

# **The Effects of Sleep Deprivation on Memory, Problem Solving and Critical Thinking**

*An Ex-Post Facto Experimental Study*

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*Psychology 211*

*Research Methods for the Behavioral Sciences*

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May 2015

### **ABSTRACT**

The main focus of this research was to obtain a deeper insight of the negative implications sleep deprivation had on particular cognitive functions. The research aimed to assess the correlation, if any, sleep deprivation had on critical thinking, problem solving skills, and short-term memory of college students. The purpose was to gain new information, which would better inform college students of the importance of routinely obtaining the recommended 7-8 hours of sleep. The method applied in this research was a simple ex post facto design model along with simple stratified random sampling. The stratum was separated in to two strata of twenty-five male and females per for a total sample size of fifty. The experiment took place on the Loudoun campus of Northern Virginia Community College. The instrumentation used was a Cognitive Function Abilities Assessment. The data failed to support the hypothesis in this experiment. The data supports a conclusion, which makes determining any correlation difficult; however, by accounting for limitations not accounted for initially, better results could be obtained upon conducting the experiment a second time.

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## **Chapter 1**

### **INTRODUCTION**

Sleep is an essential element of the human condition, which allows us to, when obtaining the correct amount, perform critical daily functions at peak optimization. However, the community at large often underestimates sleep and its importance, therefore leading people to not be as concerned with a proper night's sleep, thereby preventing them from performing at peak efficiency.

#### **Background**

Sleep is a normal human function that is detrimental to sustaining life yet; individuals are affected differently by their sleep schedule. There is no doubt that in today's modern world college students are busy individuals. Whether from the grueling demands of regularly assigned homework coupled with major projects assigned from a full schedule of classes, or the boss asking them to "stay for just a few hours longer," they are stretched thin. Sleep is a detrimental necessity that when not enough is obtained, a noticeable depreciation in the daily functioning of the sleep-deprived individual(s) can have a detrimental impact on the adequate performance of certain critical daily functions.

When an individual routinely has poor sleep habits paired with sleep loss can have a negative impact on one's health. Sleep is important because it has a determining role in your mental and physical health, along with quality of life ("How Much Sleep is Enough", 2012). However, regardless of the reason for one to not receive the proper amount of sleep it is imperative that individuals, especially college students receive the proper amount in order to avoid depreciation in their ability to problem-solve, think critically and remember adequately.

### **Problem Statement**

Everywhere you go, you hear people complain that they are tired and do not have any energy. Students stay up late because they had to work the night before in order to pay for school, they are trying to finish an assignment that is due the next day, there is some sort of issue at home, or they decided they would rather do some other leisure activity they enjoy rather than go to bed at a more appropriate time. However, studies have shown that sleeping is one of the most important things a person can do. Sleep plays a vital role in learning and when a person fails to obtain enough sleep the night prior, neurons in the brain might not fire properly, the body becomes out of synch, and it can even lead to accidental physical injuries ("Benefits of Sleep", 2007).

Students need to learn to be able to put down their computers, turn off the TV, say no to a night on the town, or limit some of their work hours so that they can ensure themselves at least the minimum number hours of sleep required. Perhaps teachers will even notice a noticeable difference in student performance if all of their students are receiving the appropriate amount of sleep every night.

### **Purpose of this Study**

The purpose of this study is to enlighten the community at large of the adverse effects that a lack of sleep can have on the human mind. This study will also provide insight as to how much sleep is necessary each night for adults and the maximum number of hours a person should remain awake before going to sleep. The data gathered would help people to create a new sleep pattern that will guarantee peak performance.

### **Major Research Question**

How does a lack of sleep impact memory, problem solving and critical thinking skills amongst college students?

### **Minor Questions**

- What are the differences between genders?
- What age group will be most affected by sleep deprivation?
- Is there a point where the skills stagnate after a certain number of hours of sleep?

### **Hypothesis**

College students that obtain between seven to eight hours of sleep each night will achieve higher scores on the tests administered than those who receive six or less, or nine or more hours of sleep per night.

### **Theoretical Framework**

People claim to understand that sleep is an important aspect of their life, yet they prove their ignorance by refusing to get sleep, even when they are tired, because they want to get though one more level in a game, read one more chapter, watch one more episode, or have “just a little more work to accomplish.” Studies have determined that total sleep deprivation negatively effects an individual’s filtering capabilities. Though their visual working memory capacity is left unhindered, if one cannot filter out the information being taken in, they cannot store anything in their memory (Drummond, Anderson, Straus, Vogel, & Perez, 2012).

Many people tend to allow themselves to be sleep deprived throughout the week because they generally believe they can make up for the sleep on the weekend when they get a break from the work or school week; however, during the period of sleep deprivation, their ability to complete tasks will be hindered, causing a decrease in the quality of work primarily due to a reduction in attention, memory, and problem solving tasks (Chiang, Arendt, Zheng, & Hanisch, 2014).



As studies have been conducted, the majority have seemed to come to similar conclusions: a lack of sleep can have detrimental side effects on the human mind and body, and by regularly obtaining enough sleep each night, a person can function more efficiently. As a person becomes more sleep deprived, their attention span shortens and their working memory begins to deteriorate (McCubbin, Peach, Moore, & Pilcher, 2012). It can then be easily concluded that as these skills decline, the quality of work will do the same, which is contrary to the mindset of a majority of college students today.

Especially during the time of midterm and final exams, and when project deadlines loom overhead, a common behavioral pattern becomes apparent in most, if not all, students. Sleep is sacrificed in order to allow them to continue their work or studying, attempting to finish their work on time or memorize everything they need to in order to secure a good grade. However, if the past studies and the results are accurate, these students could be setting themselves up for failure, or at least keeping themselves from achieving the highest grade possible, while simultaneously negatively affecting their health.

In all actuality, when otherwise healthy students deprive themselves of sleep, there is an alteration in the neurophysiological and endocrine systems, rendering all learned and practiced events during the period of sleep deprivation moot. It can be determined that this is likely due to a decrease in vigilance and maintained attention (Klumpers, Veltman, van Tol, Kloet, Boellaard, Lammertsma, & Hoogendijk, 2015).

### **Significance of Study**

This study will prove to be of significance by determining the optimum number of hours required for individuals to be able to perform at their peak efficiency. As people enter different stages of life, they become preoccupied with different activities and interests that end up taking up their time and focus. Some are at a point where they are in school, pursuing their education, while others are in the

workforce, some are raising children and others spend their time engaging in different hobbies and pleasurable activities, and many are doing any combination of these things.

Unfortunately, people get so distracted with their activities and attempting to do everything that they want and need to do, their sleep cycles suffer. Sometimes it is unintentional, people get completely preoccupied and they lose track of time. On other occasions, they purposefully force themselves to remain awake because there is something they want or feel they need to do, so they lose even more sleep that night. There are times when a lack of sleep is to be expected; for instance when parents are raising an infant. Nevertheless, people still do not make sleep enough of a priority.

It is the desire of the researchers in this study to educate the community of the true importance of getting enough sleep. By showing them the difference that a proper night's sleep can have compared to a night without the proper amount; hopefully people will then make an effort to ensure that they get enough sleep to be able to function efficiently each day.

### **Definition of Terms**

**Sleep:** The naturally recurring (esp. nightly) condition of repose and inactivity assumed by people and most higher animals, in which consciousness, response to external stimuli, and voluntary muscular action are largely suspended.

**Adult:** All individuals that are 18 years of age or older

**Memory:** The faculty by which information is remembered; the capacity for retaining, perpetuating, or reviving the thought of things past; an individual's faculty for remembering information.

**Problem Solving:** A person's ability to be confronted with mathematical word problems and solve them to find the correct answer.

**Confidence Interval:** A range of values so defined that there is a specified probability that the value of a parameter lies within it.

**Critical Thinking:** The individual's ability to think logically and answer questions with obvious yet trick answers.

**Circadian Rhythm:** The cycle of biological activity based on a 24-hour period of time and is influenced by the regular variations in the environment

**Standard Deviation:** a quantity calculated to indicate the extent of deviation for a group as a whole

**Fatigue:** A condition of muscles, organs, cells, or materials characterized by temporary reduction in power, efficiency or sensitivity following prolonged use or activity.

(Shorter Oxford English Dictionary, Fifth Edition, 2002)

### **Delimitations of Study**

- Study is based at the Loudoun Campus of Northern Virginia Community College
- Students in this study are eighteen years of age or older
- All subjects receive the exact same test

### **Limitations of Study**

- Some participants might provide inaccurate information
- Some participants might not put in true effort when completing the tests
- No equipment to test the full extent to which the brain is functioning

## **Chapter 2**

### **LITERATURE REVIEW**

#### **Overview**

Sleep is a major aspect in our everyday lives; however, fewer people are getting enough sleep each night and more are slowly becoming sleep deprived. Sleep deprivation is defined as a condition that occurs when an individual does not get enough sleep each night (What Are Sleep Deprivation, 2012). There is an immense amount of research being conducted in order to determine how to overcome sleep deprivation, but in order to surpass any issue, it is important to know who is at risk of being afflicted by it.

It is important to understand that people of all ages, and ethnicities are at risk of becoming sleep deprived. More specifically, individuals who have limited time for sleep, such as students, people who work a lot of hours either at either one or more jobs, as well as caregivers. Also, those who have schedules that conflict with circadian rhythms such as; shift workers, first responders and individuals who travel for work can also be at risk of suffering from sleep deprivation. Other individuals that could be included would be those whose life style choices do not allow them to receive adequate amounts of sleep such as; individuals who take medication to stay awake, those who abuse alcohol and or drugs, or those who don't place sleep high on their priority list. Individuals who suffer from various medical conditions such as heart failure, heart disease, obesity, high blood pressure, diabetes, stroke, transit ischemic attack (mini stroke), attention-deficit hyperactivity disorder, and depression can all suffer from sleep deprivation as well (Who is at Risk, 2014)

So many people fail to maintain a proper sleep schedule, but sleep is one of the most important aspects of mankind's everyday life. There are several important aspects to maintaining an adequate

amount of sleep on a nightly basis. These would include: committing new information to memory, maintaining normal body processes such as proper carbohydrate storage and maintaining proper hormone levels, reduced tendency for day time sleepiness, thereby reducing human errors such as medical mistakes and traffic accidents, reduction in irritability and patience, improves concentration and reduces moodiness and laziness. Sleep disorders have been linked with hypertension, irregular heartbeat, and increased cortisol levels, while an adequate amount of sleep assists in maintaining proper immune system function (Benefits of Sleep, 2015).

### **Overview of Research Question**

It is the desire of a majority of research in the field of sleep deprivation to determine what the optimum amount of sleep is for each person. This would be determined by the efficiency of a person's memory, problem solving and critical thinking skills after a night of sleep. It is important to understand what might keep an individual awake at night in order to be able to avoid these obstructions in the future. The subject is constantly explored and the consensus is that seven to eight hours of sleep is the optimum amount, but it is the desire of the researchers of this study to confirm these conclusions, while also aiming to determine at which point, if any, when sleep becomes redundant or a hindrance and conversely negatively impacts everyday functions.

### **Overview of Literature**

The purpose of this study is to determine the efficacy of sleep and the adverse effects of failing to receive the proper amount on a consistent basis. The varying articles and studies have all appeared to come to a complementary consensus on the importance of a consistent sleep cycle, which allows for seven to eight hours of sleep. Many studies have been conducted within recent years, all of which seem to use a wide array of different procedures. While at the same time accumulating a plethora of data on

the subject matter showing sleep's benefits and the adversities that can arise from not receiving enough on a consistent basis.

### **Causes of Sleep Deprivation**

Just like other problems that humanity faces, there is not a single cause for sleep deprivation. If a person suffers from a sleep disorder, it is very likely that the individual will become sleep deprived, the issue is determining which disorder the person suffers from so that help can be sought after to assist in receiving enough sleep. People have been known to suffer from insomnia, sleep terror disorder, narcolepsy, sleep walking, and sleep apnea; these are just a few of the many disorders that individuals can suffer from, which can prevent them from achieving an optimum sleep regimen each night as witnessed by researchers Murphy and Delanty (Murphy, & Delanty, 2007).

Along with officially diagnosable sleep disorders, it has been observed through empirical studies such as Hershner and Chervin's *Causes and Consequences of Sleepiness Among College Students* that schedules set by colleges and public schools are partially responsible for students being afflicted with sleep deprivation. With class times being set early in the morning and late in the evening as well as work-loads being increased outside of the class room, individuals' circadian rhythms can become discombobulated, causing them to have an inadequate sleep cycle (Hershner, & Chervin, 2014).

The third major factor that can lead to an insufficient amount of sleep is when an individual makes personal and professional commitments beyond that of what is reasonably accomplished. Different careers can lead individuals to go extended periods of time without adequate amounts of sleep each night, for example; medical professionals and shift workers. When said individuals do finally have the opportunity to go home and rest, they still have to deal with the demands of their socio-economic factors such as raising a family and environmental noise pollution (Murphy, & Delanty, 2007).

### **Effect on Memory, Problem Solving, and Critical Thinking**

By failing to obtain an efficient amount of sleep each night, there is an increased possibility of there being one or more adverse effects on the individual's cognitive capabilities. The actual ability to store information is not completely hindered when a person is suffering from total sleep deprivation; however, when a person is suffering from a lack of sleep, they may tend to lose the ability to filter information; therefore, storing more irrelevant information into their working memory, leaving less room for that which is relevant, making it appear that the memory itself is being hindered. This was clearly observed through the empirical research study titled: *The Effects of Two Types of Sleep Deprivation on Visual Working Memory Capacity and Filtering Efficiency*, which was conducted by researchers Drummond, Anderson, Straus, Vogel, & Perez (Drummond, Anderson, Straus, Vogel, & Perez, 2012).

Sleep loss has been shown to be inversely proportional to academic performance; when one fails to receive an adequate amount of sleep on a nightly basis, the literature states that an individual's skills in learning capacity, such as memory, attention and problem solving skills are effected the most. Sleep deprivation can also lead to daytime sleepiness. When these factors are all being faced, students are likely to achieve lower test scores and lower grade point averages; however, it has been shown that cognitive function is not hindered as drastically when the individuals are working in groups as when working alone (Chiang, Arendt, Zheng, & Hanisch, 2014)

An individual's physical and mental health and abilities have been shown to have direct correlation with sleep deprivation. Research has shown that people who suffer from sleep deprivation, are more likely to have issues with their cognitive abilities, such as memory and problem solving skills when the individual also suffers from hypertension, but the relationship does not end there. The empirical research study *Decreased Cognitive/CNS Function in Young Adults at Risk for Hypertension:*

*Effects of Sleep Deprivation*, which was conducted by researchers; McCubbin, Peach, Moore & Pilcher have also shown that individuals who do not have hypertension are more likely to develop this issue when constantly depriving themselves of sleep (McCubbin, Peach, Moore, & Pilcher, 2012).

The brain is most effectively influenced by the different chemicals that are naturally released by the body, but it is very possible to disorient the brain by not releasing, or releasing too much of, a certain chemical. The empirical research study *Neurophysiological Effects of Sleep Deprivation in Healthy Adults*, has shown that people suffering from total sleep deprivation have an increase in dopamine output and a decrease in cortisol, thereby requiring an increase in a combined effort of production from the prefrontal and limbic cortical regions. Despite the increase of activity in the brain, individuals still suffer from decreased cognitive performance (Klumpers, Veltman, van Tol, Kloet, Boellaard, Lammertsma, & Hoodendijk, 2015).

### **Overcoming Sleep Deprivation**

There are multiple ways in which individuals can work to overcome their sleep deprivation and return to functioning at an appropriate efficiency. Insomnia has been shown to be a lead cause in sleep deprivation, causing individuals to lie awake at night, unable to achieve sleep, or constantly waking throughout the night, there are multiple treatments that have been tested and of these, one seems to stand out. With all the different drugs being used to aid with sleep, acupuncture is actually proving to be an effective aid and more research is going into discovering the true potential of this treatment (Yuan-Fang, Jian-Hua, Neng-Gui, Zhao-Hui, Zhen-Hua, Shu-Jun, & Wen-Bin, 2013).

Another aid in the fight against sleep deprivation is natural sleep aids. It is remarkable how many natural aids there are, most of which come from leaves, roots and tree bark. Some of these aids include: kava-kava, which is an herbal remedy that relaxes the body and enhances dreaming. Valerian root, which eases nerve and muscle tension as well as relieves anxiety and chamomile, which is a flower



that is most often drunk as a tea, aids in reducing restlessness and digestion. There are a plethora of natural remedies that help with releasing Melatonin and Tryptophan, which are natural chemicals in the body that aid in healthy sleep. One should always choose a natural remedy over its synthetic counterpart when available (Kopparapu, Puranik, Nargund, Samuel, Shahapurkar, & Mathew, 2012).

A full night of sleep is not always an option with people's nonstop lives, so the majority of people turn to different stimulants in order to keep them going during the day. Studies have shown that when 20mg of d-amphetamines are ingested orally, the individual returns to a cognitive state that was present prior to being sleep deprived, allowing for an improvement in addition and subtraction as well as logical reasoning tasks. Amphetamines also reduce a person's response bias by increasing their confidence in their actions and decisions. It has long been believed that nicotine has the ability to aid in the retention and enhancement of cognitive functions, when the individual is sleep deprived, due to the fact that it is a stimulant, but research has actually shown it has no positive effect on the brain's cognitive capabilities, due to its inability to improve sleep latency. L-deprenyl, like nicotine, fails to improve sleep latency in sleep-deprived individuals thereby negating any improvements on cognitive performance during the sleep deprivation period. These findings were discovered in the empirical research of *Stimulant Drug Effects on Performance and Behavior After Prolonged Sleep Deprivation: A Comparison of Amphetamine, Nicotine, and Deprenyl* (Newhouse, Penetar, Fertig, Thorne, Sing, Thomas, & Belenky, 1992).

### **Research Methodologies and Evaluation of Research Designs**

From the literature reviewed prior to conducting this research experiment, these researchers came to the conclusion that multiple types of methodologies and designs have been used in the various studies of sleep deprivation reviewed. Some researchers have used methods which primarily studied the deterioration of the individual's cognitive abilities as they become deprived of sleep. As others

compared those who were sleep deprived to those who were well rested. Multiple researchers in order to screen for general intellect and testability used tests such as the Peabody Picture Vocabulary test and the Raven's Progressive Matrices. The majority of the prior experiments reviewed for this study tend share a balance in being both quantitative, hours of sleep, and qualitative, the individuals cognitive abilities. Overall, the consensus amongst the researchers of the studies reviewed for this experiment, was that the preferred method of data collection was by direct observation in a laboratory environment, complete with EEG, EMG, fMRI and the like. This would include observers, inspectors, scientific research and data logging each performing a particular piece of the research puzzle.

### **Summary**

The focus of this study is to inform students and possibly individuals in the work force of the importance of receiving the recommended 7-8 hours of sleep each night and what the possible negative effects are when sleep is neglected. If individuals are to function at full functional capacity, it is imperative they receive the optimum amount of sleep on a continuous basis.

## Chapter 3

### RESEARCH DESIGN AND METHODOLOGY

#### Introduction

The purpose of this study is to gain a better understanding in to the detrimental effects, which sleep deprivation can have on memory, problem solving and, or critical thinking skills among college students. As college students today, schedule demands are becoming more vigorous while free time is diminishing. Whether because of demands from classes, homework assignments, or having a job, less priority is being given to health. Especially when associated with routinely obtaining the recommended seven to eight hours of sleep, it becomes imperative that students ensure they get the proper amount of sleep.

#### Overview of Research Design

The purpose of this study is to provide insight to college students on the positive effects sleep can have on their everyday functions and the detrimental consequences of neglecting to obtain the recommended seven to eight hours of sleep on a consistent basis. This study will be a simple ex post facto design. Simple ex-post facto design methods are quasi-experimental research techniques, which compare preexisting groups on a dependent variable. Ex post facto designs masquerade as genuine research experiments because both are attempting to prove a change in an independent variable causes a change in a dependent variable, but they differ in that ex post facto designs do not use random assignment. Ex post facto designs place subjects in groups based off of a particular characteristic or condition they have experienced or has occurred in the past. Although ex post facto design models masquerade as regular experiments, they do have the same limitations as non-experimental research.

**Figure 3.1** is a graphical representation of a simple ex post facto design model.

Figure 3.1



(Rahimi, 2014)

Data will be obtained through experimentation, more specifically by having the research subjects sequence the Cognitive Function Abilities Assessment. The Cognitive Function Abilities Assessment will be distributed among a variety of students throughout the Loudoun Campus of Northern Virginia Community College. The Cognitive Function Abilities Assessment will be relatively short in order to ensure it can be facilitated in a timely manner, which will allow the students the ability to return to their busy schedules as quickly as possible. The desired outcome of this study is to gain information, which will provide the researchers with knowledge that will potentially aide the students attending the college in their understanding of the importance of obtaining the recommended seven to eight hours of sleep each night, and of doing so routinely.

### **Sampling Design**

This study will be using simple stratified random sampling of male and female research studies at the Loudoun Campus of Northern Virginia Community College. There is no age or ethnicity stratum for this experiment; however, the strata will be divided into two stratum by gender and equal number of subjects (25). The data collected will be obtained through the completion of fifty assessments, being completed by twenty-five males and twenty-five females. It is the desire of this assessment to gain a better understanding of the correlation between an individual's amount of sleep and their memory, problem solving and critical thinking skills, and also the correlation between these factors and how, or if they differ from one gender to the next.

### **Data Collection**

The instrumentation that will be utilized for this ex post facto experimental design will be the Cognitive Function Abilities Assessment, which will be administered to fifty research subjects from the Loudoun Campus of Northern Virginia Community College. The simple stratified random sampling design was chosen due to the need for an equal number of males and females for the study. All research subjects will be given a consent form, **Figure 3.2** (located in the appendix) to read and sign before being allowed to participate in the experiment. The Cognitive Function Abilities Assessment will be divided into three sections: 1) a visual experimentation of memory, 2) analytical problem solving questions; and, 3) critical thinking questions. All participants will be volunteers and will be given a maximum of fifteen minutes to complete the Cognitive Function Abilities Assessment in its entirety. After all of the Cognitive Function Abilities Assessments have been completed and returned, the researchers will then properly analyze the data acquired. Strict adherence to all data analysis procedures and statistical calculations will be followed in order to ensure proper and thorough analysis of the data.

The Cognitive Function Abilities Assessment will be distributed in various locations throughout the Loudoun campus of Northern Virginia Community College, but the number of men and women taking the Cognitive Function Abilities Assessment will be kept track of in order to ensure that simple stratified random sampling occurs. All participants will be seated in front of one or both researchers from the time of reading and signing the consent form, until the completion of the visual memory portion of the Cognitive Function Abilities Assessment. This amount of time will be approximately, but no more than fifteen minutes per individual. The equipment required will be comprised of an ample supply of writing utensils and the sixty copies of both the consent form, and Cognitive Function Abilities Assessment. Also the print out required for the visual short-term memory portion of the assessment. If requested, a draft of the data collection instrument can and will be provided.

Multiple field-tests of the data collection instrument, or the Cognitive Function Abilities Assessment, were conducted on various participants who were a close representation of the desired sample population prior to administering the proctored Cognitive Function Abilities Assessment amongst the research subjects. Multiple field-tests were conducted to determine the most effective instrument to utilize in the experiment along with ensuring the fifteen minutes the researchers allotted for completion of the Cognitive Function Abilities Assessment was an adequate amount of time for the lot of research subjects. After conducting the field tests of the instruments all flaws and possible kinks were accounted for and were mended accordingly. This gave the researchers peace of mind regarding the fluidity during the administration of the Cognitive Function Abilities Assessment.

The validity of the instrumentation was verified through the respected authors and their websites. The critical thinking test is composed of questions, which were taken from a preexisting test used by the College of Forestry at the Oregon State University Graduate School. The author of the test is unknown, but the university and the pilot test ensured the validity. Taking SAT prep test questions,

which have been proven to be valid by Study Mode, the problem-solving portion was created. Study Mode is not affiliated with College Board but has ensured the validity of the questions. Finally, the memory test was taken from a preexisting test created by Eric H. Chudler, Ph. D. from the Department of Bioengineering at the University of Washington. All three parties who had created the individual tests, which make up the field instrument, have been contacted in order to receive permission to use their respective test, and each party granted us their permission. **Figure 3.3** is the final version of the Cognitive Function Abilities Assessment, which was the instrumentation, utilized in this experiment and can be found in the appendix. **Figure 3.4** is the answer key for the Cognitive Function Abilities Assessment.

### **Data Analysis Procedures**

Ethnicity and age will not be factors when selecting participants for this study; but gender will be a factor when choosing participants in order to ensure an equal number of males and females comprise each stratum. There are no qualifying prerequisites research subjects to be able to participate in the study, apart from being a current student at the Loudoun campus of Northern Virginia Community College. All data will be analyzed based on the research question; also the mean test scores of each stratum will be compared through the use of a t-test. The t-test will be used to see which of the two experimental groups, males or females, if any, were more negatively affected by sleep deprivation.

Results will be calculated based on the ability to answer questions accurately and compare scores to the number of hours of sleep in an attempt to determine a correlation between sleep deprivation and their memory, critical thinking and problem solving skills through the use of bivariate correlation. The bivariate correlation will measure the strength of the relationship between participant test scores and their respective number of hours of sleep. This relationship can range from absolute value 1-0, and the stronger the relationship; the closer the value is to one.

### **Precautions Taken to Ensure Data Validity and Reliability**

All participants partaking in this research experiment will remain anonymous throughout the testing procedures and will not be required to state any personal information other than providing their age and gender for documentation. Each individual will be monitored to ensure proper effort is being engaged during the completion of the assessment, which will aid in the accrual of accurate results. A pilot test was administered on multiple levels to ensure the allotted time provided deemed appropriate and also that the assessments will be able to provide accurate data. The external validity of this experiment is shown in the ability of this project to be carried over to a larger population; more specifically shift workers, first responders, military personnel, etc.

### **Limitations of the Research**

By limiting the amount of time allotted for individuals to complete the Cognitive Function Abilities Assessment, they may feel rushed to finish, causing them to make careless mistakes or to not put in the appropriate amount of effort. There is also the issue of participants providing false information about themselves such as age, or the number of hours of sleep they received on average and the night prior to experimentation. In addition, the setting may play a factor in careless mistakes due to distracting external stimuli in the surrounding area. Due to the nature of this study, internal validity cannot be completely guaranteed due to the limitations of undergraduate research, to be more specific there is a lack of access to functional magnetic resonance imaging equipment, electroencephalogram, electromyography, and psychopharmacology. All other measures to ensure internal validity have been accounted for. A somewhat major limitation in this methodology is having a confidence interval of fourteen, which is due to having a smaller sample size for such a large population.



### **Expected Findings**

It is expected to find the results will show a correlation between the numbers of hours of sleep the subjects obtained the night prior to experimentation and how well they performed on the Cognitive Function Abilities Assessment. Results should show the individuals who receive fewer hours of sleep, and are therefore more sleep deprived, would have less success on the tests than individuals who are well rested. It is possible; however, due to individual ability in certain aspects of the exam, that some subjects will do inherently better than others which could skew the correlation. It is also possible that the data could be skewed due to the other limitations, which may arise, whether be from the large confidence interval or confounds that arise during administration of the assessment.

### **Ethical Considerations**

There are several different aspects taken into consideration after reviewing the ethical guidelines. All participants partaking in the experiment will be given a consent form to be signed prior to completing the test. If there is any point where they decide they no longer wish to complete the Cognitive Function Abilities Assessment, they will be allowed to stop. Ensuring anonymity will protect confidentiality of all subjects. There will be no manipulation of the data being analyzed in order to skew the results one way or another.

### **Conclusion**

This methodology will provide insight to college students about the effects their sleep schedule may have on their memory, problem solving, and critical thinking skills; which would, as a result, have an effect on their grades. The collected data will assist college students with the necessary information for them to alter their daily schedule to ensure they routinely receive enough sleep in order to function at peak efficiency each and every day.

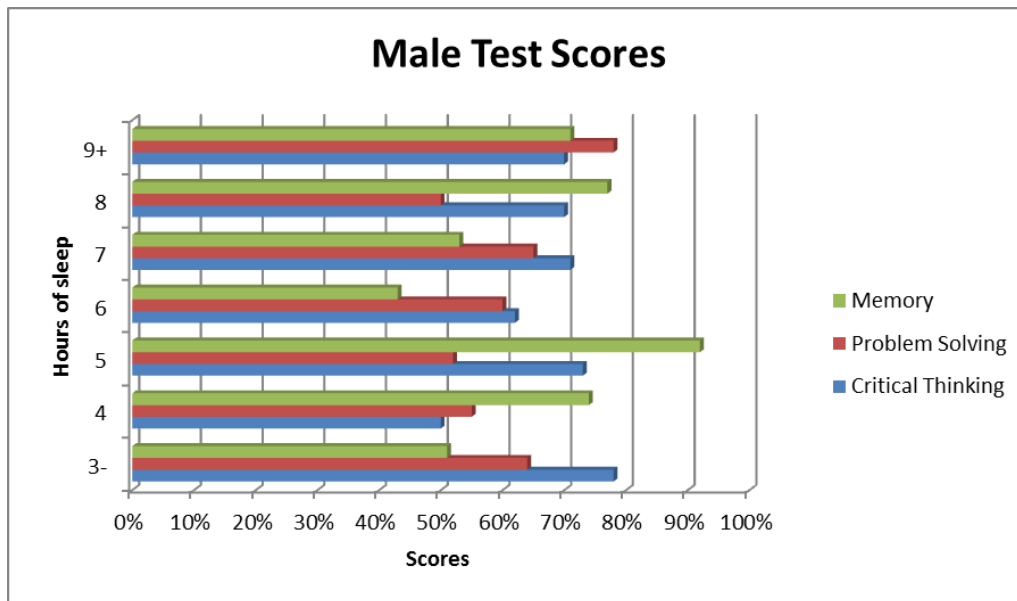
## Chapter 4

### DATA ANALYSIS AND DISCUSSION

#### Overview of Data Analysis

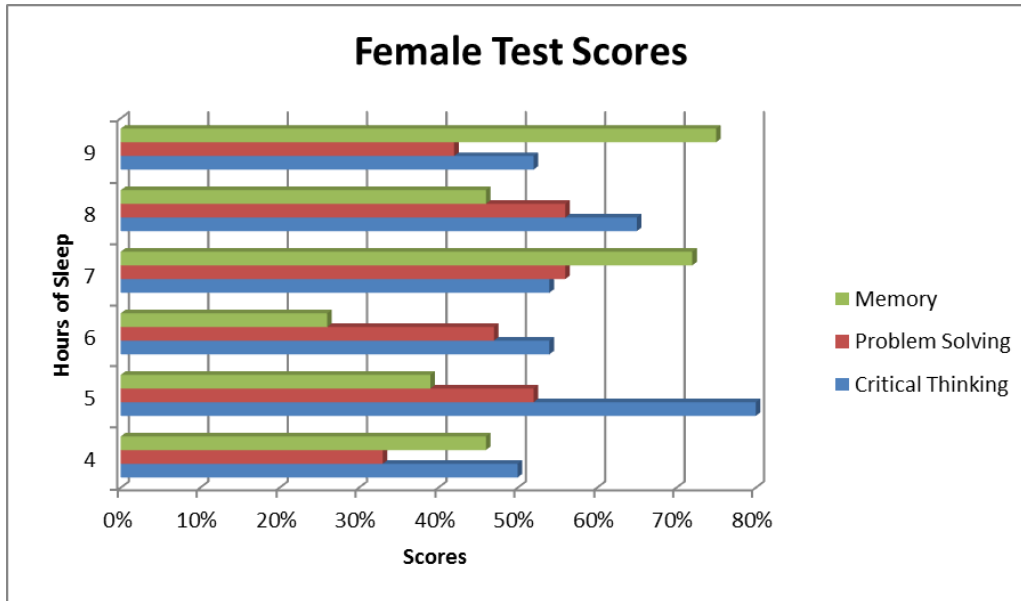
The intention of this research experiment was to more accurately inform the student body of the Loudoun campus of Northern Virginia Community College about the detrimental effects sleep deprivation could have on memory, problem solving and critical thinking skills. It was the desire of the researchers involved to provide, through the data collected, encouragement for the students to create and adhere to a proper sleep schedule. It is the aim of these researchers to provide a visual representation of the data collected and analyzed over the course of this research through the following graphs and charts. Each display will be provided with a synopsis of the data being represented.

#### 4.1: Bar Graph of Male Students' Test Scores Compared to Number of Hours of Sleep



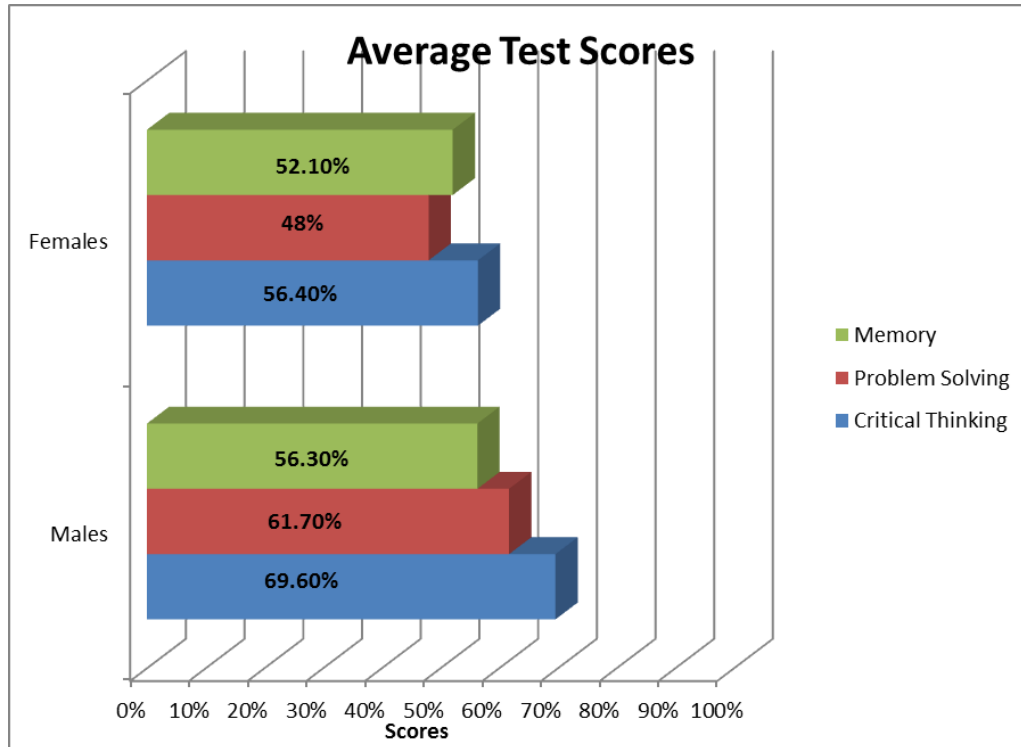
- Figure 4.1 represents the average test scores of males in each of the three tested areas on the X-axis, and the number of hours of sleep that were obtained by the research subjects the night prior to experimentation on the Y-axis.

4.2: Bar Graph of Female Students' Test Scores Compared to Number of Hours of Sleep



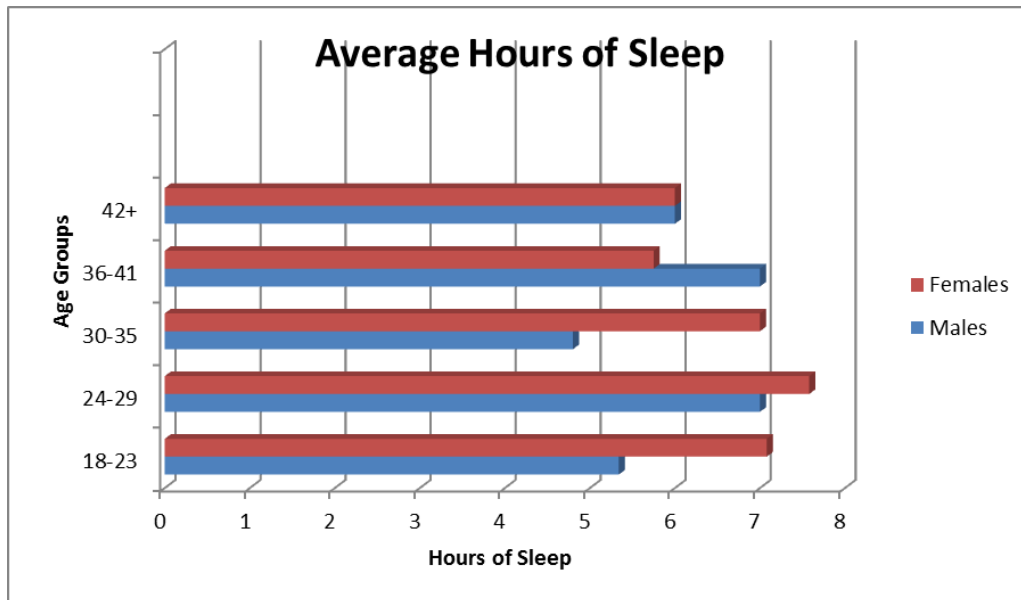
- Figure 4.2 represents the average test scores of females in each of the three tested areas on the X-axis, and the number of hours of sleep that were obtained by the research subjects the night prior to experimentation on the Y-axis.

4.3: Bar Graph of Average Test Scores Comparing Male Students to Female Students



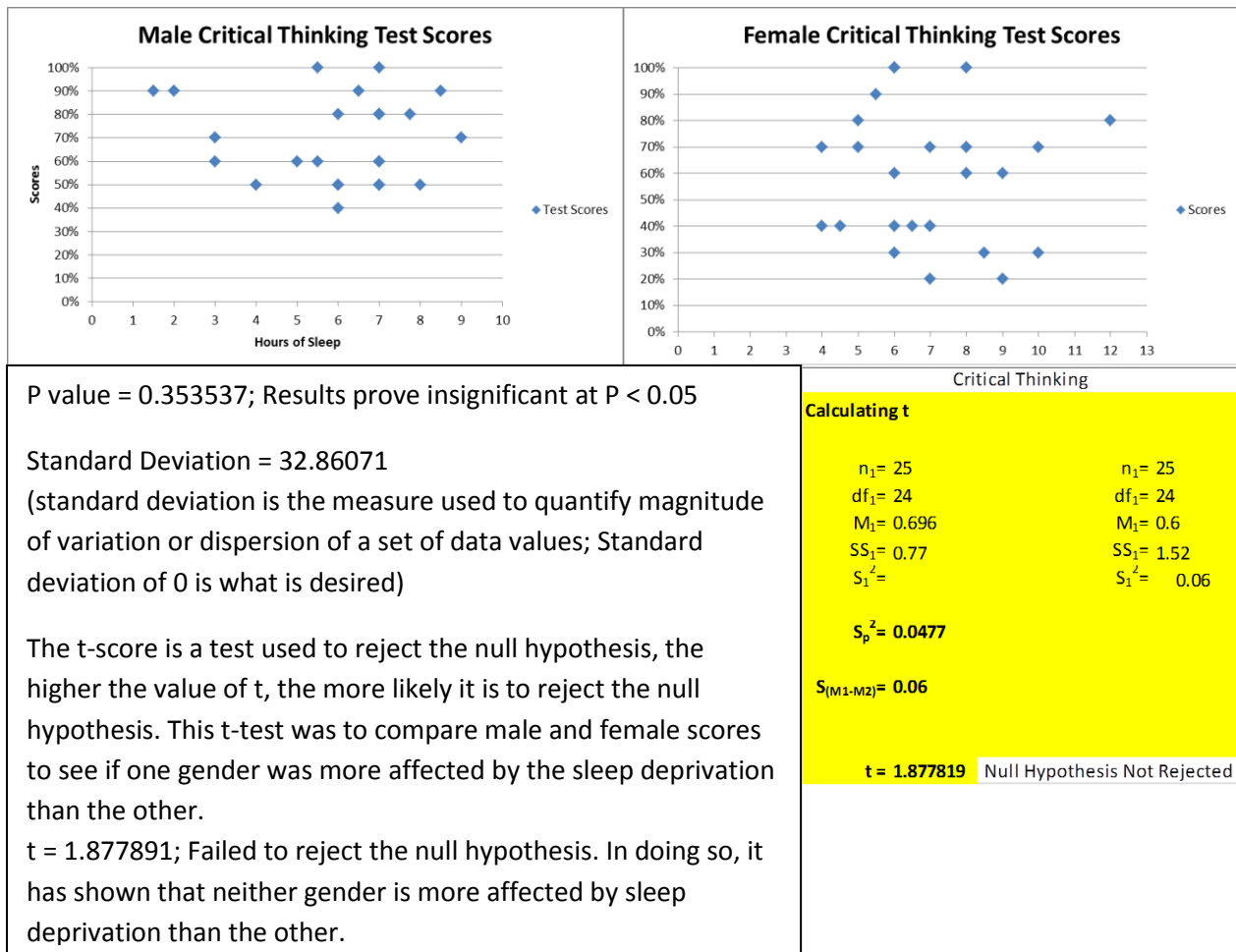
- Figure 4.3 shows the overall average test scores shown on the X-axis and comparing males to females on the Y-axis in each of the three tested areas.

**4.4: Bar Graph of Average Number of Hours of Sleep Based on Age Comparing Males to Females**

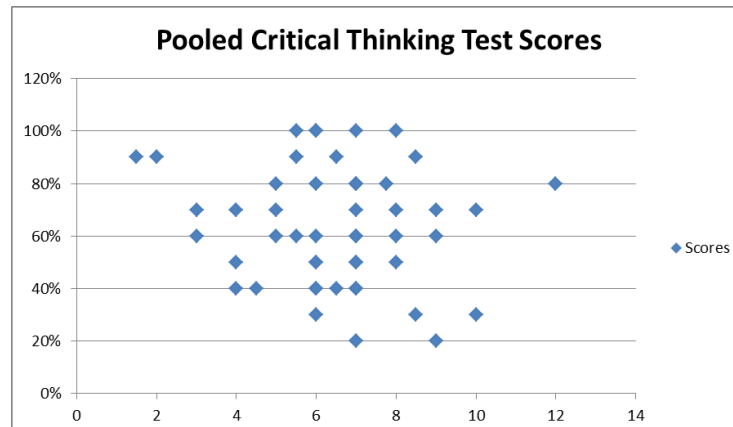


- Figure 4.4 compares average number of hours of sleep as shown on the X-axis between males and females based on age as shown on the Y-axis.

#### 4.5: Correlation Charts of Hours of Sleep Compared to Critical Thinking Test Scores for Males and Females



- Figure 4.5 consists of two scatter plots that are used to provide a visual representation of the correlation, if any were to exist, for males and females separately, between the research subjects' critical thinking scores represented on the Y-axis and number of hours of sleep represented on the X-axis, comparing the differences between the two genders.
- The desired P value is less than 0.05, because the value is greater, it has proven the findings of this research to be insignificant.
- The calculated t-score shows that there is no significant difference between the two genders to claim that one gender is more affected by sleep deprivation than the other.

**4.6: Correlation Chart of Hours of Sleep Compared to Critical Thinking Test Scores for All Participants***X Values*

$$\Sigma = 324.25$$

$$\text{Mean} = 6.485$$

$$\Sigma(X - M_x)^2 = SS_x = 199.551$$

$$r = \Sigma((X - M_y)(Y - M_x)) / \sqrt{(SS_x)(SS_y)}$$

$$r = -0.1319$$

Although there is technically a negative correlation, it is weak and very close to 0.

*Y Values*

$$\Sigma = 3190$$

$$\text{Mean} = 63.8$$

$$\Sigma(Y - M_y)^2 = SS_y = 24578$$

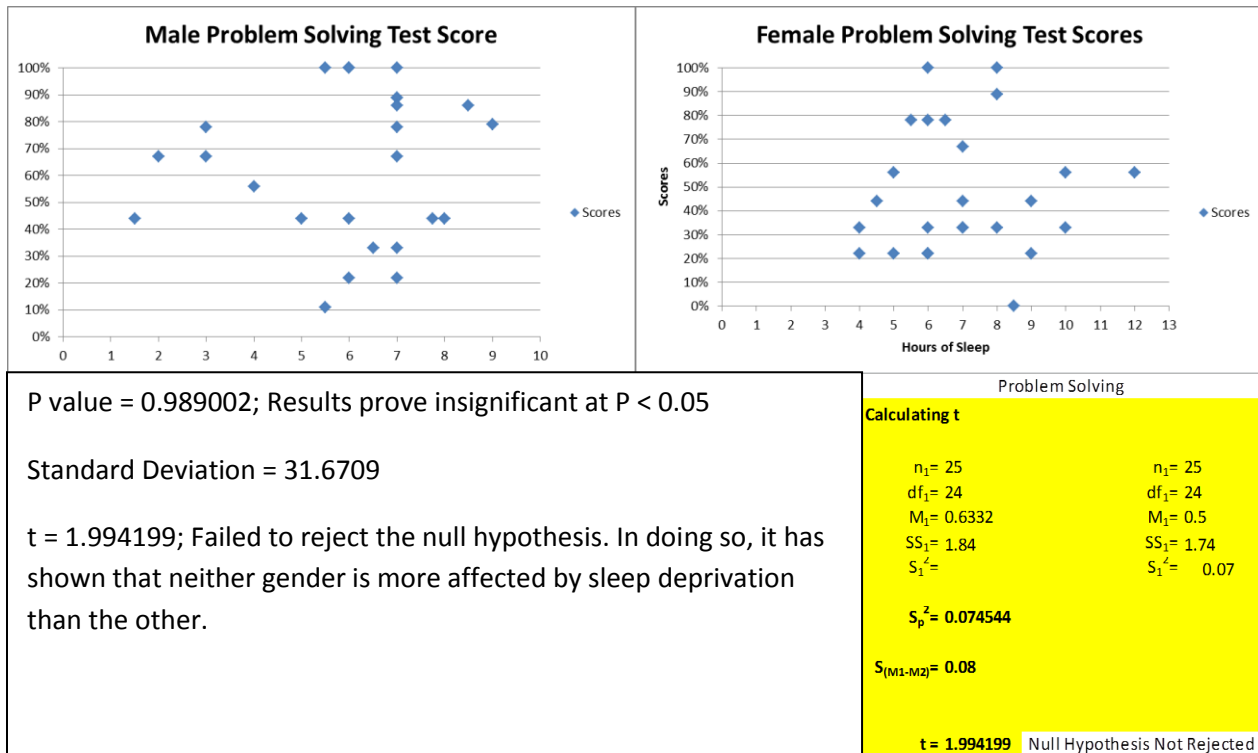
*X and Y Combined*

$$N = 50$$

$$\Sigma(X - M_x)(Y - M_y) = -292.15$$

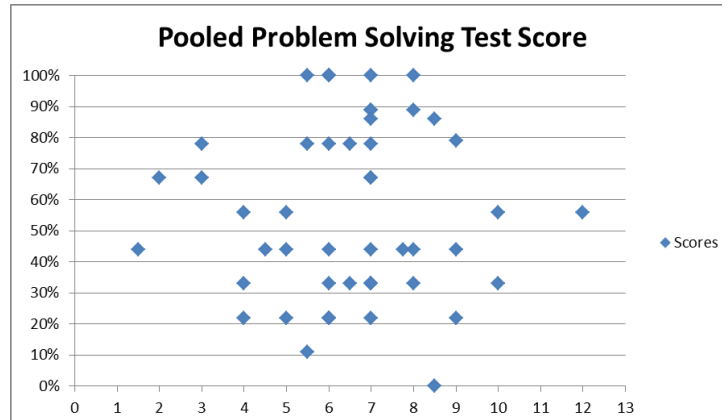
- Figure 4.6 provides a visual representation of the pooled results of males and females in the critical thinking scores of the test subjects, determining a correlation between the scores represented on the Y-axis and number of hours of sleep of the subjects represented on the X-axis.
- The calculated data presented provides mathematical evidence that there is little to no correlation between hours of sleep and the scores achieved on each segment of the assessment. The slight correlation found proved to be negative, which is the opposite of the hypothesized results

#### 4.7: Correlation Charts of Hours of Sleep Compared to Problem Solving Test Scores for Males and Females



- Figure 4.7 consists of two scatter plots that are used to provide a visual representation of the correlation, if any were to exist, for males and females separately, between the research subjects' problem solving scores represented on the Y-axis and number of hours of sleep represented on the X-axis, comparing the differences between the two genders.
- The desired P value is less than 0.05, because the value is greater, it has proven the findings of this research to be insignificant.
- The calculated t-score shows no significant difference between the two genders; therefore unable to show one gender was more affected by sleep deprivation than the other.



**4.8: Correlation Charts of Hours of Sleep Compared to Problem Solving Test Scores for All Participants***X Values*

$$\sum = 324.25$$

$$\text{Mean} = 6.485$$

$$\sum(X - M_x)^2 = SS_x = 199.551$$

$$r = \frac{\sum((X - M_y)(Y - M_x))}{\sqrt{(SS_x)(SS_y)}}$$

$$r = -0.0024$$

*Y Values*

$$\sum = 2781$$

$$\text{Mean} = 55.62$$

$$\sum(Y - M_y)^2 = SS_y = 38745.78$$

*X and Y Combined*

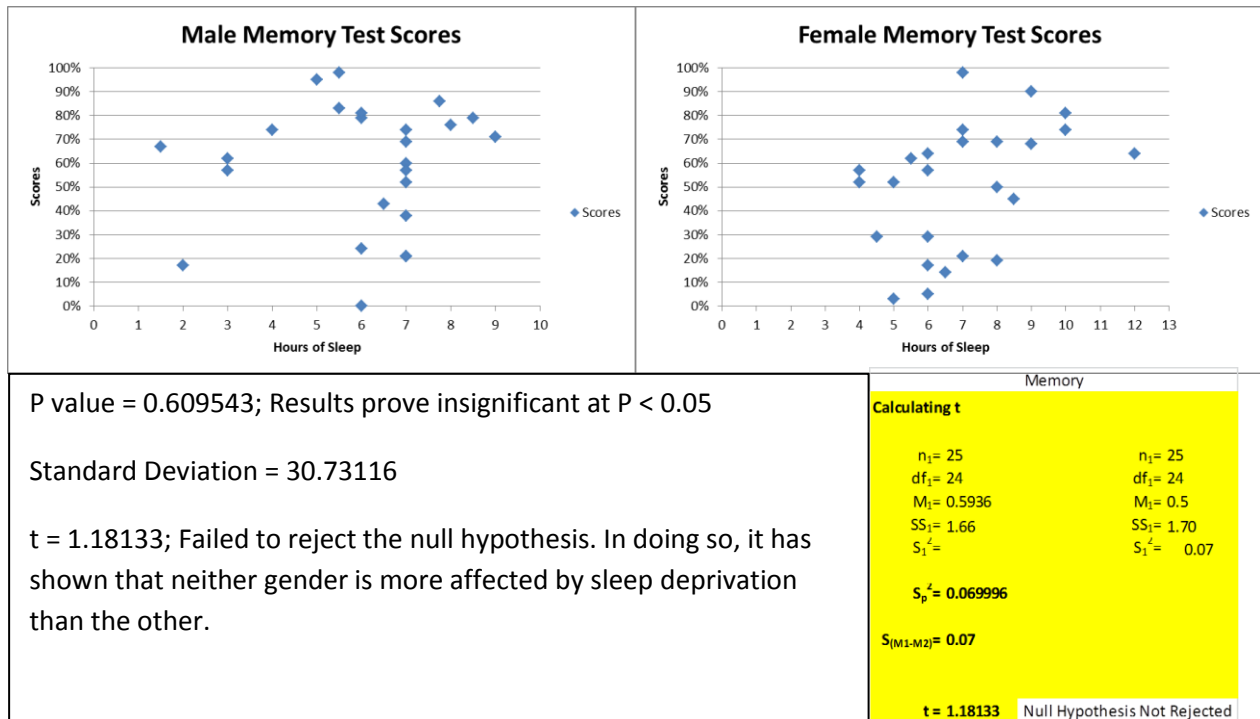
$$N = 50$$

$$\sum(X - M_x)(Y - M_y) = -6.785$$

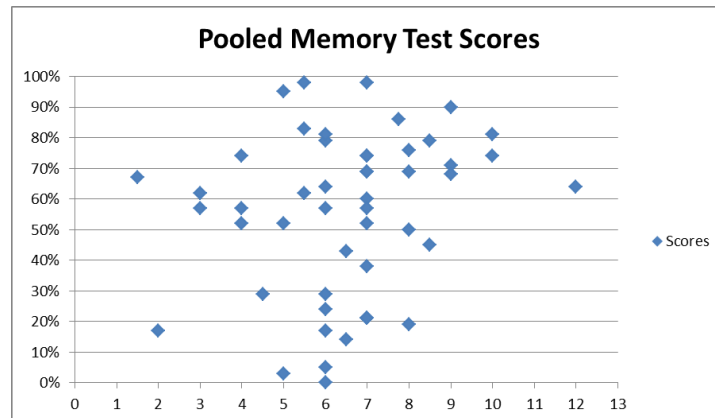
Although there is technically a negative correlation, it is weak and very close to 0.

- Figure 4.8 provides a visual representation of the pooled results of males and females in the problem solving scores of the test subjects, determining a correlation between the scores represented on the Y-axis and number of hours of sleep of the subjects represented on the X-axis.
- The calculated data presented provides mathematical evidence that little to no correlation exist between hours of sleep and the scores achieved on each segment of the assessment.
- The slight correlation found proved to be negative, which is the opposite of the hypothesized results.

## 4.9: Correlation Charts of Hours of Sleep Compared to Memory Test Scores for Males and Females



- Figure 4.9 consists of two scatter plots that are used to provide a visual representation of the correlation, if any were to exist, for males and females separately, between the research subjects' memory scores represented on the Y-axis and number of hours of sleep represented on the X-axis, comparing the differences between the two genders.
- The desired P value is less than 0.05, because the value is greater, it has proven the findings of this research to be insignificant.
- The calculated t-score shows that there is no significant difference between the two genders therefore unable to claim that one gender is more affected by sleep deprivation than the other.

**4.10: Correlation Charts of Hours of Sleep Compared to Memory Test Scores for All Participants***X Values*

$$\sum = 324.25$$

$$\text{Mean} = 6.485$$

$$\sum(X - M_x)^2 = SS_x = 199.551$$

$$r = \sum((X - M_y)(Y - M_x)) / \sqrt{(SS_x)(SS_y)}$$

$$r = 0.1988$$

*Y Values*

$$\sum = 2747$$

$$\text{Mean} = 54.94$$

$$\sum(Y - M_y)^2 = SS_y = 34574.82$$

*X and Y Combined*

$$N = 50$$

$$\sum(X - M_x)(Y - M_y) = 522.205$$

Although there is technically a positive correlation, it is weak and very close to 0.

- Figure 4.10 provides a visual representation of the pooled results of males and females in the memory scores of the test subjects, determining a correlation between the scores represented on the Y-axis and number of hours of sleep of the subjects represented on the X-axis.
- The calculated data presented provides mathematical evidence that there is little to no correlation between hours of sleep and the scores achieved on each segment of the assessment.

**Discussion**

It was originally hypothesized that sleep deprivation would greatly affect the test scores of the sample. It was believed that the research subjects who were more sleep deprived would score less on the Cognitive Function Abilities Assessment than those who obtained a proper amount of sleep the night prior. As the data shows in Figures 4.1-4.10, these researchers failed to reject the null hypothesis. This research had a large margin of error, making the results rather skewed, thereby not allowing the

outcome to render results which would have been fully accurate or properly represent the total population.

The total population mean hours of sleep was 6.48 hours, the median was 6.75 hours, and the mode was 7 hours of sleep the night prior. The standard deviation of the entire sample was 2.015 and the variance of the sample was 4.061: considering both of these figures were quite large, the data demonstrated the number of hours of sleep varied greatly from 1.5 hours to 12 hours over the course of the sample. The strata were then divided into stratum of males and females, each contained twenty-five research subjects. The mean for the male stratum was 5.98 hours, the median was 6.5 hours, and the mode was again 7 hours of sleep the night prior. The standard deviation of the male stratum was 1.931 and the variance was 3.728, which was a slightly smaller range in the number of hours of sleep the night prior to experimentation amongst the male stratum than that of the entire sample. The female stratum posted comparable numbers with a mean of 7 hours, a median of 7 hours and a mode of 6 hours of sleep the night prior respectfully. The standard deviation for the number of hours of sleep the night prior to experimentation of the female stratum was 2 and the variance was 4. The female stratum posted a similar standard deviation as the male stratum, but had a much larger range in the number of hours of sleep the night prior to experimentation.

The average score on the critical thinking portion of Cognitive Function Abilities Assessment for the male stratum was 69% and considerably lower amongst the female stratum at 56%. The average score on the problem-solving portion of the Assessment amongst the male stratum was 61% and much lower within the female stratum at 48%. The memory portion of the assessment was closer between the two stratum; the male stratum averaged 56% and the female stratum 52%. The data was broken down even further by comparing scores on each portion of the Cognitive Function Abilities Assessment to the average number of hours slept the night prior to experimentation by stratum.

The average critical thinking score for the 3 hours or fewer male stratum was 78%, the average problem-solving score on the assessment was 64% and the average score on the memory portion of the assessment was 51%. There were no research subjects in the female stratum, which received 3 hours of sleep or fewer the night prior to experimentation. Pertaining to the 4 hours of sleep category; the male stratum scored an average of 50% on the critical thinking portion, 55% on the problem-solving portion, and 74% on the memory portion, while the average score on the critical thinking portion amongst the female stratum was 50%, 33% on the problem-solving portion, and 46% on the memory portion. The 5-hour male stratum scored an average of 73% on the critical thinking portion of the Cognitive Function Abilities Assessment. The average problem-solving score was 52%, and the average memory score was 92% within the same 5-hour male stratum. The 5-hour female stratum scored an average of 80% on the critical thinking portion of the assessment, an average of 52% on the problem-solving portion, and a 39% on the memory segment of the assessment. The 6-hour male stratum scored an average of 62% on the critical thinking segment of the assessment, a 60% on the problem-solving segment and a 43% on the memory segment of the assessment; whereas the female stratum of the same category scored an average of 54% on the critical thinking section of the assessment, a 47% on the problem-solving section, and a 26% on the memory section.

As for the 7-hour category, the male stratum critical thinking average score was 71%, 65% average score for the problem solving, and a 53% for the average score on the memory portion of the assessment. The female 8-hour category scored an average of 70% on the critical thinking section, an average of 50% on the problem solving section, and a 77% on the memory section of the assessment, whereas the female stratum of the same category scored an average of 65% on the critical thinking portion, an average of 56% on the problem solving portion, and an average of 46% on the memory section of the assessment. The final category was the 9 hours + group. In the male stratum the average score on the critical thinking section was 70%, an average of 78% on the problem solving, and an

average of 71% on the memory section while the female stratum scored an average of 52% on the critical thinking portion, an average of 42% on the problem-solving portion, and an average of 75% on the memory portion respectfully.

In an attempt to determine the significance of the data collected in this experiment, these researchers calculated the correlation coefficient or r-score using the corresponding equation:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

From there, the p-values of each segment of the assessment were determined using a significance level of 0.05. The p-value for the critical thinking segment of the Cognitive Function Abilities Assessment for the entire sample was  $0.354 < 0.05$ , which is not significant. The p-value for the problem-solving segment of the assessment for the entire sample was  $0.990 < 0.05$ , again proving not to be significant. Also, the p-value for the memory segment of the assessment for the entire sample was  $0.074 < 0.05$ , also proving no significance at this level. These researchers' data failed to be significant at the 0.05 level, thereby failing to prove the null hypothesis. What this means is there was not a proven correlation between sleep deprivation and the three cognitive abilities, which were assessed in this experiment.

Based on these data, it is extremely difficult, if not impossible to prove any positive correlation between sleep deprivation and critical thinking, problem solving, and memory. This is not to say the experiment was completely flawed, upon performing the experimentation a second time while accounting for limitations, which were neglected during the initial trial, these researchers hypothesize the data would show a positive correlation between sleep deprivation and critical thinking, problem-solving, and memory just as prior researchers and experiments have proven in the past.

### **Limitations Discovered Post Experiment**

Any experiment is subject to limitations and it can be difficult to predict all the limitations that may arise during the experimental process. These researchers discovered that without the proper imaging machines, it is very difficult to observe the level of impairment, which sleep deprivation can have on an individual. When it comes to the three areas assessed in this experiment, each individual had a different level of ability, so one research subject could still do better in the different areas after receiving little to no sleep than one who has had a full night of uninterrupted sleep.

It has been determined by these researchers, should this experiment be repeated at the same level, it would be best to have the research subjects complete the Cognitive Function Abilities Assessment prior to any period of sleep deprivation, also during a period of sleep deprivation and then again after receiving a full night of sleep. This would better show how sleep deprivation affects each individual rather than basing the results on an average that may not be compatible to each subject's abilities.

### **Future Research**

If this research were to be conducted again, it would be advantageous to have equipment such as functional Magnetic Resonance Imaging equipment, Electroencephalogram, or an Electromyography machine available to image and analyze the brain and its function as it works to solve the problems are placed before the research subjects. Due to the fact these researchers are undergraduate students, such equipment was unavailable for their use. Another factor that would greatly improve the results of the experiment would be to obtain a larger sample size.

Due to a lack of time and resources, these researchers only managed to obtain a sample size of fifty students to function as research subjects. With a campus population of 11,000 students, a more

appropriate sample size would be one with a size of five hundred subjects, thereby more accurately representing the population and the effects of sleep deprivation. These researchers used a sample size and confidence interval calculator in order to determine an appropriate sample size by use of the equation:  $\overline{X} \pm t \frac{s}{\sqrt{n}}$  thereby showing that with such a huge population, these researchers would have needed to obtain a sample size of five hundred subjects in order to have a confidence interval of four. However, with the small sample size of fifty, the confidence interval was fourteen, thereby leaving a large margin of error.



## **Chapter 5**

### **CONCLUSION**

#### **Gaps in Research**

Many researchers have taken the time to focus on the different aspects of the cognitive abilities of individuals in multiple different populations as well as what sleep deprivation is and how it can affect each person differently, whether in mood, cognitive abilities, or in overall health. Though this particular research project is lacking, there is a wide range of previous research on the subject, and even more will be conducted in the future to help the world population fully understand why sleep is so important and help lead to a healthier future.

#### **Summary of Findings**

The hypothesis of this study states that college students who obtain between seven to eight hours of sleep each night will achieve higher scores on the tests administered than those who receive six or less, or nine or more hours of sleep per night. It was also predicted that one gender would be affected more by sleep deprivation than the other. The data obtained failed to support either of these hypotheses due to the lack of resources, a small sample size and the limited time allotted for the experiment. As shown in figures 4.6, 4.8, and 4.10, there was very slight correlation between sleep and the abilities of the research subjects, and two of the correlations were negative, showing the opposite of the desired results. However, all three correlations were close enough to zero to determine that there is no correlation between the two factors. The results of this research project are not in line with previous research and it would be advised to conduct this research again in an attempt to find more accurate data.

### **Implications and Recommendations for Further Study**

This research experiment should be repeated using a larger sample size as well as the appropriate instruments for measuring brain functions and activity. It would also be recommended to expand the population to more than just one campus of a single community college. There could be a drastic shift in the efficiency of all students if they were to maintain an appropriate sleep schedule on a daily basis. By accounting for all of the limitations, which these researchers encountered throughout the experimental process, the next time the experiment is conducted, the data obtained will establish a correlation between sleep deprivation and critical thinking, problem solving, and memory.

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## **APPENDICES**

## **APPENDIX A**

### **Figure 3.2 Informed Consent Document Template**

#### **Effects of Sleep Deprivation**

##### **INTRODUCTION**

You are invited to join a research study to look at Sleep Deprivation. The decision to join, or not to join, is up to you. In this research study, we are investigating/testing/comparing/evaluating the effect that a lack of sleep has on memory, problem solving and critical thinking skills.

##### **WHAT IS INVOLVED IN THE STUDY?**

If you decide to participate you will be asked to complete a questionnaire and a test. We think this will take you a maximum of 10 minutes.

The investigators may stop the study or take you out of the study at any time they judge it is in your best interest. They may also remove you from the study for various other reasons. They can do this without your consent.

You can stop participating at any time.

##### **RISKS**

This study does not involve any risks.

##### **BENEFITS TO TAKING PART IN THE STUDY?**

It is reasonable to expect the following benefits from this research: learning exactly how your sleep habits are effecting you and determine if you need to alter them in any way. However, we can't guarantee that you will personally experience benefits from participating in this study. Others may benefit in the future from the information we find in this study.

##### **CONFIDENTIALITY**

We will take steps to keep information about you confidential, and to protect it from unauthorized disclosure, tampering, or damage. All tests will be anonymous so that no identities will be shared with anyone.

### **YOUR RIGHTS AS A RESEARCH PARTICIPANT?**

Participation in this study is voluntary. You have the right not to participate at all or to leave the study at any time. Deciding not to participate or choosing to leave the study will not result in any penalty or loss of benefits to which you are entitled, and it will not harm your relationship with Desmond Sipes or Matthew Schumacher.

### **CONTACTS FOR QUESTIONS OR PROBLEMS?**

Contact Desmond Sipes at 703-798-3267, [inheritance4dragon@aol.com](mailto:inheritance4dragon@aol.com), or Matthew Schumacher at 703-477-9552, [mschumacher7099@email.vccs.edu](mailto:mschumacher7099@email.vccs.edu) if you have any questions or concerns about the study, any problems, unexpected physical or psychological discomforts, any injuries, or think that something unusual or unexpected is happening.

### **Consent of Subject (or Legally Authorized Representative)**

Signature of Subject or Representative

Date

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## APPENDIX B

**Figure 3.3 Cognitive Function Abilities Assessment**

### Cognitive Function Abilities Assessment

This is an undergraduate research experimental procedure in which research subjects will be given a total of fifteen minutes to complete this assessment. Subjects are asked to complete as much of the assessment as possible. This assessment is divided in to three sections. Each section will test a different ability. The three abilities tested will be critical thinking, problem solving, and short-term memory. The critical thinking and problem solving sections are to be done on your own without any assistance, i.e. calculators, cell phones, peers, etc. When the short-term memory portion is reached, raise hand and a researcher will assist with the final memory portion.

Date: \_\_\_\_\_

Age: \_\_\_\_\_

Hours of Sleep on Average: \_\_\_\_\_

Hours of Sleep Last Night: \_\_\_\_\_

Gender: \_\_\_\_\_

### Critical Thinking

**1. Do they have a 4th of July in England?**

- A. Yes
- B. No
- C. Maybe
- D. I don't know

**2. How many birthdays does the average man have?**

- A. 78
- B. 65.5
- C. one per year
- D. None



**3. Some months have 31 days, how many have 28?**

- A. One month and that is February
- B. February, every 4 years.
- C. All months have (at least) 28 days
- D. None of the above

**4. A woman gives a beggar 50 cents, the woman is the beggar's sister, but the beggar is not the woman's brother. How come?**

- A. The beggar is the woman's sister!
- B. Not possible.
- C. The beggar is an in-law.
- D. The woman is the beggar.

**5. Why can't a man living in the USA be buried in Canada?**

- A. The Canadian Government does not allow Americans to be buried in Canada.
- B. The man is not dead yet!
- C. It is a trick question and the man is a Canadian living in America.
- D. The man is living between the border.

**6. How many outs are there in an inning?**

- A. There are 3 outs.
- B. There are 6 outs.
- C. There are 4 outs.
- D. None of the above

**7. Is it legal for a man in California to marry his widow's sister?**

- A. Yes, as long as she is alive.
- B. Yes, if the man is from California.
- C. You can't marry like this in California.
- D. No, the man would be dead.

**8. Two women play five games of checkers. Each woman wins the same number of games. There are no ties. Explain this.**

- A. Because they aren't wearing ties!
- B. The women are not playing each other.
- C. These two women are playing men.
- D. Women don't wear ties.

**9. Divide 30 by  $\frac{1}{2}$  and add 10. What is the answer?**

- A. 25
- B. 50
- C. 65
- D. 70

**10. A man builds a house rectangular in shape. All sides have southern exposure. A bear walks by the house. What color is the bear? Why?**

- A. ...black...bears are black
- B. ...white...
- C. ...brown...the house is on a steep slope
- D. There is no answer and this is a stupid question.

## Problem Solving

**1. The distance from town A to town B is five miles. C is six miles from B. Which of the following could be the distance from A to C?**

**I 11**

**II 1**

**III 7**

- A. I only
- B. II only
- C. I and II only
- D. II and III only
- E. I, II, or III.

**2. Of the following, which is greater than  $\frac{1}{2}$ ?**

- A.  $\frac{2}{5}$
- B.  $\frac{4}{7}$
- C.  $\frac{4}{9}$
- D.  $\frac{5}{11}$
- E.  $\frac{6}{13}$

**3. If an object travels at five feet per second, how many feet does it travel in one hour?**

- A. 30
- B. 300
- C. 720
- D. 1800
- E. 18000

**4. What is the average (arithmetic mean) of all the multiples of ten from 10 to 190 inclusive?**

- A. 90
- B. 95
- C. 100
- D. 105
- E. 110

**5. If the product of 6 integers is negative, at most how many of the integers can be negative?**

- A. 2
- B. 3
- C. 4
- D. 5
- E. 6

**6. Which of the following can be used to illustrate that not all prime numbers are odd?**

- A. 1
- B. 2
- C. 3
- D. 4
- E. 5

**7. Half the people on a bus get off at each stop after the first, and no one gets on after the first stop. If only one person gets off at stop number 7, how many people got on at the first stop?**

- A. 128
- B. 64
- C. 32
- D. 16
- E. 8

**8. The total weight of a tin and the cookies it contains is 2 pounds. After  $\frac{3}{4}$  of the cookies are eaten, the tin and the remaining cookies weigh 0.8 pounds. What is the weight of the empty tin in pounds?**

- A. 0.2
- B. 0.3
- C. 0.4
- D. 0.5
- E. 0.6

**9. In a sports club with 30 members, 17 play badminton and 19 play tennis and 2 do not play either. How many members play both badminton and tennis?**

- A. 7
- B. 8
- C. 9
- D. 10
- E. 11

## Memory

A researcher will show a picture, which will depict a series of letters. The picture will be shown for a period of three seconds, after that time the researcher will take the picture away. The subjects are to write down as many letters as remembered. There will be six trials, letters from each trial should be written on a separate line.

<b>Trial #</b>	<b>The letters I remember are:.....</b>
1	
2	
3	
4	
5	
6	

## **APPENDIX C**

**Figure 3.4 Cognitive Function Abilities Assessment Answer Key**

### **Critical Thinking**

1. A
2. C
3. C
4. A
5. B
6. B
7. D
8. B
9. A
10. B

### **Problem Solving**

1. E
2. B
3. E
4. C
5. D
6. B
7. B
8. C
9. B

## Memory

1. U M

2. T Z L D

3. K X C E J O

4. A V C Y I S E H

5. L B F Q R P M A U X

6. Z Q E C T B U M O N R V