findings and conclusions for the study. The chapter analyzed the results and their interpretations. The chapter also addressed whether the findings from the current study were supported in peer-reviewed literature and how it contributed to the field of study. Social implications, study limitations and future recommendations for continued research in this area of study were also presented in Chapter 5, and were based on the strengths and weaknesses grounded to this study.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

This study investigated the effect of sleep on vigilance, short-term memory, and learning. Additionally, I attempted to determine whether the study variables of sleep, vigilance, short-term memory, and learning had predictive ability concerning GPA. The study results confirm that sleep has an effect on short-term memory and learning. However, this study failed to show that sleep has an effect on vigilance. Findings also implied that sleep, vigilance, short-term memory, and learning were not strong predictors of academic success as reflected by students' GPA.

Further, it is important to note that there are a number of factors that could have played a role in the study outcome. One such factor is the sample size. This study involved the collection of data from a very small sample, which could explain the large effect in the variables.

This study also involved the collection of data for only one night of sleep, which may not have been sufficient in depicting an impact on vigilance. Consecutive nights of sleep deprivation may have yielded a different outcome on cognitive functions such as vigilance, as well as overall learning capacity. At the same time, this study was able to establish a satisfactory association between sleep and major cognitive functions such as memory and learning by illustrating the effect it had due to just one night of inadequate sleep (less than 6 hours).

Considerable research has investigated the effects of sleep on cognitive processes such as vigilance, short-term memory, and learning. Although previous studies were successful in finding a significant relationship between sleep and academic performance, many of then failed to perform a comprehensive examination of the effect of sleep on variables such as vigilance, short-term memory, and learning that play a crucial role in predicting academic performance. Thus, this study was successful in providing a glimpse into the effect of sleep on short-term memory and learning with even minimally reported sleep. Findings support the significance of sleep for cognitive functions that are crucial for optimal functioning. It would have been interesting to test the performance levels on vigilance, memory, and learning tasks with greater sleep deprivation, as it is not uncommon for students to go without sleep for a day or more.

Interpretation of the Results

The findings of this study demonstrate that participants who reported getting 6 or more hours of sleep scored higher on short-term memory and learning tests than those who reported getting less than 6 hours of sleep. This means that material that is introduced to short-term memory during class lectures is affected by not getting enough hours of sleep. In other words, students who are sleep deprived will not only poorly process new information to short-term memory, but also have difficulty in recalling this information and retaining for learning. Short-term memory plays a key role in the learning process because new information that is introduced is processed through short-term memory first and is an important factor in transferring that information for later recall (Abel & Bäuml, 2013; Corbin & Marquer, 2013; Finn & Roediger, 2013; Maquet, 2001).

The first hypothesis was not significant; thus, the null hypothesis that inadequate sleep does not affect sleep vigilance was accepted. The data did not contain any outliers, and assumptions were met. Therefore, the results were unbiased. Although performance on the vigilance test was not significant, those who reported getting an adequate amount of sleep performed better than those who reported getting an inadequate amount of sleep. Witkowski et al. (2015) conducted a study to investigate the neurocognitive association for changes in sleep patterns of college students through a whole semester. Witkowski et al. (2015) argued that chronic sleep restriction in real-world setting impacts neurocognition in a similar manner to sleep restriction in a controlled laboratory setting. The study results indicated that the college student sample slept less over the course of a semester, with a decrease in the ability to sustain attention during psychomotor vigilance task performance. It was noted that sleep deficiency reduced cortical arousal and impaired vigilance (Witkowski et al., 2015). Furthermore, cortical arousal and vigilance both decreased during early, mid, and late semester testing sessions (Witkowski et al., 2015). Therefore, poor vigilance performance was related to sleep restriction.

Hypothesis 2 results were significant, indicating that inadequate sleep does affect short-term memory. Although short-term memory holds information for a short while, awareness of the information presented is strengthened with repetition and aids in recall of information from memory (Fenn & Hambrick, 2012; Jugovac & Cavallero, 2012).

Findings from this study suggesting a significant impairment in short-term memory due to sleep deprivation are in concurrence with previous studies. A previous study examining the precise effects of sleep deprivation on human memory illustrated that sleep deprivation increases the occurrence of lapses, periods of lowered reactive capacity, which prevent the encoding of items in short-term memory (Polzella, 1975). Jugovac and Cavallero (2012) argued that memory impairments are also attributed to attentional failures because subjects failed to register for later recall of the items presented. This suggests that there is a link between attention and short-term memory. This study did not examine this link, but it can be inferred that attentional capacity may have contributed to recall tasks.

It was assumed in Hypothesis 3 that inadequate sleep does not affect learning. Results indicated that students who reported getting 6 hours or more of sleep, defined as adequate, did significantly better on the learning tasks presented in the WMI of the WRAML2 to assess learning of items presented. Thus, the findings in this study illustrate that learning is impaired with inadequate sleep. This implies that students who sleep adequately also perform better on learning tasks, which is beneficial to academic success.

Hypothesis 4 indicated that GPA could not be predicted by sleep, vigilance, short-term memory, or learning. Previous research conducted with a large sample size of 867 participants that focused on sleep as a predictor of academic performance showed a significant predictive effect (Taylor, Vatthauer, Bramoweth, Ruggero, & Roane, 2013). In their study, Taylor et al. (2013) argued that the relationship between sleep and GPA in college students had been understudied, given the prevalence of sleep problems with this population group. For instance, literature supports that college students report inconsistent sleep schedules and less than the recommended hours of sleep, which likely influences academic performance. This suggests that perhaps a predictive relationship could not be found between GPA and the study variables as a result of a very small sample.

Theoretical Conceptualization

The trace reactivation hypothesis and cognitivism served as a theoretical foundation to understand the variables investigated in this study that dealt with the biological and cognitive mechanisms of consciousness, attention, memory, and learning. These two models were useful in predicting the hypothesis in this study. The results of this study supported these theories by showing that adequate sleep helped students do better on tasks, arguably because a recommended amount of sleep strengthened the ability to be more alert during tasks.

Implications for Social Change

The findings from this study may be used for inform higher education students, instructors, and administrators alike for planning and implementing academic success. This study may bring social change by encouraging students to develop better sleep schedules and ultimately establish a healthier lifestyle that will allow them to not only improve quality of life, but also achieve educational goals. Social change may develop from making college students aware of the negative consequences of sleep deprivation with the study data so that they start getting more sleep for a healthier and more successful life.

This study contributes to sleep, health, and educational research, specifically in the areas of learning, memory, and attention. The findings of this study aim to improve the quality of life by highlighting the potential adverse effect of sleep on academic life, cognitive functioning, and general health. Finding will also educate and empower the target group to be better informed against the risks of sleep deprivation and how it impacts them.

The effects of sleep goes beyond academic performance. Literature presented in chapters 1 and 2 supported that poor sleep is related to mental disorders and poor health (Miccoli et al., 2008; Querstret & Cropley, 2012; Swanson et al., 2011; Taylor et al., 2013; Wulff et al., 2010). Such that, sleep deficiency has been linked to cognitive impairments, emotional instability, poor immune system, metabolic problems, and higher risks of cancer and heart disease (Miccoli et al.; Taylor et al.; Wulff et al.). Inadequate sleep also delays the body's reaction time for task performance, feeling fatigued during the daytime and low mood (Querstret & Cropley; Swanson et al.; Wulff et al.).

The results of the current study support positive social change aimed at broadening the understanding of behaviors that positively influence health through informing about not just the cognitive impairments related to sleep deprivation, but also the health risks associated with it. Health care costs will be reduced with better sleep and reducing risks for health problems associated with sleep deprivation. The results of this study provide valuable information for the public about a healthier and more energized lifestyle.

Limitations and Future Recommendations

There are some limitations of this study that are important to note. Sleep and GPA data were based on self-report and, therefore, may not be as accurate and reliable as scores on the standardized tests. It would have been beneficial to measure vigilance, short-term memory, and learning for both adequate and inadequate sleep using the same samples to depict individual effect of sleep on the study variables.

Despite the limitations presented in this research, the findings will provide important insights to school administrators, instructors, students in planning and implementing academic success. The potential social change this study may bring is by encouraging students to develop better sleep schedules and ultimately establishing a healthier life style that will not only improve the quality of life but also achieve educational goals.

Future studies investigating the relationship between sleep and vigilance would benefit from using a larger sample. Additionally, combining measure of these variables with cumulative GPA would show a direct effect on academic performance. Though self-report data on sleep is widely used method in many sleep research due to its cost-effectiveness, using a physiological sleep recording technique, such as a polysomnography recording, would be the most accurate assessment of the amount of sleep.

Conclusion

Finally, the aim of this research study was to further examine the relationship between sleep, vigilance, short-term memory, learning and academic performance using reported GPA. The results showed some relationship between the amount of sleep and performance scores on measures of vigilance, short-term memory, learning, and GPA but was differences in the scores were only significant for short-term memory and learning in college students. Students who reported getting an adequate amount of sleep performed significantly better on the working memory and learning indexes of the WRAML 2. Although students with 6 or more hours of sleep had higher scores on the DVT and cumulative GPA scores compared to students with less than 6 hours of sleep, this group difference was not significant. This implies that further examination may explain this difference better.

In conclusion, this study offered some insight to the effect of sleep on college students. Although insufficient sleep has been consistently shown to be correlated with lower vigilance and academic performance (Jugovac & Cavallero, 2012; Kaida et al., 2008; Kronholm et al., 2011), this study did not observe a relationship between vigilance and academic performance. Though previous studies have examined the many negative consequences of poor sleep that can be used to imply how it may affect college students, there is little evidence to prove it. Most studies did not address multiple variables that coincide with sleep and learning using college students to assess how much of an effect it has on academic performance, which has a lot to do with success in the future, specifically career outcome. There is a lack of studies focusing on the relationship between sleep and academic performance in college students. Therefore, greater focus needs to be given to this area.

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Appendix A: Research Study Participation

We are looking for volunteers to participate in a research study examining how the amount of sleep influences learning.

❖Who's Eligible:

➢Undergraduate students between the ages of 18 and 39 years.

❖Who's NOT Eligible:

➢If you: smoke, were diagnosed with a sleep disorder, attention disorder, memory disorder, psychomotor movement disorder, or recently experienced a trauma to the head.

❖What’s Involved:

➢Screening: 5-10 minute phone call.

➢Data collection session: fill out 2 questionnaires (1-2 minutes) and take a few short tests (each test/subtest will take approximately 10-15 minutes).

➢A $5 gift card.

If you are interested and eligible to participate, please inquire here:

ayesha.uddin@waldenu.edu

Thank you!

Principal Investigator: Ayesha Uddin, Doctoral Student
Walden University

Appendix B: Phone Screening

Researcher: I am calling you because you've expressed interest in participating in this study. As stated in the invitation, the purpose of this study is to examine the role of sleep on learning. In order to proceed, I will need to ask you questions about the inclusion and exclusion criteria listed on the flyer to verify that you are eligible to participate. Is that okay with you?

Participant: Yes/No

Researcher: What is your age?

Participant: ____

Researcher: Are you in undergraduate study?

Participant: Yes/No

Researcher: Does any of the following apply to you: experienced a recent trauma to the head, or have been diagnosed with a sleep disorder, attention disorder, memory disorder, or psychomotor movement disorder?

Participant: Yes/No

Researcher: Please note that your participation is voluntary. You have the right to withdraw from this research at any time. Should you agree to participate, you will need to come in for about an hour at your convenience to sign the informed consent, complete a basic demographic data form, a sleep questionnaire, and take 2 psychometric tests. One of the test is timed to up to 10 minutes and only 4 subtests of the other test will be administered, not more than 10 to 15 minutes each. The data collected will be used for the purpose of this research. Results will be reported confidentially. You will receive more information when you come in. Are you willing to come in for the data collection session?

Participant: Yes/No

Researcher: What is a good day and time for you to come in?

Participant:____

Researcher: Please note this appointment date/time. I will give you a reminder call at least 24 hours before the appointment. Do you have any questions for me at this time?

Appendix C: Consent Form

Consent Form

You are invited to take part in a research study examining the role of sleep on vigilance performance and short-term memory during learning. The researcher is inviting undergraduate students between the ages of 18 and 39. Those who smoke, experienced a recent trauma to the head, or have been diagnosed with a sleep disorder, attention disorder, memory disorder, or psychomotor movement disorder will be excluded from the study. This form is part of a process called "informed consent" to allow you to understand this study before deciding whether to take part. I will describe this study to you and answer any of your questions.

This study is being conducted by a researcher named Ayesha Uddin, who is a doctoral student at Walden University.

Background Information:
The purpose of this research is to determine if there is an association between the amount of sleep in terms of adequate (six or more hours) and inadequate (less than 6 hours) sleep and vigilance, short-term memory, and learning.

Procedures:
Your eligibility to participate in this study has already been determined through an earlier screening phone call. If you agree to be in this study, you will be asked to:

- Come in for one session based on your availability. Session will include informed consent followed by data collection using assessment tools.
- Complete a demographic questionnaire that may take one to two minutes.
- Take two psychometric tests to measure vigilance, short-term memory, and learning. The vigilance test that is timed to 10 minutes for completion. The other test consisting of two short-term memory subtests and two learning subtest may each take approximately 10 minutes.
- Complete a simple sleep questionnaire that may take one to two minutes.
- Anticipate being at the test session for at least one hour. Be advised that the session may take longer if you need extra time to complete tests and questionnaires. No follow up visit is required.
- There is compensation for participating in this study.

Voluntary Nature of the Study:
Your participation in this research is voluntary. You may refuse to participate before the study begins or discontinue at any time with no penalty to you or your academic standing, record, or relationship with the college/university involved with the research. Please note, in order to ensure accuracy in the data analysis, I can only include assessments which have been fully completed. If there are questions you do not want to answer then please know you can discontinue participation at any time.

Risks and Benefits of Being in the Study:
I do not anticipate any risks to you participating in this study other than those encountered in daily life. However, should you become stressed or anxious, you can go to Mercy College counseling center. There are no personal benefits to you. However, the study may contribute

further insight in areas of sleep, health, and educational research. Findings from this study will highlight the effect of sleep on academic life, cognitive functioning, and general health.

Payment:
In appreciation of your time, a five dollar gift card to Dunkin' Donuts will be given to you when you come in for the test session. The gift card will be given to you at the beginning of the session.

Privacy/Confidentiality:
Your information will be kept private. Research records will be kept in a locked file that only the researcher will have access to. Any information that might make it possible to identify you will not be included in any report that I may make public. Though I am taking precautions to protect your privacy, you should be aware that information sent through e-mail could be read by a third party since email communication in general is neither private nor secure.

Contacts and Questions:
You may ask any questions you have now. Or if you have questions later, you may contact the researcher via email at [redacted]. If you want to talk privately about your rights as a participant, you can call [redacted] She is the Walden University representative who can discuss this with you. Her phone number is [redacted]. Walden University's approval number for this study is 01-14-15-0176558 and it expires on January 13, 2016. The institutional Review Board (IRB) of Mercy College has also approved recruitment of participants for this research study. The IRB chair, [redacted] can be contacted at [redacted] if you have questions about the rights of research participants.

You will be given a copy of this form to keep for your records.

Statement of Consent:
I have read the above information and I feel I understand the study well enough to make a decision about my involvement. By signing below, I understand that I am agreeing to the terms described above.

Printed Name of Participant ______________________________

Date of consent ______________________________

Participant's Signature ______________________________

Researcher's Signature ______________________________

This consent form will be kept by the researcher for at least five years beyond the end of the study.

Appendix D: Basic Demographic Data

Subject's Initials________ ID#____________________ Date______________________

Age	
Gender	
Study Major	
Year in College	
Enrollment Status	
GPA	
Current term credits	
Study/assignment hours per week	
Employment Status (hours/week)	

Appendix E: Sleep Questionnaire

Instructions: Please answer the following questions for the previous night as accurately as possible.

1. How many hours of sleep did you get last night? ________:________
2. Did you use the smartphone app, SleepBot? __________________
    a) If yes, what was the recorded sleep length? ________:________

Appendix F: IRB Approval

MERCY COLLEGE

MEMO

To: Ayesha Uddin
From: [redacted]
Chair, Mercy College Institutional Review Board
Subject: IRB Review of Proposed Research
Date: January 25, 2015

Protocol No.: 15-4
Project Title: ***The Role of Sleep on Vigilance Performance and Short-Term Memory during Learning in Lecture Classrooms among College Students***

The committee has reviewed and **Approved** your research proposal for a period of one year. Attached is the IRB approved and stamped consent form that should be used in data collection.

Listed below are the responsibilities to your study participants regarding informed consent and confidentiality, and to the IRB. Please sign, date, and return one copy of this memo to the IRB at mcirb@mercy.edu. Good luck with your research.

Research investigators are responsible for:

- Insuring that informed consent is obtained by the use of the written consent form approved by the IRB.
- Protecting study subject confidentiality and confidentiality of their records.
- Submitting for IRB review, any advertisements to recruit research subjects. This includes, but is not limited to electronic, newspaper, radio, and television advertisements and notices, public service announcements, posters and flyers.
- Reporting the progress of the research to the IRB, as often as and in the manner prescribed by the IRB, but no less than once per year.
- Reporting promptly in writing to the IRB, any injuries to human subjects or any unanticipated problems that involve risks to the human research participants or others. Investigators are encouraged to call the IRB with these reports in addition to preparing a written report.
- Reporting promptly, in writing to the IRB, any proposed changes in a research protocol that shall not be initiated by research investigators without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subject.
- Reporting promptly, in writing to the IRB, any serious or continuing noncompliance with the requirements of this approval or the determinations of the IRB.

Principal Investigator(s) | Date 1/25/15