AN INVESTIGATIVE STUDY OF THE NEUROPSYCHOLOGICAL AND NEUROPHYSIOLOGICAL FEATURES OF SUBJECTIVE SLEEP QUALITY

by

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Background: Disordered sleep is a national health issue affecting an estimated 50-70 million US adults. The documented consequences of disordered sleep include impaired daily function, increased risk for chronic health conditions, and greater morbidity. To abate the deleterious consequences and to better understand the development and maintenance of disordered sleep, researchers have attempted to study the influence of emotional, cognitive, and behavioral features of sleep and sleep-related behaviors.

Purpose: The purpose of the present study was to explore the neurophysiological and neuropsychological features of subjective sleep quality to conceptualize disordered sleep within various existing theoretical models.

Methods: Participants were 75 University undergraduate students enrolled in introductory psychology and neuroscience classes across several semesters (Age: 18-39, M = 20.15, SD = 3.01; 67% Female). Participants were asked to complete a series of self-report inventories assessing personality, mood, affect, and sleep behavior. Next, participants underwent neurophysiological investigation (via encephalographic recordings) with the purpose of establishing a measurement of baseline cortical asymmetry and recording of event-related

potentials during a modified oddball task. Finally, participants completed the Psychomotor Vigilance Task (PVT) as a measure of neuropsychological functioning.

Results: Correlational analyses and regression models highlighted the significant contribution of personality, affect, and mood, to subjective sleep quality. Specifically, poorer sleepers reported higher levels of self-reported negative personality traits (e.g., neuroticism and behavioral inhibition), affect and mood in addition to being more likely to endorse more dysfunctional beliefs and attitudes about sleep. When considering neuropsychological performance on a psychomotor vigilance task, poorer sleepers had slower reaction times and made more errors. However, there were no significant neurophysiological findings relating to subjective sleep quality.

Discussion: Findings were reviewed within the context of various theoretical models including the reinforcement sensitivity, stimulus control, cognitive, and neurocognitive models of disordered sleep. Implications for future research and clinical practice are discussed.

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AN INVESTIGATIVE STUDY OF THE NEUROPSYCHOLOGICAL

AND NEUROPHYSIOLOGICAL FEATURES

UNDERLYING SLEEP IMPAIRMENT

by

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CHAPTER I: INTRODUCTION

The literature is replete with studies describing the emotional, physical, and economic costs of poor and disordered sleep. Approximately 50-70 million adults in the United States are living with sleep or wakefulness disorders (Institute of Medicine [IOM], 2006), and the estimated direct and indirect costs of disordered sleep range between 92.5 billion to 107.5 billion dollars (Léger & Bayon, 2010; Stoller, 1994). Contributing to these costs are daytime sleepiness, fatigue, and neuropsychological consequences. Substantial sleep loss is specifically associated with poor attention, memory, and slowed reaction times, which significantly contributes to poor work performance (absenteeism, errors, and work limitation) and motor vehicle accidents (Durmer & Dinges, 2005). Moreover, newer research highlights an association between poor sleep and a growing number of medical comorbidities including stroke (Wallace, Ramos, & Rundek, 2012), high blood pressure (Lombardi, Bilo, & Parati, 2012), diabetes (Bopparaju & Surani, 2010), cancer (Stepanski & Burgess, 2007), and obesity (Beccuti & Pannain, 2011).

Because poor sleep quality is related to many factors associated with health, it is imperative to explore these contributing facets to improve our understanding of normal and impaired sleep. Over the years, researchers have attempted to study the influence of personality traits and emotions on sleep and sleep-related behaviors. For instance, highly neurotic individuals report more problems with sleep hygiene, sleep quality, and sleepiness (Duggan, Friedman, McDevitt, & Mednick, 2014). Other studies have cited personality features such as high affectivity, particularly negative affect, as possible precipitants of disordered sleep (Ottoni, Lorenzi, & Lara, 2011). Further consideration of personality and behavior patterns may potentially identify those individuals at risk of developing sleep disorders and facilitate the implementation of preventative measures (i.e., sleep education and sleep hygiene training).

In addition to the study of behavioral patterns, advancements in our understanding of the biobehavioral and psychophysiological contributions to sleep regulation might give rise to more comprehensive theoretical models capable of clarifying the development and maintenance of sleep problems. For instance, an adaptation of Gray's Reinforcement Sensitivity Theory (1990)—which posits that behavioral intentions are regulated by three biobehavioral systems—can assist in conceptualizing sleep-related behavior as manifestations of motivational (approach versus withdrawal) and emotional (positive versus negative affect) influences (Coan & Allen, 2003; Smillie, Pickering, & Jackson, 2006). Relatedly, electrophysiological measures using electroencephalography can provide insight into the role of resting frontal asymmetry and event-related potentials to sleep-related phenomena (Everhart et al., 2014; Lehockey et al., 2014). Thus, the theoretical underpinnings of the Reinforcement Sensitivity Theory provide a framework that can easily be applied to the study of disordered sleep.

The purpose of the present study is to examine the relationship between individual differences (personality, affect, and psychophysiology) and self-reported sleep quality and impairment. Investigation of individual differences in the areas above may lead to further understanding of the complexity of sleep as it relates to the development of disordered sleep patterns and the resultant emotional, physical, and economic consequences. In turn, a greater understanding of the complexity of sleep may lend itself to the development of improved detection of and intervention for sleep disorders. The aim is to explore possible relationships between sleep quality and chosen aspects of personality, affect, and psychophysiology with particular emphasis on sleep quality, neurocognitive performance, as well as physical and mental health.

CHAPTER II: LITERATURE REVIEW

Classification of Sleep Problems and Sleep Disorders

There are several professional sources used to aid in the identification, diagnosis, and treatment of sleep disorders. The International Classification of Sleep Disorders-Third Edition (ICSD-3), published by the American Academy of Sleep Medicine (AASM; 2014), contains descriptions of over 90 sleep disorders grouped into six categories: 1) Insomnia; 2) Sleep-related breathing disorders; 3) Central disorders of hypersomnolence; 4) Circadian rhythm sleep-wake disorders; 5) Parasomnias; and 6) Sleep-related movement disorders.

Insomnia disorders are of particular interest in the present study as it is the most prevalent of any sleep disorder. Approximately 6-10% of the general population presents with symptoms consistent with a diagnosis of insomnia disorder— problems with sleep onset, sleep maintenance, and early termination from sleep. In primary care settings, the prevalence is even higher with an estimated 10-20% of individuals complaining of symptoms of insomnia (Ohayon, 2002; Roth, 2006). Due to the prevalence of insomnia disorder and insomnia-related symptoms, and the associated reduction in sleep quality, the present study explores the relationships between sleep quality with aspects of personality, affect, and psychophysiology.

Consequences of Impaired sleep

Neurocognitive dysfunction. Cognitive performance is greatly affected by poor sleep quality and resultant sleep loss (Lim & Dinges, 2008). At present, alertness, attention, vigilant attention, and memory are the most well-researched, and most likely to be impaired, aspects of cognition related to poor sleep in the literature (Lim & Dinges, 2008).

Alertness, attention, and vigilance. In a review article, Lim and Dinges (2008) evaluated the current literature with specific interest on vigilant attention. Vigilant attention, simply

defined as the ability to sustain attention to the task at hand, has received much interest in sleep research because it is proposed to be a prerequisite of all upstream cognitive processes. Consequently, vigilant attention significantly declines with increased sleep loss (Dinges et al., 1997; Lim & Dinges, 2008).

The "gold standard" for measuring alertness and vigilance during periods of sleep loss is the psychomotor vigilance task (PVT; Dinges & Powell, 1985). The PVT is a brief, simple reaction time task requiring participants to quickly and repeatedly respond (button press) to pseudo-randomly presented visual cues. The PVT is highly sensitive to reaction time and attention lapses associated with sleep loss, and it maximizes sensitivity in discriminating between alert and sleep-deprived individuals (Basner & Dinges, 2011).

Learning and memory. The literature is inundated with studies demonstrating the critical importance of sleep to learning and memory processes. Relatedly, one hypothesized purpose of sleep is that sleep states function as favorable times for neuronal growth and brain plasticity for learning and memory (Maquet, 2001).

As a result, neural correlates of learning and memory impairment following sleep loss have been investigated. Drummond et al. (2000) used functional magnetic resonance imaging (fMRI) to measure the effects of sleep deprivation (35 hours) on cerebral activation. The researchers specifically focused on the prefrontal cortex (PFC), hypothesizing it to be less activated during cognitive demands following sleep loss. Findings of the study showed that sleep-deprived subjects performed significantly less well than their rested counterparts on a list-learning task. These findings are consistent with their expectation of increased activation in the temporal lobe (hippocampal area) in the rested group than the sleep-deprived group. Contrastingly, the PFC was significantly more activated during cognitive tasks in sleep-deprived

individuals. These results objectively identify changes in brain response and cortical activity for learning and memory as a result of sleep loss. Moreover, the findings allude to a possible compensatory function of the PFC in response to sleep deprivation.

Yoo, Hu, Gujar, Jolesz, and Walker (2007) demonstrated similar findings. They conducted an fMRI study examining the brain responses of sleep-deprived participants (kept awake for approximately 35 hours) during a picture-learning task in a sample of 28 participants in either a sleep deprived or sleep control group. As expected, memory performance was significantly worse for individuals in the sleep-deprived group, suggesting a possible impairment related to encoding. Furthermore, functional imaging findings showed potential temporal lobe dysfunction relating to impaired memory performance in the sleep-deprived individuals as indicated by significantly different hippocampal activity patterns as compared to the sleep controls. Prefrontal cortex activity was abnormally disrupted (middle lateral PFC impairment) in the sleep-deprived individuals, suggesting related difficulties with encoding and memory consolidation. Altogether, these findings demonstrate the importance of regular sleep patterns for optimal cognitive performance and neural functioning.

Impaired productivity and daily functioning. As might be predicted from research presented in the previous section exploring sleep loss and cognitive dysfunction, it is no surprise sleep loss also contributes to impaired work performance, productivity, and general daily functioning (Rosekind et al., 2010).

To assess the impact of sleep disturbances on work performance and productivity, Rosekind and colleagues (2010) surveyed a large sample (N = 4188) of employees at four U.S. based corporations. Using a web-based anonymous survey, the researchers assessed sleep patterns with questions explicitly aligned with diagnostic criteria of several highly prevalent

sleep disorders (predominantly insomnia). Further, work performance and productivity were measured using the Work Limitations Questionnaire (WLQ). This measure assessed the extent to which health problems interfere with specific work-related responsibilities (i.e., time management, physical performance, mental performance, interpersonal functioning, and output). Findings showed persons self-reporting disturbed sleep and symptoms of insomnia had significantly worse productivity, performance, and safety outcomes. Specifically, these individuals reported marked impairment in attention, memory, social functioning, and communication. Further, economic costs of productivity loss due to disturbed sleep were estimated to be approximately 54 million dollars annually.

Moreover, one of the most researched aspects of daily function concerning sleep is driving. Drowsy driving is deemed to be as dangerous as driving while under the influence of alcohol and other drugs (Dawson & Reid, 1997). Specifically, drowsy drivers are noted to be less attentive, have poorer reaction times, and impaired decision making required for driving (Jackson, Croft, Kennedy, Owens, & Howard, 2013). A recent study by Howard et al. (2014) investigated whether professional drivers were as susceptible to the effects of acute periods sleep deprivation via extended wakefulness (i.e., maintaining wakefulness for approximately 24 hours) as compared to their non-professional counterparts. Analyzing performance on the PVT and a simulated driving task revealed that professional drivers were just as susceptible to the impairing effects of sleep deprivation as non-professional drivers.

Impaired health and mental health. A considerable amount of research has demonstrated the influence of sleep and sleep loss on the development and maintenance of chronic health problems. Obesity is a growing public health concern that appears to co-occur with a general decrease in sleep (Beccuti & Pannain, 2011). Simple models for understanding the

obesity phenomena focused primarily on energy balance, that is, the balance between energy intake and energy expenditure (Hill, Wyatt, & Peters, 2012). However, as our scientific understanding of obesity has expanded so to have our models. Newer obesity research has explored this obesity-sleep trend and has identified the importance of sleep in modulating neuroendocrine functioning. Sleep loss has been associated with increased ghrelin levels (hunger-promoting hormone), increased cortisol levels (stress hormone) and decreased leptin (satiety hormone; Leproult & Van Cauter, 2010). Thus, sleep can biologically contribute to an unbalanced energy intake and expenditure ratio. Relatedly, chronic sleep loss has also been linked to altered glucose metabolism—decreased glucose tolerance and increased glucose resistance—associated with the development of diabetes (Knutson & Van Cauter, 2008; Bopparaju & Surani, 2010).

Equally as important are the effects of disordered sleep on mental health. Disordered sleep has been cited to co-occur frequently with mental health concerns such as depression (Ford & Cooper-Patrick, 2001) and anxiety disorders (Mellman, 2008). In fact, the American Psychological Association (2013) has acknowledged this relationship and included symptoms of disordered sleep as key diagnostic features of mood and anxiety disorders. However, research has yet to identify the direction of the relationship—whether disordered sleep predisposes one to psychological disorders or vice versa.

Taken together, it is evident disordered sleep negatively impacts work performance, productivity, and general everyday functioning. The economic and corporeal costs represent an unmet public health need deserving of further inquiry. As such, the present study aims to investigate neuropsychological sequelae of perceived sleep loss with a particular emphasis on sustained attention and vigilant attention.

Basic Overview of Normal Sleep

Humans spend approximately one-third of their lives asleep, yet sleep remains a mysterious phenomenon that people know very little about (Altevogt & Colten, 2006). Once thought to be a passive state, neuroimaging and psychophysiological tools have elucidated many misconceptions often associated with sleep. The advent of electroencephalography has revealed sleep as a dynamic process. Impaired sleep negatively impacts personal well-being and quality of life through disruptions in behavioral, emotional, psychological, and physiological functioning; but it is rarely recognized as contributing to one's overall aspect of health and well-being.

Sleep architecture. The basic organizational structure or architecture of sleep consists of two main states of sleep, rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep, comprised of five distinct stages. NREM consists of Stages 1-4. Simply put, electroencephalography measures the electrical activity resulting from ionic changes within the neurons of the brain. Each stage of sleep is defined by a unique waveform of varying frequency (measured in hertz; Hz). The sleep cycle typically begins with a short period of NREM Stage 1 sleep, and then progresses through the remaining stages sequentially, finally completing a cycle with REM sleep. Cycle durations may vary individually but are noted to endure for approximately 90 to 120 minutes. This progression is easily recognized via patterns on EEG tracings that show initial fast and frequent waveforms developing greater amplitudes and exhibiting pronounced slowing. During these stages, physiological processes are much like those during a wakeful state (Carskadon & Dement, 2000; Altevogt & Colten, 2006).

Specifically, Stage 1 sleep serves as an easily interruptible transitional period initiating the sleep cycle response. Stage 1 sleep, lasting approximately 1-7 minutes, is associated with a wakeful relaxation and consists of rhythmic alpha waves (8-13 Hz) that gradually become slower

when advancing toward Stage 2 sleep. Stage 2 sleep can be described as a light sleep characterized by the presence of sleep spindles and k-complexes. Sleep spindles, bursts of oscillatory EEG activity of approximately 12-14 Hz waves occurring for approximately 0.5 seconds are thought to promote sleep quality by increasing the arousal threshold required for waking and aiding in memory consolidation (De Gennaro & Ferrara, 2003; Astori, Wimmer, & Lüthi, 2013). K-complexes are brief negative high voltage peaks occurring predominantly during Stage 2 sleep. Evidence suggests K-complexes function in much the same was as sleep spindles (Cash et al., 2009). In fact, K-complexes and sleep spindles frequently occur together, respectively. Stages 1 and 2 represent the lightest of the sleep stages, meaning that one may be easily awakened or aroused during these stages.

Together Stages 3 and 4 are known collectively as slow wave sleep (SWS) and primarily occur during the first third of the night. Due to a lack of clear distinction between Stages 3 and 4, the American Academy of Sleep Medicine has discontinued the use of Stage 4 (Shulz, 2008). Nevertheless, SWS has the highest arousal threshold and is characterized by synchronized EEG activity with slow waves at a frequency less than 1 Hz. As with the other stages of sleep, SWS appears to play a role in the consolidation of memories (Marshall, Helgadóttir, Mölle, & Born, 2006).

Rapid Eye Movement (REM) sleep is characterized by fast and desynchronized EEG wave patterns appearing very similar to EEG recordings of a wakeful state, hence given the nickname of "paradoxical sleep." REM sleep is closely associated with the phenomena of dreaming and may be extremely important in learning and memory. Further, it is most overtly recognized stage of sleep as seen by fast rapid eye movement beneath the eyelids (Carskadon & Dement, 2000; Altevogt & Colten, 2006). Table 1 provides a brief overview of the core features

of the varied stages of sleep.

Table 1. Features of the stages of sleep

Stage of Sleep	Duration of Stage in Initial cycle	Percent of Total Time Asleep	EEG Wave Activity	Brief Description
Stage 1	1-7 minutes;	2-5%	Alpha (8-13 Hz)	Light sleep; Low voltage, mixed frequency waves; Transitional stage from wake to sleep
Stage 2	10-25 minutes	45-55%	Theta (4-7 Hz)	Low voltage, mixed frequency waves; sleep spindles; K-complexes
Stage 3	1-5 minutes	3 to 8%	Delta (0.5-2 Hz)	High voltage; slow wave activity
Stage 4	20 to 40 minutes	10-15%	Delta (0.5-2 Hz)	High voltage; slow wave activity; highest arousal threshold
REM	1 to 5 minutes	20-25%	Beta (13-30 Hz)	"Paradoxical Sleep;" Fast, desynchronized wave activity; Dreaming

Sleep needs across the lifespan. Numerous studies have investigated the sleep patterns at different stages throughout the human life cycle. Our need for sleep drastically changes as we age. Newborns and infants require the most sleep with approximately 16 to 18 hours per day (Parmelee, Schulz, & Disbrow, 1961); whereas an adult requires a mere 7 to 8 hours (Centers for Disease Control and Prevention [CDC], 2013). Sleep requirements for children underscore the importance for sleep for normal physical and mental development; with childhood sleep disorders contributing to observed delays in cognitive development and neurocognitive consequences (Paavonen, Porkka-Heiskanen, Lahikainen, 2009; Sadeh, Gruber, & Raviv, 2002). Despite trends in research revealing specific sleep requirements for different age groups across the lifespan, it is important to note that sleep needs also vary for among people based on their lifestyle (Hartmann, Baekeland, Zwilling, & Hoy, 1971). Table 2 provides an overview of reported sleep requirements across the lifespan (CDC, 2013).

Table 2. Required Sleep Needs Across the Lifespan

Age Group	**Required Sleep (hours/day)**
Newborns	16-18
Preschoolers	11-12
School Age Children	At least 10
Adolescents	9-10
Adults	7-8

Sleep requirements for adolescents, approximately 9-10 hours per night (CDC, 2013), have received much attention over the past decade due to its assumed relationship to healthy adolescent development. Sleep is thought to contribute substantially to brain maturation and behavioral/emotional regulation (Dahl & Lewin, 2002). Moreover, adolescent sleep research has revealed changes during pubertal development that lead to alterations of the sleep-related

circadian rhythm functions (i.e., melatonin secretory pattern and light sensitivity; Carskadon, Acebo, & Jenni, 2004). These changes in the bioregulatory systems controlling sleep have spurred research investigating the negative effects of the typical social demands of adolescents, such as early school start times, on their cognitive and physical development, as well as, academic performance. Together these findings are prompting officials to consider later school start times to accommodate these biological changes (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998).

Healthy adults require approximately seven to eight hours every night (CDC, 2013); however, this is an estimate which does not account for other contributing factors such as basal sleep need and sleep debt. Basal sleep need refers to the amount of sleep an individual's body needs for optimal physical and mental function; whereas, sleep debt refers to the accrued sleep lost due to poor sleep habits, sickness, and other environmental factors (e.g., loud noises). Together basal sleep and sleep debt are thought to contribute to individual differences in required sleep needs, which is based on the number of hours of sleep loss on the individuals' specific daily need (requirement) for sleep (Van Dongen, Rogers, & Dinges, 2003). Nevertheless, while the verdict is still out concerning how much sleep an individual requires, it is well-established that disrupted sleep and sleep deprivation contribute to neurocognitive dysfunction (Durmer & Dinges, 2005), undermine workplace productivity (Rosekind et al., 2010), and increase the risk for health and mental health problems (Stein, Belik, Jacobi, & Sareen, 2008).

There is a long-standing myth that older adults require much less sleep than their younger counterparts. However, it is just that, a myth. There are many external stimuli and environmental factors that can contribute to sleep disruption. These include diet, exercise, physical health, and mental health (Altevogt & Colten, 2006). Studies on the sleep habits of older adults show an

increase in sleep latency, decline in REM sleep, and increase in sleep fragmentation with age. However, to some extent sleep in older adults is more susceptible to issues related to aging such as pain, physical illness, and medication use (Altevogt & Colten, 2006). Moreover, as we age, changes in sleep architecture occur that may affect circadian rhythms. Consequently, older individuals are prone to developing advanced sleep phase syndrome—simply defined as a sleep schedule that is shifted forward. Persons with advanced sleep phase disorder still achieve the required hours of sleep, but the timing (bed time and wake time) has changed (Dijk, Duffy, & Czeisler, 2000).

Neurophysiology of Sleep- and Wake-Generating Mechanisms

Previous research of normal and impaired sleep has emphasized psychological and behavioral mechanisms (see section on theoretical models of impaired and poor sleep). These models fail to incorporate the underlying neurobiological components essential for comprehensively conceptualizing sleep and its disorders. Advanced techniques in neuroscience and biological sciences have allowed for in-depth investigation of sleep at the neural level with new emerging models highlighting the biological, psychological, and social aspects of sleep.

The two process model of sleep-wake regulation. The dominant model used to explain regulation of sleep and wakefulness is the Two-Process Model of Sleep-Regulation. Proposed by Alexander Borbély in the 1980s, the model posits that sleep-wake regulation is dependent upon the dynamic interplay between two main processes- circadian rhythm (Process C) and homeostatic sleep drive (Process S). Process C is thought to promote wakefulness, whereas Process S is thought to drive the need for sleep (Altevogt & Colten, 2006; Fuller, Gooley, & Saper, 2006). More specifically, process C factors refer to the human body's natural approximately 24-hour circadian rhythm or biological clock, which coordinates numerous

physiological processes based on day-night/light-dark cycle. Such processes include but are not limited to sleep patterns, feeding schedules, body temperature changes, and hormone fluctuations (Moore, 1997). The hypothalamic suprachiasmatic nuclei govern Process C functions via photic input from the retinohypothalamic tract (Buysse et al., 2011). Opposing those functions underlying wakefulness are those associated with Process S, often referred to as the homeostatic sleep drive, which contribute to increased sleep propensity. These processes are largely biochemically driven, with the most researched somnogen being adenosine. Adenosine acts a neuromodulator inhibiting many of the biological processes underlying wakefulness. Adenosine levels in the basal forebrain rise simultaneously with a rise in sleep debt (lack of or insufficient sleep), inducing a behavioral drive to sleep. Adenosine levels also rise naturally throughout the day as a result of metabolism of glycogen (Basheer, Strecker, Thakkar, & McCarley, 2004; Porkka-Heiskanen, Alanko, Kalinchuk, & Stenberg, 2002). Together these two processes work with and against each other to regulate sleep and wakefulness.

The neurobiology of sleep and wakefulness. No single neural substrate is responsible for promoting wakefulness or sleep. Rather the orchestration of several neural systems, both neuroanatomical and biochemical in nature, regulate sleep and wakefulness. Wakefulness results from activity within the nuclei in the brainstem and hypothalamic nuclei (collectively known as the ascending reticular activating system) including the locus coeruleus, raphe nuclei, pedunculopontine tegmentum nuclei, and ventral tegmental nuclei. These structures regulate neurotransmitters and neuromodulators such as dopamine, orexin, histamine, serotonin, and choline, which are related to increased alertness, arousal, and wakefulness. In particular, orexin-containing neurons in the lateral hypothalamus reinforce activation of the ascending reticular activation system during wakefulness, while low levels at night help drive sleep onset (Buysse,

Germain, Hall, Monk, & Nofzinger, 2011; Fuller, Gooley, & Saper, 2006).

Sleep onset is typically associated with increased activity in the ventrolateral (VLPO) and median preoptic (MnPO) areas of the anterior hypothalamus. Projections from these brain areas inhibit hypothalamic arousal centers. Additionally, during wakefulness, neurons in this area are responsible for inhibiting sleep onset in the VLPO. For this reason, the VLPO is often referred to as the "sleep-switch" (Buysse et al., 2011).

Theoretical Models of Impaired Sleep

Many theoretical models for conceptualizing and understanding sleep impairment exist. Prominent models include the stimulus control model (Bootzin, 1979), cognitive model (Harvey, 2002), and neurocognitive model (Perlis et al., 1997). While many of these models share several characteristics, each model proposes unique facets for a greater understanding of impaired sleep.

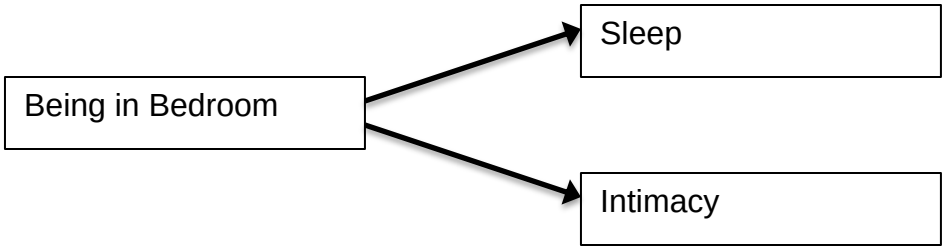
Stimulus Control Model. Proposed by Bootzin (1979), this behavioral model of sleep impairment is based on classical conditioning principles. The model explains sleep induction as a function of individual learning histories. *Stimulus control* represents a relatively simple learning history in which the bedroom (the stimulus) is associated with few responses, typically including sleep and intimacy. Therefore the chance that one would engage in either of the responses is approximately 50/50, thus increasing the odds of sleeping. In contrast, *stimulus dyscontrol* describes the presence of multiple behavioral responses to the stimulus of preparing for bed or being in the bedroom, consequently diminishing the probability of sleep onset. Figure 1 provides a visual overview of the model proposed by Bootzin (1979) emphasizing stimulus control and stimulus dyscontrol.

Clinical utility, strengths, and weaknesses of the Stimulus Control Model. The ultimate goal of stimulus control treatment is to promote a disassociation with a large number of

maladaptive learned responses and encourage few behavioral responses to occur in the presence of the stimulus. This model has many strengths. One such strength is its clinical utility. The treatment protocol provides a set of specific instructions, which lends itself well to clinical study and has since proven to be quite efficacious as a stand-alone treatment for disordered sleep, namely insomnia (Smith et al., 2002). However, this model is not without its weaknesses. For instance, the model focuses solely on instrumental learning and neglects the presence of any underlying biological or neurophysiological components, such as the naturally occurring sleep and wake cycle (Kryger, Roth, & Dement, 2005).

STIMULUS CONTROL

Odds of sleeping when in the bedroom are 1 of 2.



STIMULUS DISCONTROL

Odds of sleeping are when in the bedroom are 1 of 6.

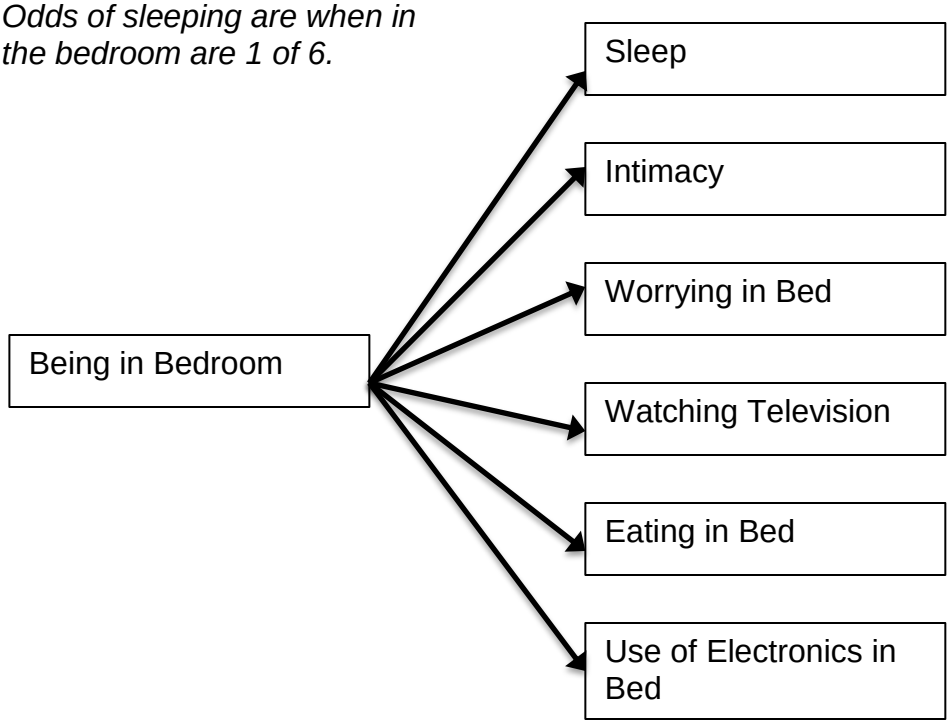


Figure 1. Stimulus control and dyscontrol as adapted from Perlis, Shaw, Cano, & Espie, (2011). Top, being in the bedroom (stimulus) is associated with few activities (behavioral responses), thus the one of these two responses has a high probability of occurrence. Bottom, being in the bedroom is associated with multiple activities, diminishing the probability that sleep will occur upon stimulus presentation.

The Cognitive Model. Harvey (2002) suggested the first cognitive model emphasizing internal phenomena such as thoughts, feelings, and beliefs as the main contributors to sleep disturbance. She proposed that excessive negatively-toned cognitive activity leads to increased arousal and distress. For instance, Harvey (2002) suggested that people with impaired sleep constantly worry about getting poor sleep and its daytime effects (i.e., fatigue during the day or an inability to optimally perform at work). This maladaptive thinking leads to the selective attention of insignificant internal and external threat cues related to their sleep. This more sensitive monitoring of sensations and external stimuli is believed to reinforce previously distorted beliefs about deficits and perhaps lead to an overestimation of perceived deficits in daytime performance related to sleep difficulties.

Dysfunctional beliefs and attitudes about sleep. Dysfunctional beliefs and attitudes about sleep have been studied extensively as a core feature in cognitive models of impaired sleep. Morin (1994) postulated that dysfunctional beliefs played an important mediating role in the development and maintenance of insomnia and subsequently created the Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS) to measure the nature of these cognitions objectively (see Methods for a detailed description of DBAS). Morin's work was further tested when he and his colleagues (2001) developed a clinical trial to test the effectiveness of several insomnia interventions: Cognitive Behavioral Therapy (CBT), pharmacotherapy (PCT), combined CBT + PCT (COMB), or medication placebo. There was a particular interest in the effectiveness of the CBT intervention—a treatment approach focused on identifying and changing maladaptive sleep beliefs—which formally addressed this hypothesis. The study, comprised of 72 older adults (65% women) with late-life insomnia, utilized both subjective (DBAS; Sleep Diary) and objective (polysomnography) sleep measures over the eight-week

treatment course. The authors hypothesized that changes in beliefs and attitudes about sleep would relate to sleep improvements. Results indicated that dysfunctional thoughts and beliefs are improved during treatment in the CBT groups (only CBT and COMB). These scores were noted to be significantly correlated with improved sleep efficiency as measured by polysomnography. Moreover, lower or improved DBAS scores were associated with better maintenance of sleep improvements at 3-, 12-, and 24-month posttreatment follow-up assessments.

In another study, Carney and colleagues (2007) assessed the link between insomnia and dysfunctional sleep beliefs across five groups: primary insomnia, good-sleepers, fibromyalgia, major depressive disorder, and community sleep clinic patients with comorbid sleep disorders. Assessing beliefs about sleep using the DBAS, the researchers found that all groups with comorbid disordered sleep showed maladaptive beliefs and attitudes about sleep. These results are consistent with another study finding dysfunctional beliefs and perceived stress mediating sleep quality in fibromyalgia patients (Theadom & Cropley, 2008). All things considered, these studies demonstrate the importance of beliefs and attitudes in perceived sleep quality and provide evidence to support cognitive interventions in the treatment of disordered sleep.

Clinical utility, strengths, and weaknesses of cognitive models. As noted in the previous section, cognitive theories of sleep impairment lend themselves well to the development of cognitive and cognitive-behaviorally based treatment approaches. As highlighted in the study conducted by Morin et al. (1994), changes in dysfunctional beliefs coincided with an overall improvement in sleep quality, suggesting a relative role for assessing and treating negative cognitions associated with disordered sleep. A relative strength of cognitive models is that they are easily modifiable and testable in clinical and research settings.

Cognitive models are not without their weaknesses. One weakness of the cognitive

models, like the stimulus control model, is that they fail to incorporate the role of neuropsychological or biological mechanisms. Another weakness is that cognitive models fail to explain whether the development of dysfunctional beliefs precedes the onset of the disrupted sleep or occurs as a result (Buysse et al., 2011).

Neurocognitive Model. Also known as the "Hyper-Arousal" model, this model proposes somatic and cognitive hyperarousal as a central component to sleep disturbance. Building upon the assumptive role of predisposing factors, precipitating events, and perpetuating factors, in the initiation and maintenance of impaired sleep, the neurocognitive model incorporates neurological and psychological factors to explain underlying mechanisms better. Specifically, this model suggests that sleep impairment results from conditioned cortical, somatic, and cognitive arousal from the association of sleep-related stimuli. Borrowing from features of both the Stimulus Control and Cognitive models, the model hypothesized that repeated pairings of sleep-related stimuli with insomnia-related arousal wakefulness leads to conditioned arousal when presented with sleep-related stimuli. Similarly, on a neurophysiological level, it is believed that this hyperarousal leads to enhanced sensory and information processing around sleep onset and during NREM sleep-promoting development of sleep-wakefulness misperception. Consequently, this framework allows cognitive processes during stages of sleep that are not typical. This phenomenon directly contradicts findings that good sleepers experience mesograde amnesia; whereas those with insomnia are better able to remember events during those times suggesting continued arousal despite being in a sleep state (Bastien, 2011; Kryger, Roth, & Dement, 2005).

Clinical utility, strengths, and weaknesses of the Neurocognitive Model. The neurocognitive model presents a high amount of clinical utility due to its pluralistic perspective of hyperarousal, which includes cognitive, cortical, and somatic arousal. This model gives rise to

potential new medical and behavioral treatments to address the cognitive, behavioral, and neurophysiological features underpinning insomnia and disordered sleep. The model's pluralistic perspective is one of its greatest strengths as it is better able incorporate various facets from other validated theoretical viewpoints into a more comprehensive model. However, although the model incorporates neurophysiological components, it still lacks specificity to neuroanatomical or biochemical processes potentially involved (Kryger, Roth, & Dement, 2005).

Personality, Emotions, and Sleep

Personality research has focused on identifying human characteristics and traits that can predict behavior. Although many personality theories exist, none has been studied as much as the "Big Five" (also known as the Five-Factor model). The five broad traits recognized within this model are Openness to Change, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. These factors have consistently and reliably been replicated to represent a hierarchical personality construct (John & Srivastava, 1999). Resultantly, traits predispose individuals to interact and experience their environment in a fairly consistent and predictable manner. The Five-Factor model has been utilized in several populations to predict health and health behavior, with a majority of studies citing high scores on neuroticism predicting maladaptive health outcomes and health behavior (Lahey, 2009). Therefore, the present investigation exploring the individual differences of sleep may assist in predicting those at risk for developing disordered sleep patterns or be prone to poor sleep quality.

Influence of neuroticism and negative affect on sleep. Neuroticism is one of the most widely studied factors of the Big Five model. Neuroticism is often described as a behavioral tendency to respond with negative emotions across a variety of situations. The negative affect typically associated with those exhibiting high neuroticism includes anxiety, hostility, and

depression. What makes the study of neuroticism, and personality in general, so important is its impact on public health. In particular, neuroticism or trait-negative-affect is frequently cited in association with poor mental and physical health outcomes (Lahey, 2009). Several studies showed that people exhibiting high neuroticism have an increased rate of mortality from cardiovascular disease (Shipley, Weiss, Der, Taylor, & Deary, 2007), a higher likelihood of smoking behavior (Terracciano & Costa, 2004), greater nonadherence to continuous positive airway treatment regimen (Moran et al., 2011), and riskier sexual behavior (Hoyle, Fejfar, & Miller, 2000).

Other studies have underscored the substantial influence of neuroticism on poor sleep and sleep-related behaviors. In one such study, Duggan, Friedman, McDevitt, and Mednick (2014) examined self-report measures for personality, chronotype (i.e., morningness or eveningness preference), sleep hygiene, sleep quality, and sleepiness in a sample of 436 ethnically diverse university students (50% male). Regression analyses revealed that high neuroticism and low conscientiousness were the best predictors of poor sleep hygiene, poor sleep quality, and increased sleepiness.

Similarly, a study by Soehner, Kennedy, & Monk, (2007) also provided evidence to support the relationship between neuroticism and sleep quality. Their survey study assessing the influence of personality on sleep-wake variables found that high scores on neuroticism were significantly related to poorer self-reported sleep quality.

In another study exploring relationships of temperamental affective dispositions with sleep quality, researchers Ottoni, Lorenzi, and Lara (2011) examined cognitive and affective styles associated with mental health disorders because of the high comorbidity with sleep disturbances. The sample of 5129 participants (25.3% men; 55.4% with a psychiatric diagnosis),

was electronically canvassed and asked to complete two measures associated with emotion/affect and sleep: 1) the Combined Emotional and Affective Temperament Scale (CEATS); and 2) a general sleep questionnaire. Their findings revealed anger to be significantly related to higher sleep onset latency, more frequent nightly awakenings, and worse sleep quality (Ottoni et al., 2011). Unsurprisingly this finding suggests that anger, an emotion related to high physical and cognitive arousal, is significantly related to poor sleep quality. Additionally, there is research suggesting other perceived negative emotional states, such as loneliness, guilt, shame, regret, and depression to negatively impact sleep quality (Kahn, Sheppes, & Sadeh, 2013).

Reinforcement Sensitivity Theory. Originally conceived to explain the biobehavioral basis of how reward and punishment related to anxiety and impulsivity, Gray's (1990) Reinforcement Sensitivity Theory (RST) developed into a widely accepted biopsychological theory of personality. The original theory proposed the presence of three central biobehavioral systems, namely the Behavioral Activation System (BAS), Behavioral Inhibition System (BIS), and the Fight/Flight System (FFS). The BIS, activated by aversive stimuli (punishment and non-reward), results in increased attentiveness, inhibition, withdrawal and negative affect. In contrast, the BAS operates in response to appetitive stimuli (reward, motivation, and non-punishment) and promotes the experience of approach-related behavior and positive affect. The remaining FFS system was hypothesized to respond to unconditioned aversive stimuli, facilitating escape (flight) or aggression (fight; Gray, 1990).

A revision of the model maintained the proposed constructs of BIS and BAS but modified the FFS to include "freezing" behavior in the presence of an aversive stimulus (as per animal studies testing the utility of RST). Hence, FFS became the Fight/Flight/Freeze System (FFFS; Gray & McNaughton, 2000). Investigative neuroimaging has corroborated the

independent and orthogonal nature of the three core systems identifying key neurophysiological correlates. Specifically, BIS corresponds with activity in the dorsal prefrontal cortex, posterior cingulate cortex, septohippocampal system, amygdala, medial hypothalamus, and periaqueductal gray; whereas BAS relates to activation in the prefrontal cortex, ventral striatum, ventral pallidum, and ventral tegmental area (Kennis, Rademaker, & Geuze, 2013).

Carver and White (1994) have championed the significant implications of the RST concerning human behavior and affect and have promoted scientific investigation. Most research regarding RST had predominantly focused on animal behavior and psychopharmacological influences on behavior until the development of their brief questionnaire: the BIS/BAS Scales, which operationalized the BIS and BAS behaviorally. Carver and Whites' (1994) BIS/BAS scales adhered to the original conceptualization for the two main motivational and affect systems but enable investigators to quantify individual differences in threat and reward sensitivities. The development of the BIS/BAS scales has significantly aided investigation of RST and promoted greater clinical and theoretical application.

Psychophysiology and RST. Traditionally, research on RST has emphasized the neurophysiological and biobehavioral aspects of BIS and BAS. Due to the nature of the theory, the research has focused on identifying psychophysiological correlates through electroencephalographic (EEG) investigation. Previous research has demonstrated frontal asymmetric activity differences related to emotional valence, motivational direction, or a combination of the two. When examining the role of emotional valence on frontal cortical activity, researchers have focused on state and trait emotions. For instance, Harmon-Jones and Allen (1993) assessed the individual differences in resting anterior asymmetry of 37 undergraduate women. The researchers hypothesized that greater left frontal than right frontal

cortical activity would be related to greater approach related dispositional tendencies and thus would hold predictive value for identifying individuals most vulnerable to developing mood disorders. The participants were asked to complete the Positive and Negative Affect Scales – State version (PANAS) and BIS/BAS scales, and then participate in a baseline resting EEG recording for four minutes, alternating between one-minute intervals of either the eyes-open and eyes-closed conditions for the duration of the time. Results supported their hypothesis. Greater left- than right frontal cortical activation was significantly related to approach-related behavior and greater positive affect. These results were thought to provide evidence that point toward a common underlying dimension that may predict mood disorders.

Similar findings supporting the psychophysiological and biobehavioral correlates of RST were obtained by Sutton and Davidson (1997). Their study examined the relationship between the biological (resting frontal asymmetry) and behavioral (BIS/BAS scales) aspects underlying the central BIS and BAS systems proposed in the Reinforcement Sensitivity Theory. They assessed 46 undergraduate participants (50% women) using the BIS/BAS scales, PANAS, and EEG recording of resting frontal asymmetry. As predicted, their findings revealed participants with greater left frontal resting asymmetry had higher BAS scores, whereas those exhibiting greater right frontal resting asymmetry self-reported higher BIS scores. Moreover, they provided evidence to support the calculation of a strength score which would suggest greater BIS or BAS presentation.

In another study, Sobotka, Davidson, and Senulis (2002) investigated approach and withdraw behavior in response to reward and punishment contingency task. Fifteen participants (47% men) volunteered to participate in a study that directly manipulated reward and punishment contingencies through a simple motor task in which the participants could win, lose, or maintain

a certain amount of money. Each participant began with five dollars and was instructed to respond to imperative stimuli by either gently pressing down on the response switch (approach response; finger press) or lifting their finger from the response switch (withdrawal response; finger lift) depending on the task block. The research specifically examined the potential influence of approach and withdrawal responses on anterior brain asymmetry. Investigative findings were consistent with previous research, suggesting that greater left anterior cortical activation is associated with the expression and experience of approach-related motivation (BAS), while greater right anterior region relates to avoidance and withdraw (BIS).

RST and sleep. There is much research investigating the influence of RST's BIS/BAS with health behavior; however, relatively few studies have examined the relationship between the BIS/BAS and sleep behavior. One such study examined the underlying personality correlates associated with non-adherence to continuous positive airway pressure (CPAP) treatment in a clinical population presenting with sleep apnea. Elevated BIS scores and neuroticism predicted non-adherence to treatment. While this study did not directly examine sleep as a primary variable, rather a treatment adherence for a disordered sleep experience (sleep apnea), the results support the potential clinical utility of examination of the relationship between personality factors and sleep behaviors (Moran et al., 2011).

Espie, Barrie, and Forgan (2012) completed a comparative investigation of sensitivity (BIS/BAS) to arousal conditioning and sleep effort in a clinical population diagnosed with one of two insomnia phenotypes, psychophysiological insomnia (PI) and idiopathic insomnia (IdI). A PI diagnosis is characterized by the presence of psychological and physiological features such as conditioned arousal, sleep preoccupation, poor sleep hygiene, and anxiety about sleep. IdI, on the other hand, is defined by the absence of precipitating and maintaining factors (typically

associated with psychosocial factors) and is thought of as being purely physiological in nature. A total of 40 insomnia patients (20 PI; 20 IdI) were administered the BIS/BAS scales to operationalize the putative neurophysiological systems underlying PI and IdI in behavioral terms. Results revealed that the PI group scored significantly higher than the IdI suggesting higher threat sensitivity in PI. There were no significant differences for any of the three BAS subscales. These findings of individual differences in threat sensitivity and vulnerability to experiencing negative affect likely contribute to the development of insomnia.

Similarly, Markarian, Pickett, Deveson, and Kanona (2013) conducted an exploratory model examining whether sleep quality directly influenced emotion regulation difficulties and psychopathology. Specifically investigating self-reported BIS/BAS sensitivity, emotion regulation, and mood symptoms (i.e., depression and anxiety) in a sample of 459 students (21% men), the researchers hypothesized that BIS and BAS would be indirectly related to anxiety through the effect on emotion regulation difficulties. They found that individuals reporting higher BIS and lower BAS self-reported emotion regulation difficulties across both sleep quality groups (good sleepers and poor sleepers as determined by global sleep scores on the Pittsburgh Sleep Quality Index; poor sleepers identified as having score > 5). Invariance testing of the pathways indicated significantly stronger associations between emotion regulation difficulties and mood symptoms in poorer sleepers. While this research does not provide definitive answers as to how the underlying BIS/BAS levels relate to sleep quality, it demonstrated that poor sleep quality may exacerbate emotion regulation difficulties and mood symptoms (Markarian et al., 2013).

All things considered, the RST framework presents as a potential model for better explaining the development of disordered sleep behavior. Consisting of both neurophysiological

and behavioral correlates, RST seemingly accounts for individual differences in approach or withdrawal related behavior and susceptibility to experience positive or negative emotions, respectively. As such, further investigation may help to clarify the complex relationships among such variables as subjective sleep quality, personality, affect, and RST (BIS/BAS).

Event-Related Potentials and their Relation to Sleep

Although psychophysiological measures of cortical activation, as measured through resting baseline asymmetry, are standard measures of sleep activity, investigation of event-related potentials (ERPs) provides further insight into the brain's cognitive and emotional processing. An ERP is the measured brain response that is the direct result of processing an external physical response or an internal psychological event over a short duration of time (measured in milliseconds). ERPs are thought to reflect the summed and averaged activity of postsynaptic voltage fluctuations (Picton et al., 2000). Waveforms are created using ERP averaging techniques that exhibit positive and negative deflections of voltage. ERP nomenclature has been created to reflect these deflections within the ERP waveform. A letter is designated to represent the positively (P) or negatively (N) valenced peaks within the waveform, whereas a number is ascribed to indicate the latency in milliseconds. For example, a P200 or P2 would suggest the presence of a positive peak at about 200 milliseconds within the ERP waveform (Luck, Woodman, & Vogel, 2000; Bastien, 2011).

Event-related potential studies are quite limited when studying sleep due to the inability to respond behaviorally to stimuli. The majority of ERP investigations attempt to assess information processing upon sleep onset or upon awakening as a means to examine daytime consequences. To do so, many investigators employ the use of the oddball paradigm task to measure cortical arousal and excitability (Bastien, 2011). This paradigm presents a series of

auditory or visual stimuli presented either frequently (standard stimuli) or infrequently (rare stimuli). Participants may be asked to respond actively or passively to stimuli to generate ERPs. Active or attentive responding to target stimuli is related to the generation of an ERP component; whereas passive (ignoring the stimuli) is shown to elicit N100, P200, and N350 ERP responses (Bastien, 2011). Since several theories cite hyperarousal at sleep onset as a factor contributing to disordered sleep, use of the oddball paradigm is a potential task for examining related hypotheses.

Yang and Lo (2007) conducted a study investigating whether hyperarousal is present during sleep. The purpose of their study was to examine auditory processing during sleep in participants with and without insomnia through investigation of event-related potentials. A total of 30 participants (15 diagnosed with primary insomnia) were invited to participate in a two-night sleep study, with the first night designated to screening and adaptation (allowing participants to become familiar and comfortable with the equipment). The second night was dedicated to the ERP study. For the study, ERP induction procedures entailed using a modified auditory oddball task with a high pitched tone (1500 Hz) or a low-pitched tone (1000 Hz) as the stimuli. Target and rare stimuli (high or low pitched tones) were counter-balanced within the group of participants. Results of their study found that insomniacs exhibited larger N100 and smaller P200 to rare tones than to their non-diagnosed counterparts. Insomniacs also showed smaller N350 to standard tones than controls. Yang and Lo (2007) findings provide support for increased hyperarousal and information processing during sleep for insomniacs.

Despite the scarcity of ERP research investigating the development of disordered sleep, the theoretical models lend themselves to psychophysiological investigation, particularly the neurocognitive/hyperarousal model. Due to its pluralistic nature, the neurocognitive model

provides a framework easily adaptable to the psychological, behavioral, and psychophysiological study. This study will explore the underpinnings of the neurocognitive model via the investigation of ERPs associated with sleep-related stimuli.

The Present Study

Purpose of the present study. The purpose of the present study was to build upon previous studies investigating sleep quality as it relates to personality, neuropsychological performance, and emotional and cognitive processing. Furthermore, the results of this study may have implications for further sleep research intended to improve identification, diagnosis, and intervention of symptoms related to the perception of poor sleep quality before the development of a potentially chronic sleep disorder. As such, there is particular emphasis on preventive care and overall health promotion.

Proposed aims, hypotheses, and statistical analyses. The current study investigated individual differences in personality, human emotion, and affect, as it relates to sleep quality. The overall aim of this study is to consider the influence of variables of personality, affect, psychophysiology (resting asymmetry and event-related potentials), and physical and mental health on sleep quality.

Hypothesis one. A primary aim of this study was to explore the constructs underlying the neurocognitive model of sleep impairment. This aim was investigated via examination of the relationships among self-reported measures of personality, affect, and behavior regarding multiple aspects of sleep quality. Noted previously, the neurocognitive model of sleep impairment suggests the presence of psychologically conditioned physical and cognitive hyperarousal as a factor precipitating and maintaining sleep disturbance and poor sleep quality (Bonnet & Arand, 1997). Thus, poor sleep quality often co-occurs with mood disorders including

depression (Ford & Cooper-Patrick, 2001) and anxiety disorders (Mellman, 2008). It was hypothesized that personality and affect will be significantly associated with sleep quality. Specifically, participants endorsing personality traits associated with negative affect were expected to report higher levels of self-reported poor sleep quality.

Analysis of hypothesis one. Correlational analyses were used to identify statistically significant relationships among the variables of subjective sleep, and state/trait affect. Next, multiple regression analyses were employed to create a model predicting sleep quality (global PSQI score) from the previously mentioned state/trait affect variables.

Hypothesis two. Another aim of the present study was to examine sleep disturbance and sleep quality within the Reinforcement Sensitivity Theory (RST) framework. This theory describes individual differences through human neurophysiological mechanisms via the Behavioral Inhibition (threat sensitivity; negative emotions) and Behavioral Activation Systems (reward sensitivity; positive emotions) and is believed to conceptualize individual differences in human emotional and behavioral experiences (Gray & McNaughton, 2003). Previous research investigating sleep within the context of RST has shown a statistically significant relationship between higher self-reported BIS and sleep impairment in a population of insomniacs of both the psychophysiologic (relating to psychological variables including heightened cognitive arousal associated with stress, anxiety, and symptoms disorders) and idiopathic (seemingly biological/neurological in nature but of no known direct cause) types, with those presenting with psychophysiologic insomnia endorsing higher levels of BIS (Espie, Barrie, & Forgan, 2012). For the current study, it was hypothesized that higher self-reported threat sensitivity (BIS) would be significantly related to poorer sleep quality.

Resting asymmetry (RA) data, which are frequently utilized as a neurophysiological

measure of BIS/BAS, were also examined. The resting asymmetry literature consistently demonstrates that greater activation in the left anterior region of the brain (as compared to the right) correlates to the expression and experience of appetitive motivation and positive affect (BAS); while the right anterior region relates to avoidance and negative affect (BIS; Harmon-Jones, & Allen, 1997). Accordingly, it was hypothesized that greater right (as compared to left) anterior activation at rest would be associated with poorer sleep quality and the presence of sleep disturbance.

***Analysis of hypothesis two*.** Correlational analyses were employed to examine relationships among subjective sleep quality (global PSQI score) and subscales from Carver and Whites' (1994) BIS/BAS Scales (BIS, BAS-Drive, BAS-Fun Seeking, BAS-Reward Responsiveness). Additional correlational analyses explored baseline resting frontal asymmetry scores at electrode sites FP21, F87, F43, and FT87. Multiple regression models predicting self-reported sleep quality (global PSQI score) from behavioral and electrophysiological measures of BIS and BAS were proposed but not examined given weak correlations among variables.

Hypothesis three. The third aim of this study was to perform an exploratory investigation of the N100, P200, and P300 ERP components as they relate to the information processing of positively and negatively valenced sleep-related images presented in a visual oddball paradigm task. According to the neurocognitive model of sleep impairment, it is suggested that people with sleep onset and maintenance difficulties are susceptible to developing conditioned cortical arousal in response to sleep-related stimuli. Previous EEG studies examining hyperarousal and enhanced information/cognitive processing associated with sleep impairment resulted in significant differences between poor and good sleepers at the N100, P200, and P300 ERP components (Bastien, 2011). Although the majority of these studies employed an auditory

oddball paradigm, it was expected that visual information processing would achieve similar results. As such, it was hypothesized that people self-reporting more sleep impairment would have larger N100 amplitudes, as well as smaller P200 amplitudes in response to standard and rare stimuli. It was also hypothesized that poorer self-reported sleep quality would produce significantly larger P300 to target stimuli in comparison to those endorsing better sleep quality.

Analysis of hypothesis three. A series of multivariate analyses of variance (MANOVA) were employed to examine differences in ERP amplitudes and latencies between identified good and poor sleepers, as designated per PSQI total scores. These analyses were limited to participants with complete EEG data.

Hypothesis four. The fourth aim of this study was to investigate the neuropsychological sequelae associated with poor sleep quality. Excessive daytime sleepiness and sleep deprivation are often noted to result from poor sleep. While there is much research exploring the impact of poor sleep on everyday functioning and neuropsychological performance, findings are mixed. For instance, studies examining neuropsychological performance among insomniacs have shown heightened attention toward tasks, exhibiting a paradoxical effect. The psychomotor vigilance test (PVT) is the most widely used measure of neurobehavioral alertness and sustained attention within the field of sleep research. The PVT was designed to be sensitive to sleep loss induced in many different ways (i.e., sleep fragmentation, prolonged waking, and shift work) and is without confounds resulting from individual differences of aptitude or learning (Doran, Van Dongen, & Dinges, 2001). It was hypothesized that individuals with poorer performance on the PVT task, as evidenced by increased reaction time, omissions, and commissions, would endorse poorer sleep quality.

Analysis of hypothesis four. Correlational analyses were conducted to investigate the relationships among PVT variables (reaction time, commissions, and omissions) with overall reported sleep quality (PSQI). Exploratory analyses investigated PVT performance across PSQI component scores including sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction.

Hypothesis five. The final aim of the current study was to examine whether sleep quality can be predicted based on beliefs and attitudes about sleep. Research evidence suggests cognitive and behavioral interventions aimed to alter dysfunctional beliefs and attitudes about sleep are significantly related to an overall improvement of disordered sleep on both subjective and objective sleep measures. Furthermore, adaptive beliefs were significantly related to better relapse-prevention (Morin et al., 1994). Therefore, it was hypothesized that current beliefs and attitudes about sleep at the time of participation would predict self-reported sleep quality. Specifically, it was anticipated that those participants endorsing higher dysfunctional beliefs and attitudes about sleep would report poorer sleep quality.

Analysis of hypothesis five. Correlational analyses were conducted to examine the expected relationships between scores on the Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS-16 total score and thematic means) and overall subjective sleep quality (PSQI global score). Additional multivariate techniques were employed to explore significant relationships. Specifically, logistic regression models predicting PSQI classification (good versus poor sleeper) were conducted to explore the clinical utility of the DBAS-16 questionnaire. Multiple regression models predicting sleep quality from multiple explanatory variables (i.e., DBAS-16 total score, themes from the DBAS) were also fitted and tested. Lastly, simple mediation analyses were conducted to explore the mediating role of dysfunctional beliefs and

attitudes about sleep as they relate to subjective sleep quality.

CHAPTER III: METHODS

Participants

An a priori power analysis using G*Power 3.1 was used to determine the required sample size for detecting large effects with 95% power. This analysis resulted in a need for a sample of approximately 130 participants, whereas, a more conservative number of participants (80% power) was calculated to be approximately 85 participants. Given the nature of this study (multiple components—surveys, EEG, PVT) and limited recruitment window, 75 participants contributed to the present study. The sample characteristics are located in Table 3. There were 50 women and 25 men in the sample (67% women). The average age of the sample was 20.15 years (*SD* = 3.01), ranging from age 18 to 39 years of age. All participants were recruited from East Carolina University's undergraduate studies programs, predominantly students from psychology and neuroscience courses. Eligibility requirements included being right-handed and of at least 18 years of age. To prevent unwanted confounds and to be consistent with established recommendations for EEG research, any participant with a history of brain injury, seizure disorder, and/or vision impairment (without correction) were ineligible to participate.

Table 3. Sample Characteristics for 75 ECU Student participants

Characteristic	*N*	**%**
Sex		
Female	50	67
Male	25	33
Age		
18-24 years	71	95
25-34 years	3	4
35-44 years	1	1
Race & Ethnicity		
White	46	61
Black	23	31
Hispanic	1	1
Asian	1	1
Other	4	5
Caffeine Use		
Yes	63	84
No	12	16
Alcohol Use		
Yes	19	25
No	56	75
Caffeine & Alcohol Use		
Yes	18	24
No	57	76
Smoking		
Yes	5	7
No	70	93

Measures and Questionnaires

Sleep questionnaires. Several sleep measures were administered to obtain a greater understanding of the individual differences in participants' sleep behavior. Sleep measures assessed varied dimensions of sleep including but not limited to such constructs as sleep duration, sleep latency, daytime sleepiness, beliefs and attitudes about sleep, and subjective sleep quality. For an overview of all measures and questionnaires used in the present study, refer to Table 4.

Epworth Sleepiness Scale (ESS). The ESS is the gold standard for assessing daytime sleepiness. The ESS is a brief measure requiring respondents to rate their usual chance of dozing

in eight commonly experienced situations. Items are rated on a four-point rating scale with responses ranging from 0-3 (i.e., "Would never doze (0);" "Slight chance of dozing (1);" "Moderate chance of dozing (2);" and "High chance of dozing (3)." A total score is obtained by summing the responses for all eight items. The score range assists in identifying those individuals with an average amount of daytime sleepiness (scores <8) and those experiencing excessive daytime sleepiness (scores >9) whom may benefit from intervention. The ESS is used as both an initial assessment and progress monitoring tool for measuring changes in sleep over time or treatment course. Internal consistency coefficients (Cronbach's alpha) have been shown to fall within the range 0.88 - 0.74 in four different groups of subjects (Johns, 1991; Johns, 1992).

Pittsburgh Sleep Quality Index (PSQI). The PSQI is a 19-item self-report questionnaire measuring sleep quality, sleep habits, and related disturbances over a 1-month period. The first four items are free-response and require the participant to answer questions about their usual bedtime, time to fall asleep (sleep latency), rise time, and the amount of time asleep (sleep duration). Questions 5-18 assess problem frequency using a four-point rating scale (i.e., "Not during the past month (0);" "Less than once per week (1);" "Once or twice a week (2);" and "Three or more times a week (3)"); whereas question 19 measures overall subjective sleep quality using an alternative Likert Scale (i.e., "Very good (0)," "Fairly good (1)," "Fairly bad (2)," and "Very bad (3)."

These items are grouped into seven component scores specifically assessing subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Together, the component scores may be combined to obtain a global PSQI score with scores ranging from 0-21, which is used to

differentiate “poor” and “good” leep quality. Higher global scores indicate poorer sleep quality, with scores greater than five identifying “poor” sleepers. The PSQI has demonstrated good overall psychometric properties. Internal consistency is indicated to be relatively high with a Cronbach’s alpha coefficient of 0.83 for the seven component scores (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989).

Medical Outcome Study 12-Item Sleep Survey (MOS-Sleep). A brief measure consisting of 12 questions, the MOS Sleep retrospectively measures six unique dimensions of sleep behavior over the duration of an individual’s past four weeks. Specifically assessed are sleep behaviors including sleep initiation, sleep quantity, sleep maintenance, respiratory problems, perceived adequacy, and daytime sleepiness. The first item (“time to fall asleep”) is rated on a 5-point scale designating times in 15 minute intervals (i.e., 1 = 0-15 minutes; 2 = 16-30 minutes; 3 = 31-45 minutes; 4 = 46-60 minutes; 5 = >60 minutes) whereas the second item is free-response asking individuals to estimate the average number of hours he or she slept each night over the past four weeks. The remaining ten questions use a five-point rating scale (1 = All of the time; 6 = None of the time) to assess the frequency of specified sleep behaviors (Hays, Sherbourne, & Mazel, 1995).

Dysfunctional Beliefs about Sleep Questionnaire (DBAS). An individual’s beliefs and attitudes regarding sleep will be assessed with the DBAS. The DBAS is a measure used to assess sleep-related beliefs and attitudes thought to be mechanisms in maintaining sleep difficulties (Morin, Stone, Trinkle, Mercer, & Remsberg, 1993). Each participant is directed to use a ten-point Likert scale (0 = strongly disagree, 10 = strongly agree) or a visual analog scale (0-100 mm) to rate the extent to which the individual personally agrees or disagrees with each presented statement. A total score is obtained by taking the average of the summed ratings for all items

(item 23 is reversed scored). Similarly, subscale scores are calculated by taking the average of all items for a particular subscale. Higher ratings indicate more dysfunctional or distorted beliefs and attitudes about sleep.

Items were developed based on their clinical relevance and usefulness in therapeutic intervention, as well as, their contribution to several conceptual domains. These domains reflect five primary areas: 1) faulty causal misattributions, 2) diminished perceptions of control and predictability of sleep, 3) unrealistic sleep expectations, 4) amplification of the perceived consequences of insomnia, and 5) faulty beliefs about sleep-promoting practices (Morin et al., 1993). The DBAS has adequate internal consistency with a noted Cronbach's alpha ranging between .72 and .80 (Espie, Inglis, Harvey, & Tessier, 2000; Morin et al., 1993). Additional data support and validate the use of this instrument with a variety of sleep disordered populations including those individuals living with primary insomnia, major depressive disorder, and fibromyalgia (Carney, Edinger, Manber, Garson, & Segal, 2007; Theadom & Cropley, 2008).

An abbreviated version of the DBAS questionnaire (DBAS-16) was validated by Morin, Vallières, and Ivers (2007). This version, which retained16 of the original 30 items, was created to reduce participant burden and to encourage the use of the measure within the sleep community. Items retained for the DBAS-16 were noted to be able to discriminate between sleepers with- and without insomnia, in addition to being particularly sensitive to psychotherapeutic change (Espie et al., 2000). Administration, scoring, and interpretation are the same as the original 30-item measure. Of note, however, the abbreviated version captures only four main themes (as opposed to the five noted in the original). These themes include Consequences of insomnia; Worry about sleep; Sleep expectations; and Medication use (Morin et al., 2007).

Insomnia Severity Index (ISI). The ISI, comprised of seven-items, assesses current (within the past two weeks) problems with several aspects of sleep including 1) severity of sleep onset, maintenance, and early morning waking problems, 2) satisfaction with current sleep pattern, 3) interference/consequences with daily functioning, 4) noticeability of impairment attributed to the sleep problem, and 5) overall level of distress caused by the sleep problem (Bastien, Vallières, & Morin, 2001). Each question is rated on a five-point rating scale (0= not at all, 4 = extremely) reflecting the content of the question (i.e., "not at all worried"; "extremely worried"). Total scores are obtained by summing all item ratings, and the score range is from 0-28. Higher scores indicate more severe symptoms of clinical insomnia. Suggested guidelines for interpretation provide several cutoff ranges: 0-7 = no clinically significant insomnia; 8-14 = subthreshold insomnia; 15-21 = clinical insomnia of moderate severity; 21-28 = severe clinical insomnia (Smith & Wegener, 2003). Moreover, a cutoff score of 14 distinguished individuals diagnosed with primary insomnia (as established per clinical interview, polysomnography, and objective measures) and those without disordered sleep in a young adult population (Smith & Trinder, 2001). Additionally, this measure is noted to have good internal consistency as indicated by Cronbach's alpha statistics between 0.74 and .078 (Bastien, Vallières, & Morin, 2001; Smith & Wegener, 2003).

Personality and state/trait affect measures. The sleep literature consistently cites individual differences in personality constructs and state/trait affect as having a significant role in sleep behavior. Participants were administered brief measures of personality and affect to assess individual differences. Specifically, negatively perceived constructs such as neuroticism, threat sensitivity, and unpleasant emotionality (i.e., sadness, depression, and anxiety) were emphasized.

Mini IPIP. The Mini-IPIP is a 20-item short form based on the 50-item International Personality Item Pool (IPIP), which was developed based on the Big Five trait factor model. For this self-administered measure, respondents are instructed to read 20 phrases describing people's behavior. Next, respondents rate themselves using 7-point Likert scale with varying degrees of agreement ranging from 1-*Disagree Strongly*, to 7- *Agree Strongly*. The scale, consisting of four items, was developed for circumstances in which lengthier personality measures may not be feasible. Nevertheless, the Mini-IPIP has been shown to be a valid and reliable measure of the Big Five factors of personality (neuroticism, extraversion, intellect/imagination, agreeableness, and conscientiousness) with notable internal consistency alphas at or > .60 (Donnellan, Oswald, Baird, & Lucas, 2006). Studies exploring the psychometric properties of the Mini-IPIP corroborate previous findings supporting a five-factor structure based on exploratory and confirmatory factor analyses in large nationally representative samples, albeit with some models demonstrating poor to moderate fit (Baldasaro et al., 2012;Cooper, Smillie, & Corr, 2010).

BIS/BAS Scales. The Behavioral Inhibition Scale (BIS) and Behavioral Activation Scale (BAS) is a 20-item measure developed by Carver and White (1994) behaviorally conceptualizes the neurophysiological nature of the reinforcement sensitivity theory. The BIS/BAS scales are believed to represent two orthogonal motivational systems underlying behavior. The BIS scale has seven items believed to measure aversive motives such as sensitivity to withdrawal behavior and expectations of punishment. The BAS scales, with a total of 13 items, are believed to measure behaviors that regulate appetitive motives including anticipation of reward, motivation toward desired goals, and desire to approach novel situations with the expectation of reward. Participants respond to each item using a 4-point Likert scale, with a score of 1 indicating *Strongly Agree* to a score of 4 indicating *Strongly Disagree* (Carver & White, 1994; Peterson,

Gable, & Harmon-Jones, 2008). Higher scores on each scale reflect the extent to which each motivational system influences behavior. For instance, a person may score high on BAS and low on BAS, which suggests the individual is likely to have motivation towards achieving positive consequences with little concern/avoidance of failure or negative consequences. Another example suggests the possibility of scoring high on both BAS and BIS dimensions, indicating a high motivation toward success with fear of failure. Carver and White's (1994) research has shown reliabilities for the varying scales ranging from 0.66 to 0.76. Further psychometric evaluation of the scales has shown efficacy within clinical populations (e.g., anxiety and depression), suggesting strong relationships of BIS to both anxiety and depression (Campbell-Sills, Liverant, & Brown, 2004).

Positive and Negative Affect Scales (PANAS). The PANAS is a self-rated objective measure developed for assessing the two primary dimensions of mood: positive and negative affect. The measure consists of 20 words that describe different feelings and emotions. The respondent rates their mood using a four-point rating scale (1 = very slightly or not at all; 4 = quite a bit) to indicate to extent he or she may have experienced the emotion/feeling over a designated time (moment, today, past few days, week, past few weeks, year, or in general). Scoring the PANAS is relatively simple and requires summing the 10 ratings for each subscale (i.e., Positive or Negative Affect). Scores can range from 10-50 per subscale, with higher scores representing higher levels of positive/negative affect. The scale exhibits good psychometrics with each 10-item scale demonstrating good internal consistency and excellent convergent and discriminant correlations. The scale has also demonstrated stability over a two-month period (Watson, Clark, & Tellegen, 1988).

The Patient Health Questionnaire – 4 (PHQ-4). Symptoms of depression and anxiety

were measured using the PHQ-4 (Kroenke, Spitzer, Williams, & Löwe, 2009). This measure is a brief four-item questionnaire comprised of the first two items of both the Generalized Anxiety Disorder-7 scale (GAD-7) and the Patient Health Questionnaire – 9 (PHQ-9), respectively. The PHQ-4 quantifies the amount of time a respondent has been bothered by 1) feeling nervous, anxious, or on edge, 2) not being able to stop or control worrying, 3) little interest or pleasure in doing things, and 4) feeling down, depressed, or hopeless. Each question is rated using the original 4-point Likert scale (0 = not at all; 1 = several days, 2 = more than half the days; 3 = nearly every day), and reflects difficulties spanning a two-week period. Total scores (ranging from 0-12) are obtained by summing the ratings of all four items, with a higher score reflecting more psychological distress and warranting further investigation (in clinical settings). Moreover, total scores can be categorized into one of four interpretive categories: None (0-2), Mild (3-5), Moderate (6-8), and Severe (9-12). Further evaluation of PHQ-4 scores involves examining the anxiety and depression subscales (2 items each) independently, with scores of 3 or greater on a single subscale considered a "positive" screen (Kroenke, Spitzer, Williams, & Löwe, 2009). Demographically associated normative data (N = 5030) for the PHQ-4 (and each subscale) can be obtained from Löwe et al., 2010. Psychometric properties have been examined in the genral population (Löwe et al., 2010) and primary care setting (Kroenke, Spitzer, Williams, & Löwe, 2009).

Questionnaires regarding health and well-being. Sleep is intimately connected to physical and mental health. In the present study, two commonly used questionnaires were administered to obtain a greater understanding of participants' physical health status and psychological well-being.

12-Item Short-Form Health Survey (SF-12). The SF-12 is a brief self-administered

quality-of-life measure used as developed for Medical Outcomes Study (MOS), which is a multi-year study of chronically ill patients (Hays, Sherbourne, & Mazel, 1995). Specifically, the SF-12 was developed to reduce subject burden for large longitudinal studies of health outcomes, yet retain the reliability and validity of its lengthier predecessor, the SF-36. Scoring of the SF-12 results in Physical and Mental health Composite Scale scores (PCS and MCS), in addition to eight subscales scores representing various areas of well-being. These domains include physical functioning, role limitations due to physical health problems, bodily pain, general health, energy/fatigue, social functioning, mental health concerns, and role limitations due to emotional problems. Each scale is transformed into a 0-100 scale, with lower scores representing more disability. Although the SF-12 demonstrated somewhat lower internal consistency as compared to the SF-36, the composite scale scores were statistically equivalent allowing for comparable interpretation (Ware, Kosinski, & Keller, 1996). It has also been established as a valid and reliable instrument among independently living older adults (Resnick & Nahm, 2001) and in chronically ill populations (Gandhi et al., 2001; Lim & Fisher, 1999; Delate & Coons, 2000).

Subjective Happiness Questionnaire (SHQ). Lyubomirsky and Lepper (1999) developed the SHQ as a brief self-report measure of global subjective happiness. The measure has four items assessing the global psychological phenomena associated with overall wellbeing which considers happiness from the respondent's perspective. Each item is rated on a 7-point rating scales specific to each question. The first question concerns the respondents' subjective rating of themselves as a "happy person," while the second question implicates comparing themselves to peers. The third and fourth questions provide a brief situational description and ask the respondent to what extent the characterization describes them. Total scores range from 4-28, with higher scores reflecting greater happiness and psychological well-being. Psychometrically,

the SHQ exhibits sound internal consistency with Cronbach alphas ranging from 0.79 to 0.94 (*M* = 0.86). The SHQ also demonstrated good construct validity as evidenced by moderate to high correlations with other published measures of subjective happiness and low correlations with theoretically unrelated measures (Lyubomirsky & Lepper, 1999).

Table 4: Measures used in the study with their scale ranges

Measure	Items	Construct(s) Measured	Scale Range
1. Demographic Survey	-	Subjective biographical information	Not Applicable
2. ESS	8	Daytime sleepiness	0-24, Higher scores suggest excessive daytime sleepiness
3. PSQI	19	Quality and patterns of sleep	0-21, Higher scores indicate poorer sleep
4. MOS Sleep	12	Sleep Initiation; quantity; maintenance; respiratory problems; perceived adequacy; somnolence	12-71, Higher scores indicate self-reported sleep disturbance
5. DBAS	30	Beliefs and attitudes about sleep and sleep practices	1-10, Higher scores suggest more dysfunctional beliefs regarding sleep
6. ISI	7	Severity of sleep initiation, maintenance, and awakening; sleep satisfaction; daily consequences; attributed impairment to sleep; concern for sleep	0-28, Higher scores suggest manifestation of clinical insomnia
7. BIS/BAS	20	Behavioral sensitivity to threat (BIS) or reward (BAS)	Higher scores indicate more sensitivity on respective subscale
8. Mini-IPIP	20	Big 5 personality factors	0-16 (per subscale), Scores represent high or low presence of a trait
9. PANAS	20	Positive and negative affect	10-50 (per subscale), Higher scores in each domain suggest higher levels of state affectivity
10. PHQ-4	4	Psychological Distress	0-12, Higher scores reflect more psychological distress associated with symptoms of depression and anxiety
11. SF-12	12	Physical and mental health	0-100. Lower scores reflect more disability
12. SHQ	4	Psychological Well-being	4-28, Higher scores suggest higher perceived psychological happiness and overall well-being

Experimental Visual Stimuli

Experimental stimuli were evaluated as part of an online pilot study investigating the valence, arousal, and dominance associated with sleep-related images. For the pilot study (N = 163), each participant gave informed consent to the protocol, which was approved by the East Carolina University Institutional Review Board (UMCIRB; Appendix A & I). The 375 experimental images represented two affective categories (positive/high pleasure and negative/low pleasure) and were matched for arousal (Bradley & Lang, 1994; Lang, Bradley, & Cuthbert, 2008). Images selected for the task represented a variety of sleep-related phenomena including but not limited to images depicting persons snoring, living with insomnia, displaying fatigue during daily activities, using electronics in the bed, and feeling refreshed or energized. Other images solely included sleep-related objects—well-made beds, disheveled beds, sleep masks, and sleep medications among other items. Participants were instructed to rate each item using a visual analog scale known as the Self-Assessment Manikin (SAM), which is a tool that assesses three dimensions of emotion –valence, arousal, and dominance (Bradley & Lang, 1994; Lang, Bradley, & Cuthbert, 2008). Means and standard deviations for valence, arousal, and dominance are available for each image in Appendix F. The rationale for selecting and piloting sleep-related images for use in the present study over already existing sets of visual stimuli (e.g., International Affective Picture System; IAPS), was to adhere to the fundamental elements of several theories underlying the development and maintenance of sleep disturbances, namely models predominantly emphasizing the role emotional and psychological components (e.g., hyperarousal, neurocognitive, and cognitive). Moreover, sleep-related images were specifically targeted due overrepresentation in the pre-sleep mentation of insomnia patients (Nelson & Harvey, 2003) and their reported ability to elicit more intense emotional and physical response

(Harvey, 2000).

Experimental stimuli were selected for the present study based primarily on participant ratings for the emotional domain of pleasure. First, during the previously noted pilot study, each image was rated on a 9-point Likert scale (1, completely unpleasant/unhappy; 10, completely pleasant/happy). Next descriptive statistics were employed to obtain means and standard deviations for each experimental stimulus. Lastly, each stimulus was sorted into one of two categories: unpleasant or pleasant categories. Sorting into the unpleasant category required the stimulus to have a mean value below 4.5, such that when the standard deviation was added to the mean, the value still remained below the value of 4.5. Sorting into the pleasant category required the stimulus ratings to remain above a value of 5.5 (even when the standard deviation was subtracted). Stimuli with ratings falling in the range of 4.5-5.5 were considered neutral and removed from the present study.

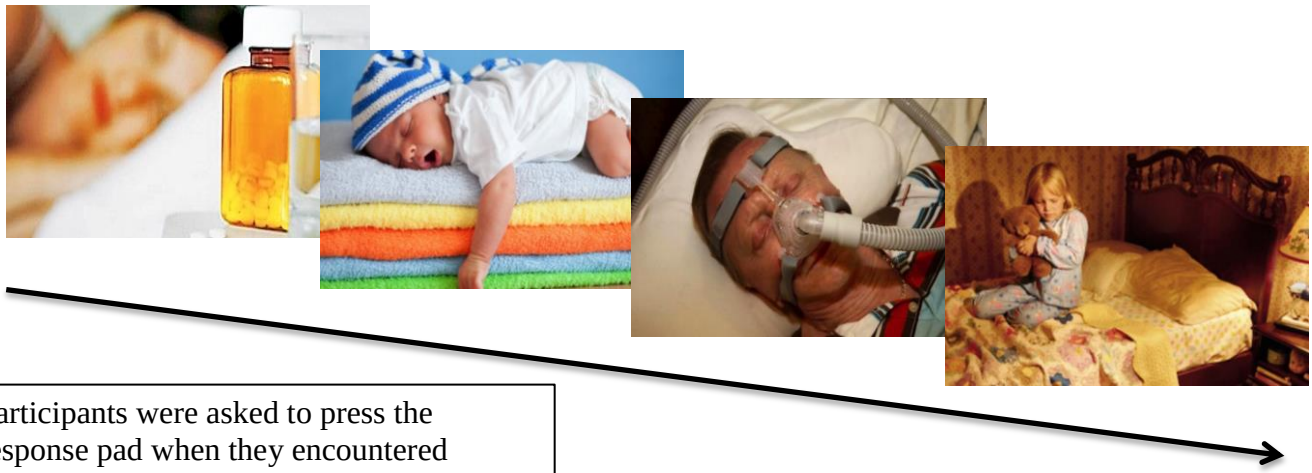
Affective Oddball Paradigm

The participants completed a visual affective oddball paradigm task. For the task, a series of sleep-related images (i.e., experimental stimuli) were presented over the course of four blocks, which was comprised of a practice phase (two blocks) and a test phase (two blocks). Each block began with a fixation cross presented in the middle of the screen for 700 ms, followed by the presentation of a sleep-related image (i.e., experimental stimuli previously described) presented for a pseudorandom selected interstimulus duration between 700-2000 ms. The practice phases (depicted in Figure 2) were to assess the participant's understanding of the task. During the practice phase, the participants were presented with ten practice items consisting of both positive and negative images. Participants were asked to press the response pad only when they saw the designated target stimuli (i.e., positive image if practice block preceded a test block with a

positive target). Participants repeated the practice block until he/she was able to identify all target images correctly. Following the practice phase, participants were informed that they would begin the testing phase and would be reminded of the task's objective and instructions. An instructional script was used to assure standardized directions (see Appendix H).

The testing phase consisted of two blocks. As per the general design of an oddball paradigm task, experimental stimuli consisted of frequent and oddball/rare stimuli. In this study, participants were exposed to two different conditions: positive standard/negative target (PS/NT) and negative standard/positive target (NS/PT). The presentation of these blocks was counterbalanced to address possible order effects. Testing blocks were created by pseudorandomly arranging positively valenced sleep-images or negatively rated sleep-images among a majority of oppositely valenced images. Each block was comprised approximately 150 images consisting of 125 standard and 25 target sleep-related images. For both testing blocks, participants were instructed to press a response pad as quickly possible every time they saw a target image for the duration of the block. They were instructed to do nothing for non-target (standard) images. Figure 3 and Figure 4 depict the general progression of the two test phase blocks.

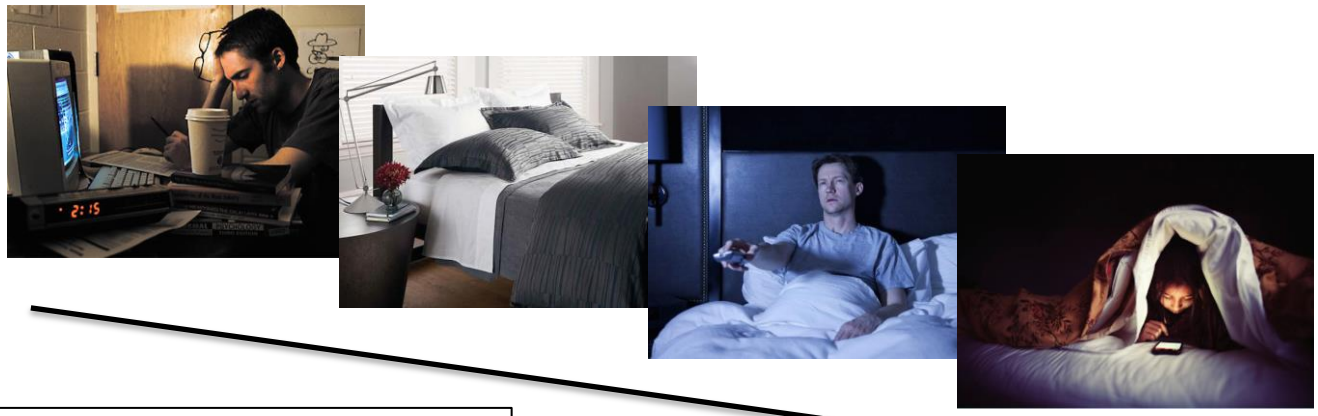
Practice Block: Positive Target



Participants were asked to press the response pad when they encountered positive sleep images. The practice blocks were used to orient participants to the task and assess their understanding of objectives.

Figure 2: Practice Phase: Negative Standard with Positive Target

Block One: Positive Target



Participants were asked to press the response pad when they encountered positive sleep images (rare stimuli) represented within a series of negative standard stimuli.

Figure 3: Test Phase: Block One, Negative Standard with Positive Target

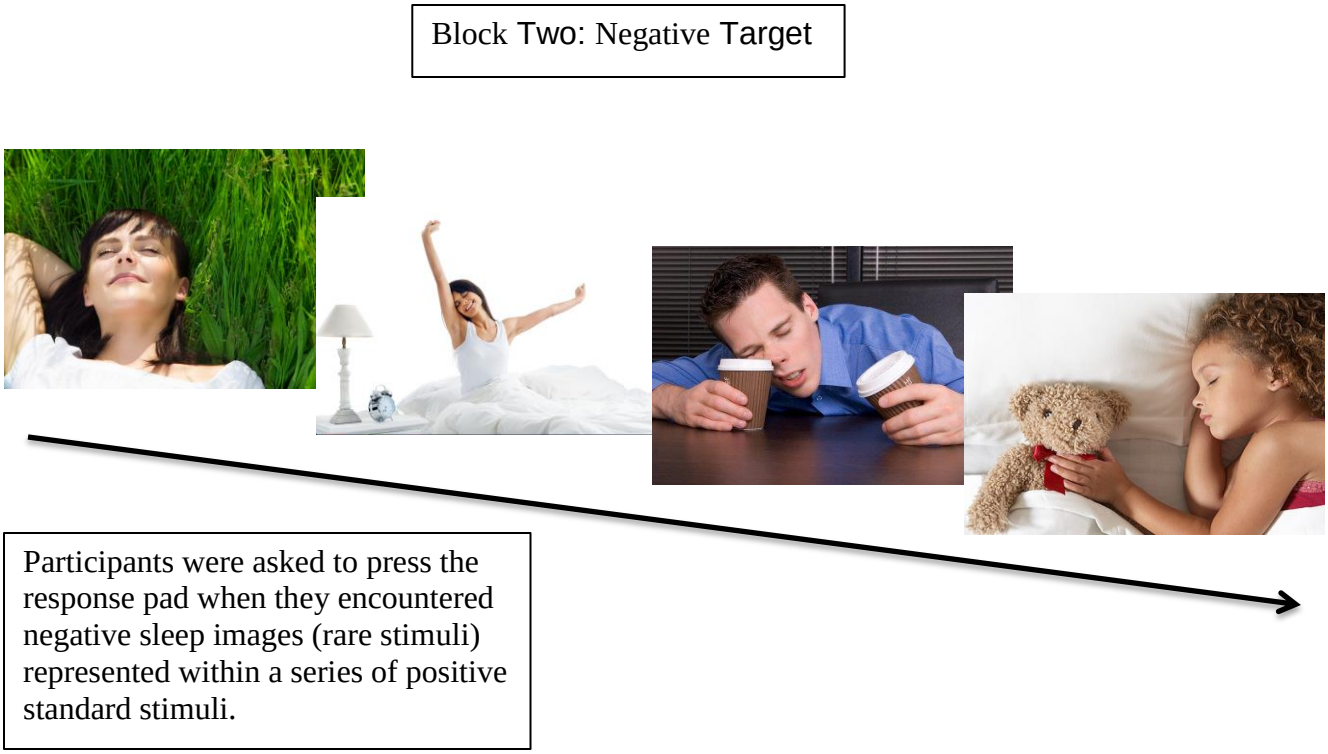


Figure 4: Test Phase: Block Two, Positive Standard with Negative Target

Experimental stimuli were selected for the present study based primarily on participant ratings for the emotional domain of pleasure. First, during the previously noted pilot study, each image was rated on a 9-point rating scale (1, completely unpleasant/unhappy; 10, completely pleasant/happy). Next descriptive statistics were employed to obtain means and standard deviations for each experimental stimulus. Lastly, each stimulus was sorted into one of two categories: unpleasant or pleasant categories

Electroencephalogram (EEG) Recording

EEG recording of cortical electrical activity was captured using Ag/AgCl - sintered electrodes mounted in an elastic Quik-Cap (Compumedics Neuroscan; Herndon, VA) at 32 scalp sites using the international 10/20 placement system. Sites captured included frontal, temporal, central, parietal, and occipital scalp regions. Additionally, ground references linked to the ears were utilized. For the current study, frontal asymmetry data were collected from comfortably

seated participants during eight one-minute eyes open and eyes closed phases. During these phases, participants were asked to relax, sit still facing forward, and limit their movement. They were instructed to either keep their eyes open or closed during these one-minute durations in order to achieve a baseline cortical measure. Phases alternated as follows: eyes open (EO1), eyes closed (EC1), eyes open (EO2), eyes closed (EC2), eyes open (EO3), eyes closed (EC 3), eyes open (EO4), and eyes closed (EC4). This method for obtaining baseline asymmetry is well established in EEG literature (Harmon-Jones & Allen, 1998).

EEG recording was maintained through the duration of the affective oddball paradigm to obtain ERP data in response to the experimental stimuli. Given the current state of the sleep literature, specific interest was placed on the N100, P200, and P300 recordings from standard electrode lead sites Fz, Cz, and Pz referenced to A1 and A2 ear lobes. Recordings were performed using Compumedics Neuroscan 4.4 software. Epochs of 1000ms were recorded using a sampling rate of 2048 Hz on a bandwidth of .01-100 Hz. Eye movement artifact was removed with a rejection level of ±100 μV. Artifact reduction was completed before all averaging which was performed on four bins reflecting the four categories of experimental stimuli—positive target, negative target, positive standard, and negative standard. The P300 was selected as the most positive peak occurring approximately between 250ms and 400ms after stimulus onset. Additional ERPs were captured for investigational purposes. These ERPs and their approximate ranges are the N100 (80-200ms), P200 (150-200ms), N200 (200-300ms), and late positive potential (LPP; 400-800ms). Grand averages for all stimuli conditions were created and are available in Figures 5 – 7.

Figure 5. ERP grand averages of responses to negative target, positive target, negative standard, and positive standard stimuli at Electrode Fz

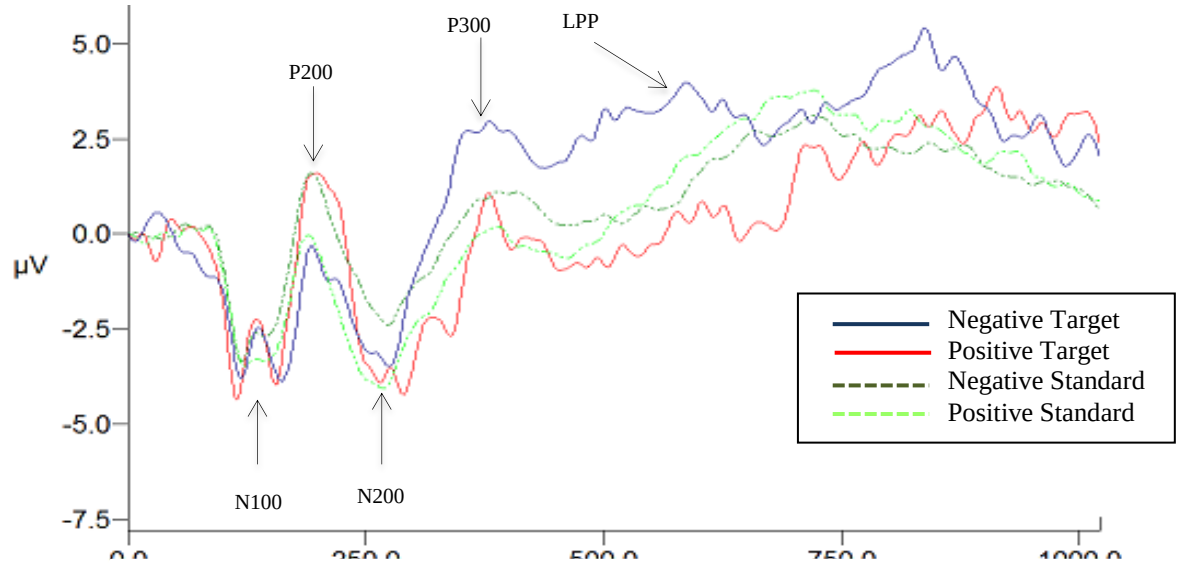


Figure 6. ERP grand averages of responses to negative target, positive target, negative standard, and positive standard stimuli at Electrode Cz

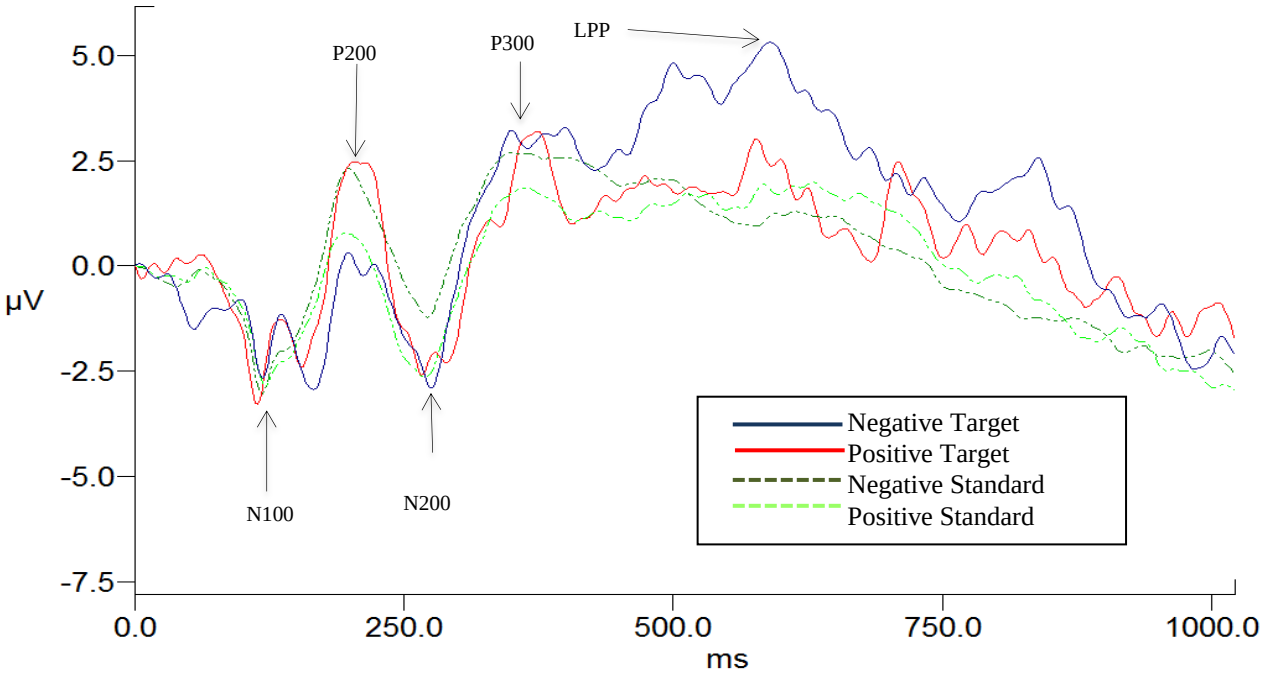
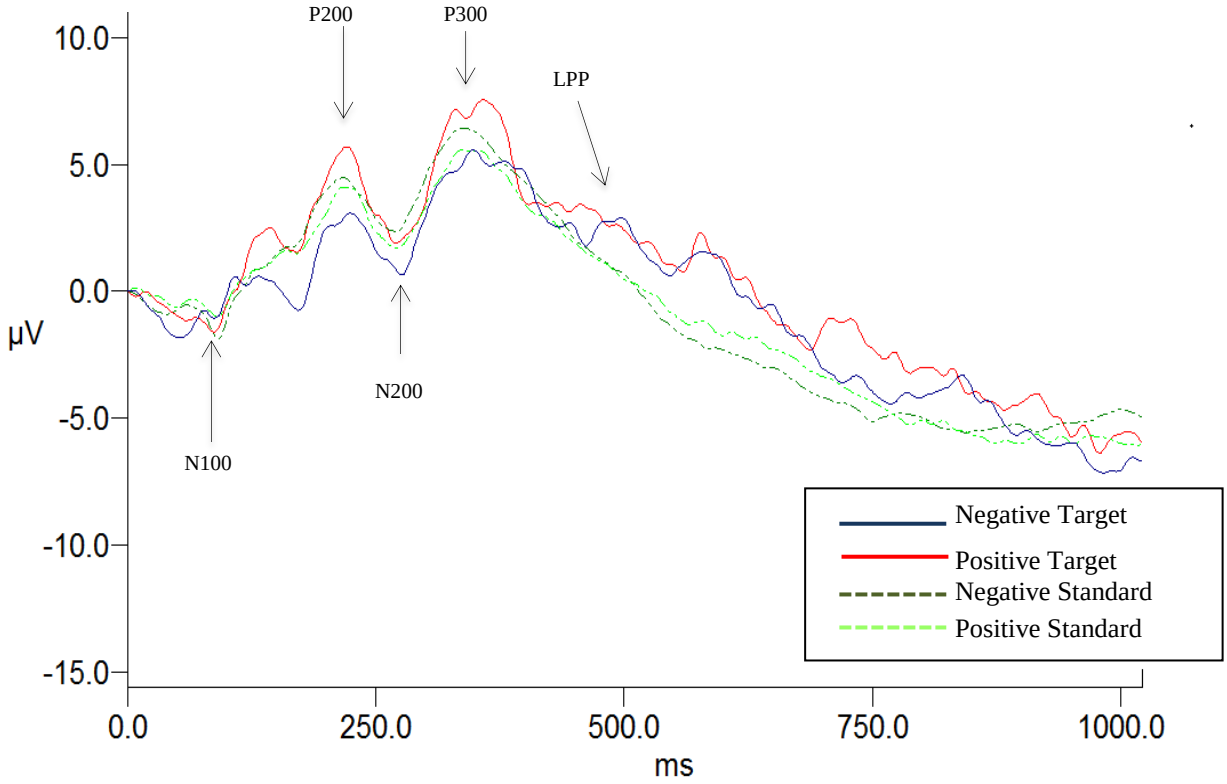


Figure 7. ERP grand averages of responses to negative target, positive target, negative standard, and positive standard stimuli at Electrode Pz



Assessment of Sustained Attention via the Psychomotor Vigilance Test (PVT)

The PVT is a visual task of sustained attention and reaction time measuring a participant's speed and accuracy in responding to a visual stimulus. It is considered the gold standard for measuring behavioral alertness and attention as it provides an objective and numeric measurement for daytime sleepiness and other neurocognitive difficulties resulting from disturbed or impaired sleep. Research has demonstrated that persons with reported poor sleep quality and sleep deprivation perform much worse on this task than good sleepers; specifically, poor sleepers exhibited a general overall slowing of reaction time and increased omission/commission errors on the task performance (Lim & Dinges, 2008). As such, each participant engaged in a brief psychomotor vigilance task (PVT) lasting about five minutes. The task was presented on a palm pilot device pre-loaded with the PVT software. Before starting the

task, participants were instructed to press and release a designated button with their preferred hand as soon as the target stimulus displayed on the screen. Because the PVT does not display appreciable practice effects, this brief test is likely one of the best estimates of sustained selective attention performance. A script was developed to ensure standardization of instructions (see Appendix G).

Procedures

Participants were students enrolled in East Carolina University's undergraduate studies. All study procedures took place in the Cognitive Neuroscience Laboratory located within the Department of Psychology (see Figure 8 for a visual overview of the study design). Before engaging in the study, each participant independently read and reviewed an informed consent document approved by the University and Medical Center Institutional Review Board of East Carolina University. The document was also reviewed with the participant to clarify any questions regarding the study design, procedures, and other frequently asked questions. Once consent was established and the documents signed, each participant was administered a battery of self-report measures utilizing the Qualtrics online survey and data collection software. Data collection included a brief demographic record form and a series of measures for general health, sleep, personality, and behavioral functioning. The demographic form addressed such areas as age, handedness, brief physical and mental health history, and lifestyle behaviors (smoking and exercise frequencies). Sleep, personality, and behavioral surveys noted in the section above addressed their respective domains.

Next, participants completed the PVT before being prepped for the EEG recording. EEG preparation involved connecting each participant to the Neuroscan EEG system with the elastic Quick-Cap and a conductive gel. Once connected, initial task instructions were provided to allow

for a brief period to acclimate to the wearing of the EEG cap. The EEG baseline recording and participation in the practice and test phase blocks of the visual oddball task followed. Finally, after the completion of the surveys and tasks accompanying the EEG recording, participants were debriefed. Any questions posed by the participant were addressed and clarified.

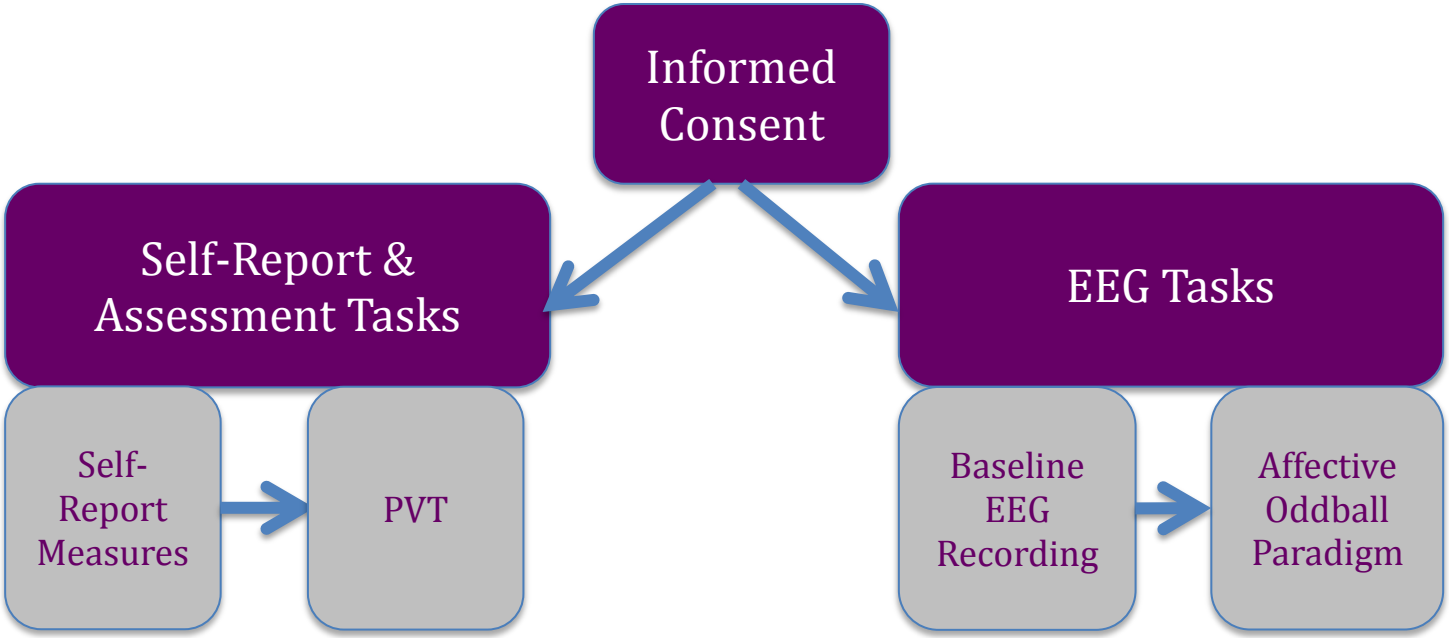


Figure 8. Visual schematic of the study procedures.

CHAPTER IV: RESULTS

Statistical analyses were conducted using SAS JMP 10.0 statistical software package (SAS Institute Inc.; Cary, NC). Raw data were inspected for missing data and normality. As a result, each hypothesis will indicate sample size relevant to the variables being analyzed accounting for missing data.

Hypothesis one: Relationships among self-reported measures of personality, affect, and subjective sleep quality

Correlational analyses were performed to determine relationships among self-reported measures of personality, affect, behavior, and sleep quality. Analyses only included those measures of negatively perceived personality traits and affect given their suspected role in models of disordered sleep. Basic descriptive statistics and zero-order correlation coefficients are presented in Table 5. Personality and behavior were represented by selected subscales obtained from the Mini IPIP and BIS/BAS scales, whereas the PANAS was primarily used to represent negative affect. All participants fully completed the self-report measures resulting in no missing data for these analyses.

As expected, self-reported sleep quality (M = 6.95, SD = 2.80) was significantly and positively correlated with Neuroticism (M = 14.92, SD = 4.66), r = .44, n = 75, p < .0001, 95%

Table 5. Zero-Order Correlations and Descriptive Statistics for Overall Sample (N = 75)

	PANAS-N	Agreeableness	Neuroticism	BIS	PSQI
Agreeableness	-.02				
Neuroticism	.53****	.07			
BIS	-.45****	-.28**	-.63****		
PSQI	.25*	.24*	.44****	-.34**	
M	14.40	22.59	14.92	14.36	6.95
SD	5.54	3.87	4.66	3.77	2.80

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: PANAS-N = PANAS Negative Total; BIS = Behavioral Inhibition Scale; PSQI = Total score of the Pittsburgh Sleep Quality Index

CI [0.241, 0.609], Agreeableness (*M* = 22.59, *SD* = 3.87), *r* = .24, *n* = 75, *p* =.04, 95% CI [0.014, 0.443], and Negative Affect (PANAS-N; *M* = 14.40, *SD* = 5.54),), *r* = .25, *n* = 75, *p* =.03, 95% CI [0.029, 0.455]. These findings suggest that people endorsing poorer sleep quality were likely characterized with increased levels of neuroticism and negative affect (e.g., negative affect/emotions, poor response to stressors, emotionally reactive). The facet of agreeableness, which is often characterized by being empathic toward others, compromising, and cooperative, was also significantly and positively correlated with self-reported sleep quality. Perhaps a function of an agreeable person's sensitivity to social harmony, people with higher levels of agreeableness may be willing to compromise their sleep quality to appease the requests of others, especially within a college environment.

Meanwhile, self-reported sleep quality was significantly and negatively correlated with behavioral inhibition (*M* = 14.36, *SD* = 3.77), *r* = -.34, *n* = 75, *p* =.003, 95% CI [-0.529, -0.126]. BIS was also significantly negatively correlated with Neuroticism *r* = -.63, *n* = 75, *p* <.0001, 95% CI [-0.750, -0.470], Agreeableness, *r* = -.28, *n* = 75, *p* =.013, 95% CI [-0.480, -0.061], and Negative Affect (*M* = 14.40, *SD* = 5.54), *r* = -.45, *n* = 75, *p* <.0001, 95% CI [-0.613, -0.247]. While it was anticipated that BIS would be correlated with self-reported poor sleep quality, the present finding was somewhat unexpected due to the modest significant negative correlation. The literature regarding the Reinforcement Sensitivity Theory and its inherent neurophysiological systems (Behavioral Inhibition System and Behavioral Activation System) suggests higher levels of BIS are associated with negative affect, sensitivity to punishment, and withdrawal behavior. These associated characteristics were hypothesized to be related to disrupted sleep and overall poor sleep quality. As such, it was anticipated that BIS would also demonstrate significant positive relationships with measures of negative affect, neuroticism, and

agreeableness.

Predicting subjective sleep quality. A multiple regression analysis was conducted to determine whether the aforementioned negative personality traits and measures of affect could predict sleep quality. Two variables were transformed before statistical analysis to reduce skewness. These included PANAS Negative Affect (inverse) and Agreeableness (square root). The full model was statistically significantly, $F(4, 70) = 5.71$, $p = .0005$, and accounted for 25% of the variance. The results indicated that neuroticism was the only predictor of subjective sleep quality with a significant partial effect. Agreeableness, negative affect (PANAS-N), and behavioral inhibition (BIS) did not have significant partial effects. Neuroticism was associated with an increase in self-reported poor subjective sleep quality ($\beta = .43$, $p = .005$).

Additional regression analyses, employing sequential multiple regression with backward selection, were used to explore simpler models for a better fit, given the investigational nature of the current study. Table 6 shows results for all regression models for predicting subjective sleep quality. The second model excludes one variable (BIS) from the first model. This model was statistically significant, $F(3, 71) = 7.71$, $p = .0002$, and accounted for 25% of the variance. Neuroticism remained a significant predictor ($\beta = .44$, $p = .001$); however, for this model, Agreeableness was also a statistically significant predictor. When controlling for other predictors, as agreeableness increased, self-reported poor sleep quality decreased ($\beta = -.22$, $p = .04$).

The third model demonstrated the best fit. This best fit model, removing PANAS-N as a predictor variable, was statistically significant, $F(2, 72) = 11.69$, $p < .0001$, and continued to account for 25% of the variance. As indicated in previous regression models, Neuroticism was associated with an increase in self-reported poor subjective sleep quality ($\beta = .42$, $p = .0005$) and

agreeableness decreased with an increase in poor subjective sleep quality (β = -.22, p = .04). Moreover, Mallow's Cp test value drops from one model iteration to the next with the most favorable statistic obtained with the third regression model (Cp = 1.07).

Table 6. Regression analysis for predicting subjective sleep quality (standardized regression coefficients; N = 75)

Variables	Models					
	1		2		3	
	β	VIF	β	VIF	β	VIF
Neuroticism	.43**	2.05	.44**	1.58	.42***	1.01
Agreeableness	-.21	1.19	-.22*	1.03	-.22*	1.01
PANAS-N	.04	1.63	.03	1.56	--	--
BIS	-.02	1.96	--	--	--	--
Mallow's Cp	--		3.01		1.07	
R^2	.25		.25		.25	
Adjusted R^2	.20		.21		.22	
F	5.71***		7.71***		11.69****	

*p <.05, **p <.01, ***p <.001, ****p <.0001

Exploratory multiple regression analyses investigating the influence of anxiety and depressive symptoms. Correlational analyses were conducted to determine relationships among previously analyzed predictors with the inclusion of predictor variables representing self-reported symptoms of depression (PHQ-2) and anxiety (GAD-2).Table 7 summarizes the means, standard deviations, and zero-order correlations which highlight statistically significant relationships PHQ-2 and GAD-2 all other variables, excluding agreeableness.

Table 7. Correlations and Descriptive Statistics for PHQ-2 and GAD-2 (N = 75)

	PHQ-2	GAD-2
GAD-2	.41***	
PANAS – N	.34**	.40***
Agreeableness	-.06	.09
Neuroticism	.40***	.59****
BIS	-.27*	-.50****
PSQI	.44****	.37**
M	1.67	.95
SD	1.49	1.26

*p <.05, **p <.01, ***p <.001, ****p <.0001
Note: PHQ-2 = Patient Health Questionnaire – two item; GAD-2 = Generalized Anxiety Disorder – 2 item.

Sequential multiple regressions with backward selection were employed to analyze these relationships further and to investigate the contribution of anxiety and depressive symptomology to subjective sleep quality. Table 8 shows the results for all regression models predicting subjective sleep quality. Of most interest was the final regression model (model 4) which indicates an overall model of three predictors (*Neuroticism, Agreeableness, and PHQ-2*) that significantly predict subjective sleep quality [R^2 = .32, R^2_{adj} = .29, $F(3, 71) = 11.09$, $p < .0001$]. This model accounted for 32% of the variance in subjective sleep quality. These findings suggest depressive symptoms, as measured by the PHQ-2 (i.e., the experience of depressed mood and loss of interest in previously enjoyed activities) significantly contributes to sleep quality.

Table 8. Regression analysis for predicting subjective sleep quality (standardized regression coefficients; $N = 75$)

Variables	Models							
	1		2		3		4	
	β	VIF	β	VIF	β	VIF	β	VIF
Neuroticism	.29	2.34	.29*	1.99	.29	1.59	.29**	1.22
Agreeableness	-.20	1.19	-.20*	1.04	-.21*	1.02	-.21*	1.01
PHQ-2	.30**	1.26	.30**	1.26	.29**	1.23	.30**	1.23
GAD-2	.12	1.56	.12	1.48	.11	1.46	--	--
PANAS-N	.10	1.68	.10	1.62	--	--	--	--
BIS	.005	2.07	--	--	--	--	--	--
Mallow's Cp	--		5.00		3.64		2.41	
R^2	.33		.33		.33		.32	
Adjusted R^2	.27		.28		.29		.29	
F	5.65****		6.88****		8.48****		11.09****	

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$, $^{****}p < .0001$

Hypothesis Two: Examination of self-reported sleep quality within RST framework

Complete data were available for 48 participants. Data for 27 participants were excluded for correlational analyses due to baseline asymmetry artifact which resulted from excessive eye and body movement. Additional artifact resulted from obtaining frequencies beyond the determined frequency range (i.e., limited frequency range) or discrete frequencies. Results for evaluation of assumptions of normality indicated a positively skewed leptokurtic distribution of resting frontal asymmetry activity, which was corrected with natural logarithmic transformations.

Asymmetry scores were calculated for overall alpha power (8-12 Hz) by subtracting left alpha power scores from right alpha power scores at electrode pairs (e.g., ln[alpha power at F4 electrode] – ln[alpha power at F3 electrode, creating the F4-F3 asymmetry score). The inverse of this asymmetry score is thought to represent increased brain activity. Negative scores suggest greater relative right hemisphere EEG activity and positive scores suggests greater relative left activity (Davidson, 1988). Frontal asymmetry data were collected from comfortably-seated

participants during eight one-minute eyes open and eyes closed phases. During these phases, participants were asked to relax and sit still facing forward. As the phase name suggests, eyes were either open or closed during these one-minute durations. These phases alternated as follows: eyes open (EO1), eyes closed (EC1), eyes open (EO2), eyes closed (EC2), eyes open (EO3), eyes closed (EC 3), eyes open (EO4), and eyes closed (EC4).

BIS/BAS and sleep measure inter-correlations. Directional correlation analyses were performed to determine relationships among subscales of the BIS/BAS scales and measures of sleep. Table 9 provides basic descriptive statistics and zero-order correlation coefficients between the BIS/BAS subscales, ISI, and PSQI. Inter-correlations among the various subscales of the BIS/BAS scales showed that BAS-Total (M = 22.04, SD = 4.44) was significantly positively correlated with BAS-RR (M = 6.38, SD = 1.65), r = .68, n = 48, p <.0001, 95% CI [0.494, 0.810], BAS-D (M = 8.21, SD = 2.29), r = .83, n = 48, p <.0001, 95% CI [0.713, 0.901], and BAS-FS (M = 7.46, SD = 2.04), r = .70, n = 48, p <.0001, 95% CI [0.512, 0.818]. Of the tripartite division of the behavioral activation system, the BAS-D subscale was significantly and positively correlated with BAS-RR, r = .44, n = 48, p = .0002, 95% CI [0.181, 0.645] and BAS-FS, r = .33, n = 48, p = .02, 95% CI [0.045, 0.558]. These relationships were expected given the BAS-Total scale is derived from the simple sum of the three BAS subscales and are believed to contribute to the conceptualization of the neurophysiological behavioral activation system. Contrastingly, the BIS scale was hypothesized to be significantly and negatively correlated with all aspects of BAS, as the behavioral inhibition, and behavioral activation systems are conceptualized to measure opposed aspects of behavior and affect. However, BIS (M = 14.33, SD = 3.65) only demonstrated a single significant positive relationship with the BAS-RR subscale, r = .30, n = 48, p = .04, 95% CI [0.015, 0.536].

When considering relationships among the BIS/BAS scales and measures of sleep, BIS was the only component within the Reinforcement Sensitivity Theory (RST) framework that showed any significant relationship with sleep. BIS was significantly and negatively correlated with self-reported sleep quality (PSQI; M = 7.33, SD = 2.72), r = -.33, n = 48, p = .02, 95% CI [-0.561, -0.050], and self-reported symptoms of insomnia (ISI; M = 8.00, SD = 5.13), r = -.53, n = 48, p = .0001, 95% CI [-0.705, -0.284]. These findings were unexpected given the current state of the sleep literature. Negative affect/mood, sensitivity to punishment, and avoidance/withdrawal behavior (all characteristics conceptualized to be associated with behavioral inhibition) have been shown to be associated with disordered sleep. As such, while a significant relationship was expected, the direction of the relationship between BIS and these measures of sleep was hypothesized to be positive—higher levels of BIS would beget higher self-reported levels of poor sleep and/or sleep disturbance.

Table 9. Zero-Order Correlations and Simple Descriptive Statistics for measures of BIS/BAS and Sleep (N = 48)

	Zero-Order Correlations						
	BIS	BAS-RR	BAS-D	BAS-FS	BAS-Total	ISI	PSQI
BAS-RR	.30*						
BAS-D	.22	.44**					
BAS-FS	.10	.18	.33*				
BAS-Tot	.27	.68****	.83****	.70****			
ISI	-.53***	-.02	-.01	.15	.06		
PSQI	-.33*	-.11	.08	.09	.05	.69****	
M	14.33	6.38	8.21	7.46	22.04	8.00	7.33
SD	3.65	1.65	2.29	2.04	4.44	5.13	2.72

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: BIS = Behavioral Inhibition System; BAS-RR = Behavioral Activation System-Reward Responsiveness Subscale; BAS-D = Behavioral Activation System-Drive Subscale; BAS-FS = Behavioral Activation System-Fun Seeking Subscale; BAS-Total = Behavioral Activation Total Scale; ISI = Insomnia Severity Index, PSQI = Pittsburg Sleep Quality Index Total Score.

BIS/BAS, sleep, and resting asymmetry. Table 10 provides basic descriptive statistics and zero-order correlation coefficients for alpha asymmetry scores, BIS/BAS subscales, and self-report measures of sleep with respect to overall baseline alpha asymmetry. With regard to overall baseline alpha asymmetry, which is the average across all eyes closed and eyes opened conditions, there were no significant relationships between overall baseline alpha asymmetry and self-reported measures of sleep quality (PSQI) or disordered sleep (ISI). Rather, significant positive relationships were found with the BAS-RR, BAS-D, and BAS-Total scales. BAS-RR was significantly positively correlated with the majority of electrode site pairs including FP2-FP1 (M = .05, SD = .13), r = .29, n = 48, p = .04, 95% CI [0.011, 0.534], F4-F3(M = .03, SD = .18), r = .32, n = 48, p = .03, 95% CI [0.042, 0.555], FT8-FT7 (M = .08, SD = .30), r = .38, n = 48, p = .008, 95% CI [0.106, 0.598], and FC4-FC3 (M = .05, SD = .19), r = .33, n = 48, p = .02, 95% CI [0.048, 0.560]. Relationships were also indicated between BAS-D and F8-F7 (M = .11, SD = .38), r = .30, n = 48, p = .04, 95% CI [0.017, 0.538] and between BAS-Total and FT8-FT7, r = .30, n = 48, p = .04, 95% CI [0.020, 0.540].

Table 10. Zero-Order Correlations and Simple Descriptive Statistics for measures of BIS/BAS, Sleep, and Baseline Asymmetry (N = 48)

	Zero-Order Correlations				
	FP2-FP1	F8-F7	F4-F3	FT8-FT7	FC4-FC3
BIS	-.04	.08	.24	.11	.10
BAS-RR	.29*	.18	.32*	.38**	.33*
BAS-D	.04	.30*	.24	.24	.16
BAS-FS	-.11	-.02	-.06	.09	-.11
BAS-Total	.08	.21	.21	.30*	.15
ISI	.12	-.15	-.07	-.03	.07
PSQI	.16	.22	.12	.24	.23
M	.05	.11	.03	.08	.05
SD	.13	.38	.18	.30	.19

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: BIS = Behavioral Inhibition System; BAS-RR = Behavioral Activation System-Reward Responsiveness Subscale; BAS-D = Behavioral Activation System-Drive Subscale; BAS-FS = Behavioral Activation System-Fun Seeking Subscale; BAS-Total = Behavioral Activation Total Scale; ISI = Insomnia Severity Index, PSQI = Pittsburg Sleep Quality Index Total Score; FP2-FP1 = alpha asymmetry score at electrode sites FP2-FP1, F8-F7 = alpha asymmetry score at electrode sites F8-F7, F4-F3 = alpha asymmetry score at electrode site F4-F3, FT8-FT7 = alpha asymmetry score at electrode site FT8-FT7, FC4-FC3 = alpha asymmetry score at electrode site FC4-FC3.

Additional correlational analyses were employed to examine relationships between baseline alpha asymmetry scores for the averaged eyes-closed and eyes-open conditions. These conditions were examined separately, as opposed to solely analyzing the previously presented combined overall alpha asymmetry, to respect the current literature regarding EEG baseline recording and differences in activation between eyes-closed and eyes-open resting conditions (Barry et al., 2007). Table 11 and Table 12 show the simple descriptive statistics and zero-order correlations for measures of BIS/BAS, sleep, and baseline asymmetry for the eyes-closed and eyes-opened conditions, respectively. Correlational analyses examining the relationships between measures of BIS/BAS, sleep and baseline alpha asymmetry for the eyes-open condition were consistent with the findings for overall baseline alpha asymmetry. BAS-RR was significantly positively correlated with the majority of electrode site pairs including FP2-FP1 (*M* = .04, *SD* = .14), *r* = .33, *n* = 48, *p* = .02, 95% CI [0.055, 0.565], F4-F3(*M* = .03, *SD* = .19), *r* = .32, *n* = 48, *p* = .03, 95% CI [0.041, 0.555], FT8-FT7 (*M* = .08, *SD* = .31), *r* = .40, *n* = 48, *p* = .004, 95% CI [0.132, 0.615], and FC4-FC3 (*M* = .07, *SD* = .20), *r* = .29, *n* = 48, *p* = .05, 95% CI [0.006, 0.530]. Relationships were also indicated between BAS-D with F8-F7 (*M* = .10, *SD* = .38), *r* = .35, *n* = 48, *p* = .02, 95% CI [0.069, 0.574] and F4-F3, *r* = .28, *n* = 48, *p* = .05, 95% CI [-0.005, 0.523]. BAS-Total was also significantly positively correlated with FT8-FT7, *r* = .29, *n* = 48, *p* = .05, 95% CI [0.005, 0.530].

With regard to the eyes-closed condition, BAS-RR was significantly positively correlated with the majority of electrode site pairs including F4-F3(*M* = .03, *SD* = .19), *r* = .30, *n* = 48, *p* = .04, 95% CI [0.013, 0.535], FT8-FT7 (*M* = .09, *SD* = .32), *r* = .31, *n* = 48, *p* = .03, 95% CI [0.029, 0.546], and FC4-FC3 (*M* = .03, *SD* = .20), *r* = .32, *n* = 48, *p* = .03, 95% CI [0.034, 0.550]. However, there were no relationships indicated for any other aspects of baseline resting

asymmetry with measures of sleep.

Table 11. Zero-Order Correlations and Simple Descriptive Statistics for measures of BIS/BAS, Sleep, and Baseline Asymmetry for the Eyes Open Condition (N = 48)

	Zero-Order Correlations				
	EO_FP2-FP1	EO_F8-F7	EO_F4-F3	EO_FT8-FT7	EO_FC4-FC3
BIS	-.05	.09	.22	.12	.10
BAS-RR	.33*	.19	.32*	.40**	.29*
BAS-D	.03	.35*	.28*	.21	.14
BAS-FS	-.06	-.02	-.08	.07	-.07
BAS-Total	.11	.24	.23	.29*	.15
ISI	.15	-.18	-.12	-.05	.03
PSQI	.17	.26	.15	.23	.18
M	.04	.10	.03	.08	.07
SD	.14	.38	.19	.31	.20

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: BIS = Behavioral Inhibition System; BAS-RR = Behavioral Activation System-Reward Responsiveness Subscale; BAS-D = Behavioral Activation System-Drive Subscale; BAS-FS = Behavioral Activation System-Fun Seeking Subscale; BAS-Tot = Behavioral Activation Total Scale; ISI = Insomnia Severity Index, PSQI = Pittsburg Sleep Quality Index Total Score; EO_FP2-FP1 = alpha asymmetry score for electrode sites FP2-FP1, EO_F8-F7 = alpha asymmetry score for electrode sites F8-F7, EO_F4-F3 = alpha asymmetry score for averaged for electrode sites F4-F3, EO_FT87 = alpha asymmetry score for electrode site FT8-FT7, EO_FC4-FC3 = alpha asymmetry score for electrode site FC4-FC3.

Table 12 Zero-Order Correlations and Simple Descriptive Statistics for measures of BIS/BAS, Sleep, and Baseline Asymmetry for the Eyes-Closed Condition (N = 48)

	Zero-Order Correlations				
	EC_FP2-FP1	EC_F8-F7	EC_F4-F3	EC_FT8-FT7	EC_FC4-FC3
BIS	-.02	.06	.23	.08	.09
BAS-RR	.22	.16	.30*	.31*	.32*
BAS-D	.05	.24	.18	.23	.15
BAS-FS	-.15	-.03	-.04	.09	-.14
BAS-Total	.04	.17	.18	.28	.13
ISI	.08	-.12	-.02	-.01	.10
PSQI	.13	.18	.08	.21	.25
M	.05	.13	.03	.09	.03
SD	.12	.41	.19	.32	.20

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: BIS = Behavioral Inhibition System; BAS-RR = Behavioral Activation System-Reward Responsiveness Subscale; BAS-D = Behavioral Activation System-Drive Subscale; BAS-FS = Behavioral Activation System-Fun Seeking Subscale; BAS-Total = Behavioral Activation Total Scale; ISI = Insomnia Severity Index, PSQI = Pittsburg Sleep Quality Index Total Score; EC_FP2-FP1 = alpha asymmetry score for electrode sites FP2-FP1, EC_F8-F7 = alpha asymmetry score for electrode sites F8-F7, EC_F4-F3 = alpha asymmetry score for averaged for electrode sites F4-F3, EC_FT87 = alpha asymmetry score for electrode site FT8-FT7, EC_FC4-FC3 = alpha asymmetry score for electrode site FC4-FC3.

Hypothesis Three: Exploratory investigation of ERP components as they relate to the information processing of positively/negatively valenced sleep-related images

Event-related potential (ERP) amplitudes (μV) were captured for each participant at the Fz, Cz, and Pz scalp sites referenced to A1 and A2 ear lobes. Each recording was performed on epochs of 1000 ms, using a sampling rate of 240 Hz with a bandwidth of 0.1 – 100 Hz. Recordings were made using the Compumedics Neuroscan software. Artifact (eye and body movements) was removed using a rejection level of ±100 μV. Averaging was performed on two occasions (target stimulus, standard stimulus). Due to the presence of artifact (as previously described in hypothesis two), the data for 38 participants were excluded from these analyses leaving a sample size of 37 participants. Of note, for the following analyses, particular attention was placed on the N100 ERP component (80 – 100 ms), P200 ERP component (150 – 200 ms),

and P300 ERP component (250 – 300 ms) due to prominence in the sleep literature.

ERP amplitudes. A series of multivariate ANOVAs were employed to assess the influence of sleep quality on ERP amplitudes at the Fz electrode site in response to varied stimuli conditions. The between-subjects factor comprised two groups: good sleepers (n = 6) and poor sleepers (n = 31), as determined by the PSQI cutoff score (score $\geq$ 5 designated a participant a poor sleeper). The variables consisted of averaged N100, P200, and P300 ERP amplitudes recorded at the Fz site for each participant as they viewed sleep-related stimuli that were valenced for positive or negative affect and frequency (target versus standard). Figures 9, 10, and 11 depict mean amplitudes for each stimuli condition. While there were no significant results for the majority of ERP components, a significant within group interaction was revealed for the P300 ERP component. Concerning the P300 ERP component (see figure 11), Mauchley's test indicated that the assumption of sphericity had been violated, $X^2(5) = 47.82$, $p < .001$, therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .66$). The results showed there was not a statistically significant difference between the two groups on the combined dependent variable of P300 amplitude, $F(1, 35) = .0005$, $p = .90$, nor was the interaction between groups and target condition significant, $F(1.84, 64.35) = .66$, $p = .84$. There was, however, a statistically significant effect of condition (valence and frequency of stimuli), $F(1.84, 64.35) = 3.28$, $p = .04$. When applying a Bonferroni adjusted alpha of .0125 (.05/4) to control for familywise error, these results were no longer statistically significant.

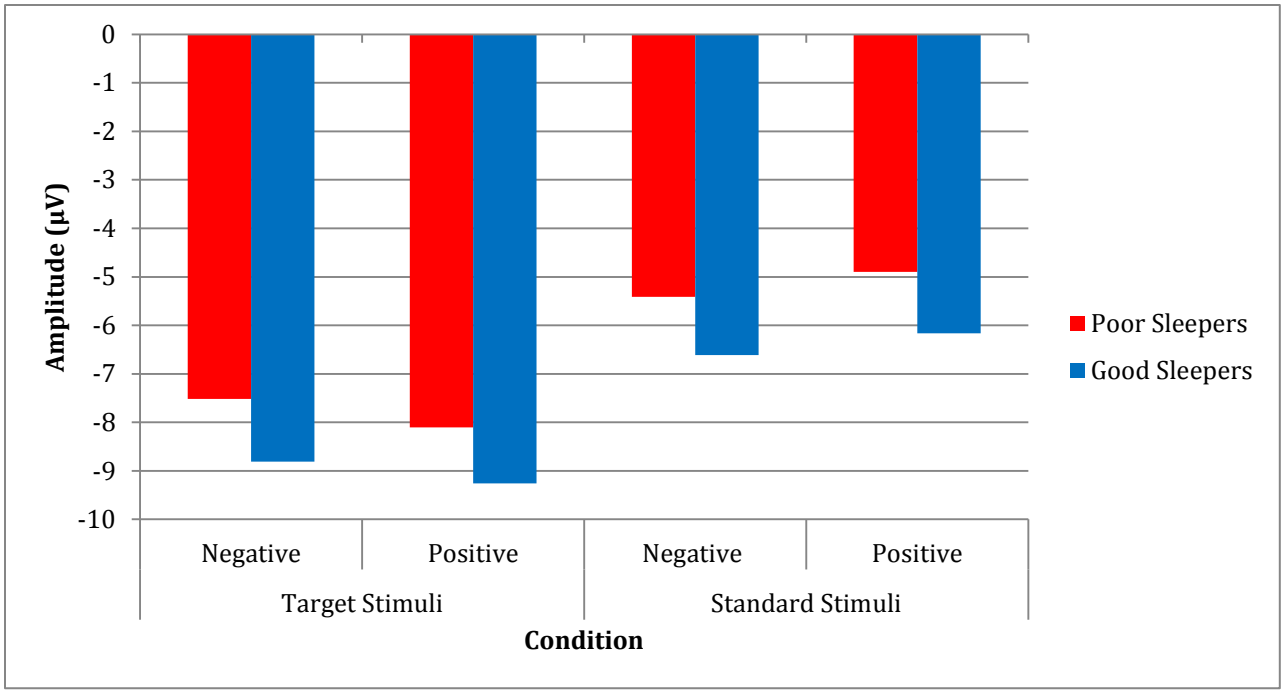


Figure 9. Mean N100 ERP amplitudes for poor sleepers and good sleepers at the Fz electrode site for each target conditions.

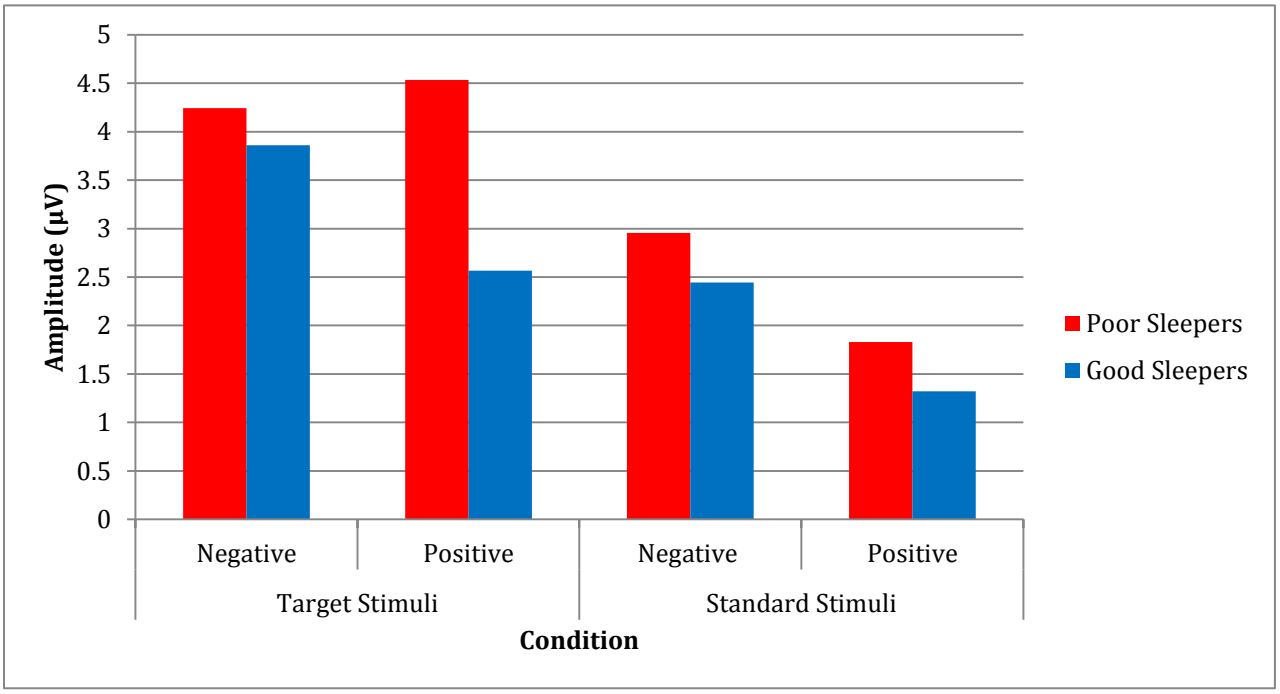


Figure 10. Mean P200 ERP amplitudes for poor sleepers and good sleepers at the Fz electrode site for each target conditions.

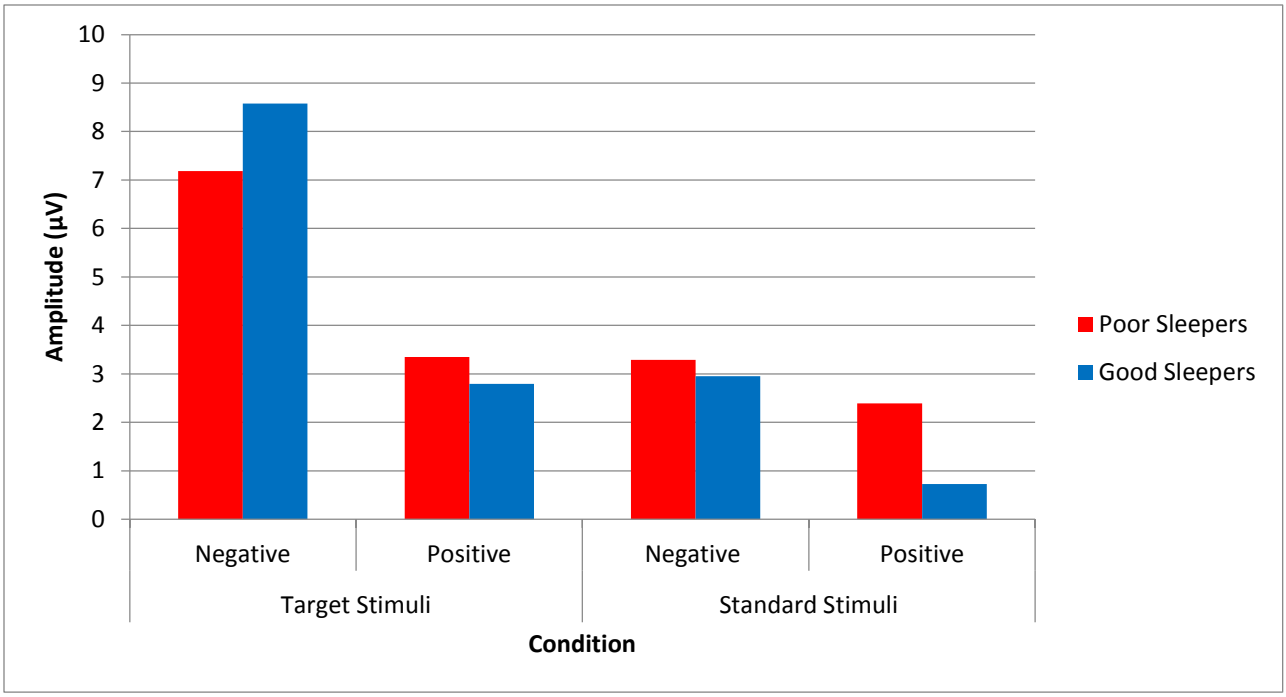


Figure 11. Mean P300 ERP amplitudes for poor sleepers and good sleepers at the Fz electrode site for each target conditions.

ERP latencies. A series of MANOVAs were also run to determine the effect of stimuli condition on ERP component latencies. These analyses revealed significance only for the latencies associated with the P200 ERP component, although the between groups examination for the P300 ERP latency just fell short of statistical significance, $F(1, 35) = 3.48$, $p = .07$. Regarding P200 ERP latencies, Mauchley's test indicated that the assumption of sphericity had been violated, $X^2(5) = .15.85$, $p = .007$. Degrees of freedom were corrected using Huynh-Feldt estimate of sphericity ($\varepsilon = .84$). A single significant interaction was demonstrated for the effect of stimuli condition on P200 latency, $F(2.51, 87.92) = 3.60$, $p = .02$, suggesting significant differences in P200 ERP latencies among stimuli conditions. The interaction between groups and stimuli condition fell short of significance, $F(2.51, 87.92) = 2.19$, $p = .11$, as did the between group examination, $F(1, 35) = .14$, $p = .71$. Of note, however, these results also fall short of significance when applying a Bonferroni adjusted alpha of .0125 (.05/4) to control for

familywise error.

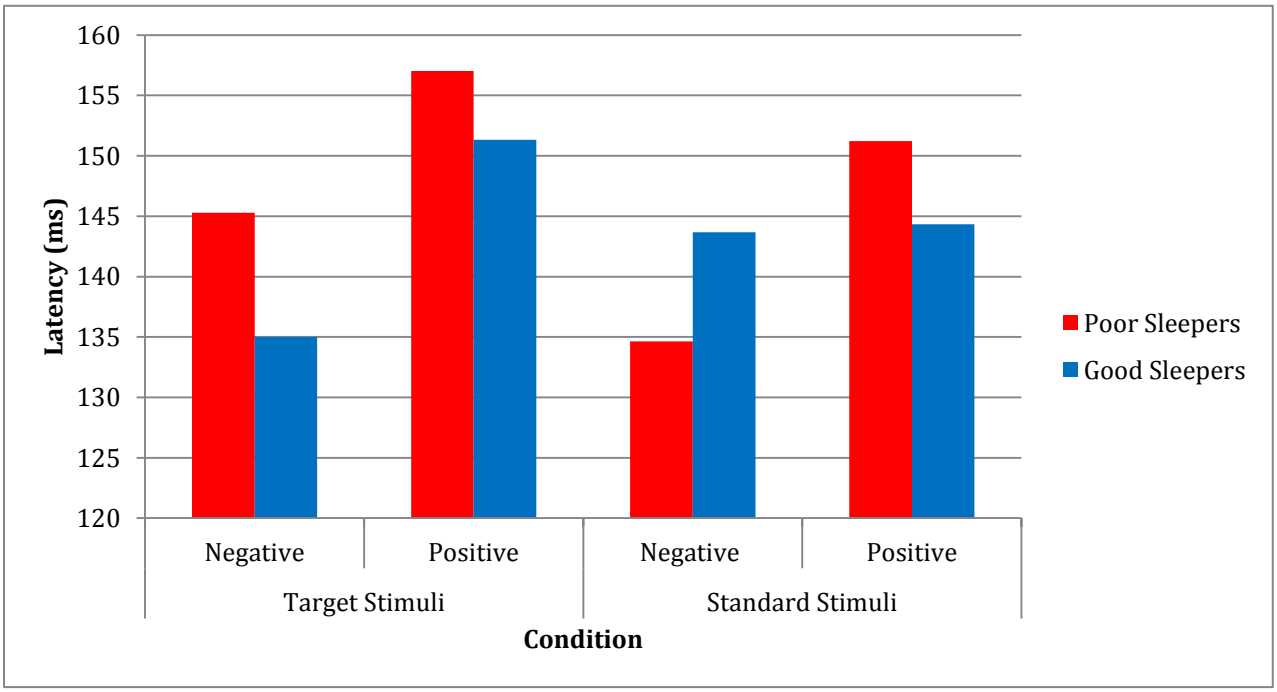


Figure 12. Mean N100 ERP latencies for poor sleepers and good sleepers at the Fz electrode site for each target conditions.

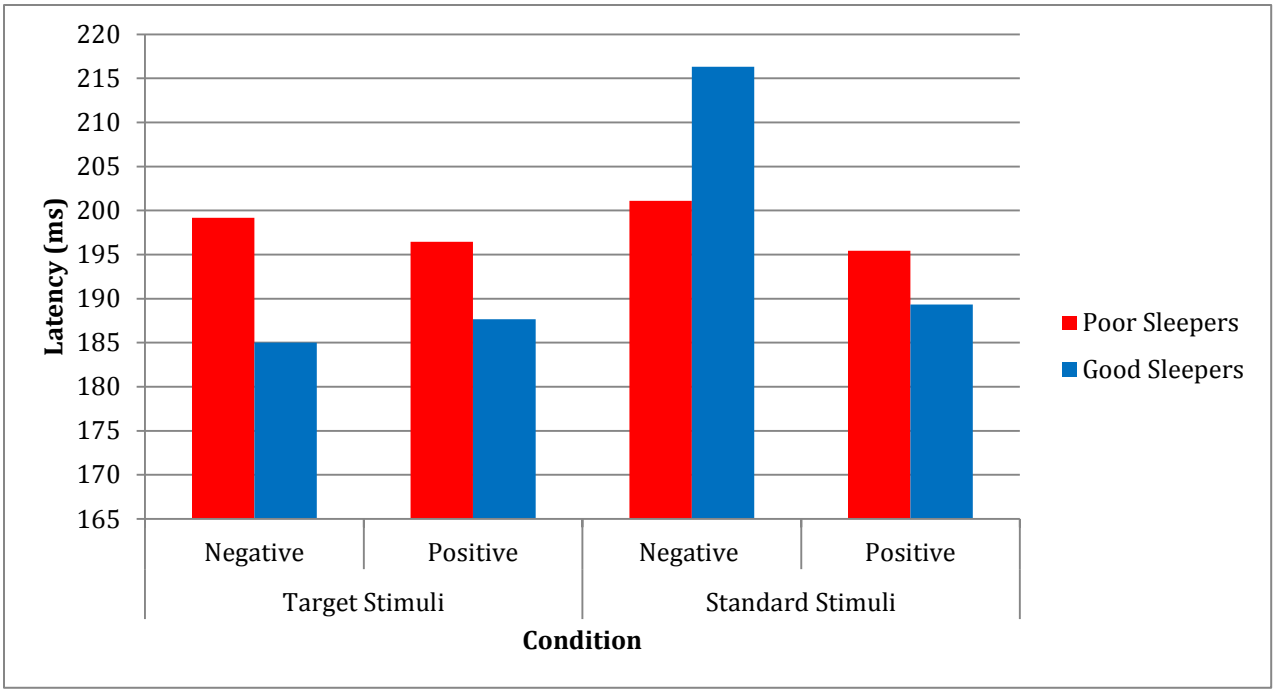


Figure 13. Mean P200 ERP latencies for poor sleepers and good sleepers at the Fz electrode site for each target conditions.

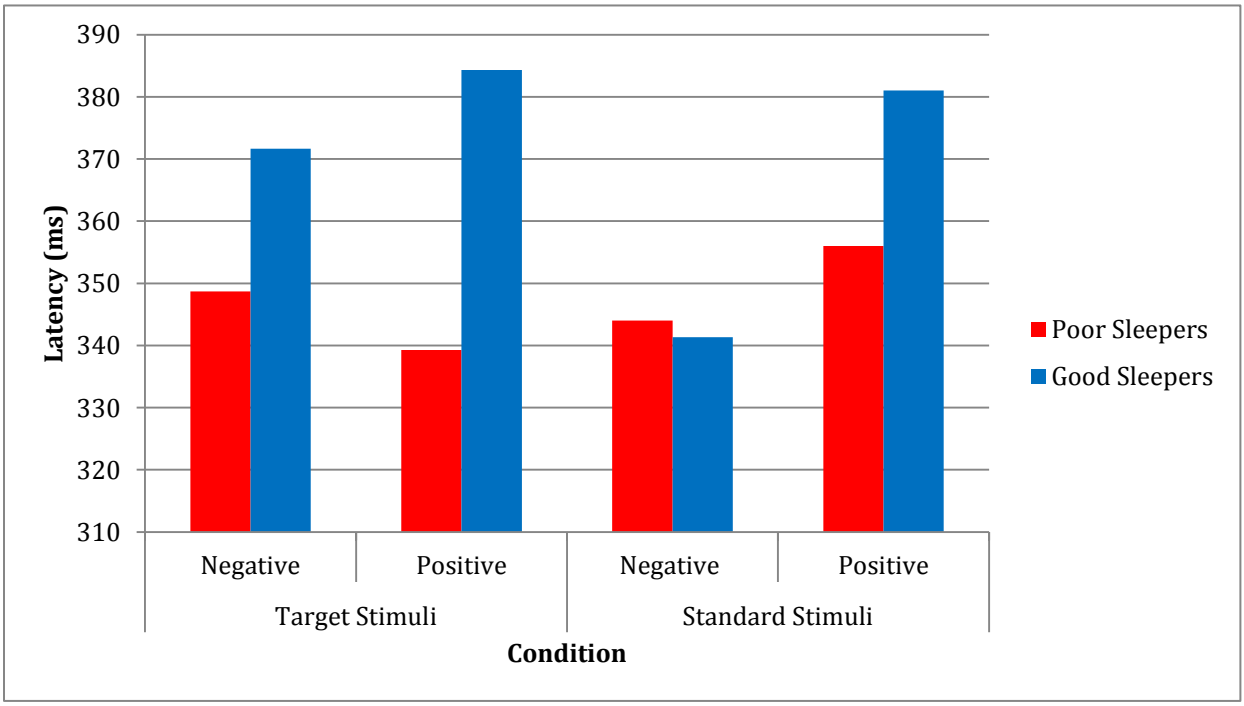


Figure 14. Mean P300 ERP latencies for poor sleepers and good sleepers at the Fz electrode site for each target conditions.

ERP amplitudes and subjective sleep quality. Table 13 provides basic descriptive statistics and correlation coefficients for mean ERP amplitudes (μV) and their correlation with global PSQI scores. There was only one significant correlation between ERP amplitude and the global PSQI score for the overall sample (N = 37) and good sleepers (n = 6). Global PSQI scores for the overall sample (M = 7.38, SD = 2.89) and mean P300 ERP amplitude for negative targets at the Pz scalp site (M = 9.90, SD = 7.64), r = -.35, N = 37, p = .03, 95% CI [-.606, -.030], which suggests that higher PSQI scores were associated with an attenuated P300 ERP (at the Pz scalp site) for negative sleep-related target images.

Good sleepers also presented with only a single significant correlation between self-reported global PSQI scores (M = 3.33, SD = 1.03) and mean N100 amplitudes for negative targets at the Pz scalp site (M = -6.40, SD = 6.55), r = .85, n = 6, p = .003, 95% CI [.124, .983]. This finding suggests that good sleepers mean N100 amplitudes to negatively valenced sleep-related images increased as their PSQI scores increased.

Poor sleepers, those with the highest PSQI scores (Global PSQI $\geq$ 5), had the greatest number of significant correlations with ERP amplitudes. PSQI scores of poor sleepers (M = 8.16, SD = 2.44) was significantly and negatively correlated with mean P300 amplitudes for positive target stimuli over the Pz scalp site (M = 9.92, SD = 8.13), r = -.45, n = 31, p = .01, 95% CI [-6.90, -.107]. Whereas there were significant and positive correlations with mean P300 ERP amplitudes for negative targets at the Pz scalp site (M = 10.15, SD = 9.09), r = .36, n = 31, p = .05, 95% CI [.004, .632] and Cz scalp site (M = 7.62, SD = 11.14), r = .39, n = 31, p = .03, 95% CI [.037, .652], in addition to a significant and positive relationship with the mean P200 ERP for negative targets at the Fz scalp site (M = 4.24, SD = 9.17), r = .37, n = 31, p = .04, 95% CI [.019, .641].

Table 13. Descriptive statistics for event-related potentials elicited by target stimuli and their correlations with Global PSQI

Waveform		Overall Sample (N = 37)			Good Sleepers (N = 6)			Poor Sleepers (N = 31)		
Negative Targets		*M*	*SD*	*r*	*M*	*SD*	*r*	*M*	*SD*	*r*
	Fz	-7.72	7.87	.06	-8.81	5.39	-.12	-7.51	8.32	.04
N100	Cz	-7.71	7.50	.11	-9.65	5.84	.23	-7.33	7.80	.03
	Pz	-7.01	8.13	-.04	-6.40	6.55	.85*	-7.12	8.49	-.08
	Fz	4.18	8.58	.28	3.86	5.03	-.34	4.24	9.17	.37*
P200	Cz	4.99	8.90	.26	3.58	7.37	-.24	5.26	9.25	.31
	Pz	7.45	8.15	.11	8.12	6.96	.11	7.32	8.46	.17
	Fz	7.41	10.38	.12	8.58	10.30	.09	7.18	10.54	.21
P300	Cz	7.85	11.45	.24	9.06	14.03	.16	7.62	11.14	.39*
	Pz	9.97	8.84	.30	9.04	8.10	.34	10.15	9.09	.36*
Positive Targets		*M*	*SD*	*r*	*M*	*SD*	*r*	*M*	*SD*	*r*
	Fz	0.27	-8.29	.27	-9.26	6.29	.06	-8.10	8.92	.31
N100	Cz	0.17	-7.85	.17	-7.59	7.01	.06	-7.90	9.03	.24
	Pz	0.17	-6.04	.17	-7.09	8.97	.09	-5.84	7.11	.18
	Fz	4.21	9.14	.09	2.57	6.96	.44	4.53	9.56	.03
P200	Cz	5.22	7.35	-.10	6.65	5.20	.16	4.94	7.73	-.07
	Pz	8.57	7.97	-.27	10.27	3.39	-.25	8.24	8.58	-.27
	Fz	3.26	9.45	-.02	2.80	6.39	-.02	3.35	10.02	-.04
P300	Cz	4.74	8.14	-.21	7.92	6.59	-.24	4.12	8.35	-.13
	Pz	9.90	7.64	-.35*	9.80	4.91	-.69	9.92	8.13	-.44**

*p <.05, **p <.01, ***p <.001, ****p <.0001

Predicting subjective sleep quality: An exploratory investigation of the P300 ERP component. Sequential multiple regressions with backward selection were employed to analyze the relationships between mean ERP amplitudes and global PSQI scores. Given the prominence of the P300 ERP component in the literature, analyses focused on investigating the unique contribution of mean P300 ERP responses to positive and negative sleep–related images in predicting subjective sleep quality. Table 14 shows the results for all regression models predicting subjective sleep quality. Of most interest was the final regression model (model 4) which indicates an overall model of three predictors that significantly predict subjective sleep quality [R^2 = .28, R^2_{adj} = .22, $F(3, 33) = 4.33$, $p = .01$]. This model accounted for 28% of the variance in subjective sleep quality. These findings suggest that mean P300 amplitudes, particularly those which are elicited by positively-valenced sleep-related images, significantly predict subjective sleep quality scores.

Table 14. Regression analysis for predicting subjective sleep quality (standardized regression coefficients; $N = 37$)

Variables	Models							
	1		2		3		4	
	1	VIF	2	VIF	3	VIF	4	VIF
NT – P3Pz	.40	4.43	.41	1.88	.37*	1.09	.39**	1.07
PT – P3Fz	.51	4.23	.51	4.13	.50	4.12	.60*	3.52
PT – P3Cz	-.67	5.93	-.66	5.41	-.65	5.35	-.82**	3.62
PT – P3Pz	-.14	2.14	-.15	1.69	-.16	1.58		
NT – P3Fz	-.07	4.49	-.05	1.80				
NT – P3Cz	.02	10.10						
Mallow's Cp			5.00		3.07		1.76	
R^2	.30		.30		.30		.28	
Adjusted R^2	.16		.19		.21		.22	
F	2.14		2.66*		3.40*		4.33*	

*p <.05, **p <.01, ***p <.001, ****p <.0001

Behavioral responses to sleep –related images. Behavioral data were also recorded for each participant. As previously noted in the methods section, participants were asked to press the response pad as quickly as possible every time they saw a target image for the duration of the block. They were instructed to do nothing for non-target (standard) images. Table 15 shows the behavioral data for the overall sample (N = 74), as well as groups determined by the PSQI—Good sleepers (n = 16) and Poor sleepers (n = 58). Data for one participant was not included in any of these analyses due to a recording error. Percent accuracy was calculated for all trials (total number correct/total number stimuli) in addition to block specific target conditions—negative targets only percent accuracy (total number target hits/total number of targets) and positive targets only percent accuracy (total number of target hits/total number of targets). Responses times (ms) were also captured for each target condition.

Exploratory independent sample t-tests were conducted to examine behavioral data between PSQI groups. Overall, there were no significant findings associated with accuracy discriminating target versus non-target stimuli (percent accuracy); however, there was a significant difference between identified good and poor sleepers regarding their response to the positively-valenced stimuli. Response times for positive sleep-images were significantly quicker for the identified good sleepers (M = 944.31, SD = 230.92) than poor sleepers (M = 1171.44, SD = 356.08), t = 3.06, p = .004. This finding suggests poor sleepers might have prolonged response times in general or that poor sleepers might need additional time to process positively-valenced visual material.

Table 15. Behavioral responses to sleep-related images (N = 74)

	Overall Sample (N = 74)		Good Sleepers (N =16)		Poor Sleepers (N =58)		t value	Degrees of Freedom	Cohen's d
	M	*SD*	*M*	*SD*	*M*	*SD*	*t*	*df*	*d*
NT – All Trials (% Accuracy)	.92	.05	.93	.05	.92	.06	.46	25.23	.17
NT – Targets Only (% Accuracy)	.76	.21	.78	.23	.76	.20	.42	21.78	.10
NT – Non-Targets Only (% Accuracy)	.95	.04	.96	.02	.95	.04	1.24	47.54	.28
NT – Targets Only (Average RT)	1458.45	632.91	1407.03	831.46	1472.63	574.58	.30	19.13	-.10
PT – All Trials (% Accuracy)	.91	.09	.91	.10	.92	.08	.39	21.22	-.12
PT – Targets Only (% Accuracy)	.81	.20	.79	.26	.81	.18	.24	19.55	-.10
PT – Non-Targets Only (% Accuracy)	.92	.10	.92	.10	.92	.10	.06	24.38	.00
PT – Targets Only (Average RT)	1122.33	344.70	944.31	230.92	1171.44	356.08	3.06**	36.95	-.69

Note: NT = Negative Target Block; PT = Positive Target Block; RT = response time in ms.
Note: There are 32 targets and 126 non-targets per block.

Note: *p <.05, **p <.01, ***p <.001, ****p <.0001

Hypothesis Four: Investigation of the neuropsychological sequelae of sleep quality on a sustained attention task.

PVT Performance. Table 16 lists PVT performance data for the overall sample (N = 75), as well as groups determined by the PSQI—Good sleepers (n = 17) and Poor sleepers (n = 58); whereas Table 17 provides PVT performance data for each of the symptom severity groups proposed by the ISI. The default performance metrics (i.e., Mean RT, Median RT, False Starts, and Lapses) were provided via the PalmPVT Windows companion software. Additional measures of performance were calculated using formulas created in Windows' Excel. These included calculation of the Mean 1/RT, Lapse probability (number of lapses divided by number of valid stimuli), Performance Score (1 minus the number of lapses and false starts divided by the number of valid stimuli including false starts), Fastest 10% RT, Slowest 10% RT, and number of lapses plus false starts.

Independent sample t-tests were conducted to examine PVT performance between PSQI groups. Findings revealed no significant differences in PVT performance between poor sleepers or good sleepers. Similarly, when considering guidelines proposed by the ISI (cutoff scores: 0-7, No clinically significant insomnia; 8-14, subthreshold insomnia; 15-21, Clinically significant insomnia, moderate; >21, Clinically significant insomnia, severe) there were no significant differences in PVT performance metrics among those individuals reporting no clinically significant symptoms of insomnia, subthreshold symptoms, or clinically significant symptoms of insomnia in the moderate range.

Table 16. Participant performance on the PVT for subjective sleep quality

Performance Metric	Overall Sample (N = 75)		Good sleepers (n = 17)		Poor sleepers (n = 58)		t value	Degrees of freedom	Cohen's d
	M	*SD*	*M*	*SD*	*M*	*SD*	*t*	*df*	*d*
Mean RT	288.28	56.19	288.94	81.15	288.08	47.43	.04	19.31	.02
Median RT	259.60	44.36	262.65	66.10	258.71	36.40	.24	18.93	.09
False Starts	.76	1.10	.88	1.17	.72	1.09	.50	24.76	.15
Major Lapses	.09	.29	.06	.24	.10	.31	.63	32.56	-.15
Minor Lapses	3.43	5.23	4.53	9.10	3.10	3.43	.63	17.35	.28
Mean 1/RT	3.86	.57	3.90	.72	3.84	.53	.28	21.43	.09
Lapse Probability	.04	.06	.05	.11	.03	.04	.68	17.31	.30
Performance Score	.95	.06	.94	.10	.96	.04	.73	17.63	-.31
Fastest 10% RT	197.75	31.43	200.52	48.14	196.94	25.08	.30	18.61	.12
Slowest 10% 1/RT	2.14	.56	2.13	.59	2.15	.56	.09	25.13	-.03
Lapses + False Starts	4.19	5.30	5.41	8.85	3.83	3.74	.72	17.71	.30

Note: RT = response time in ms; Major Lapse = RT ≥ 3 seconds; Minor Lapse = RT ≥ 500 ms; Lapse probability = calculated as the number of lapses divided by the number of valid stimuli; Performance score = 1 minus the number of lapses and false starts divided by the number of valid stimuli (including false starts)

Note: *p <.05, **p <.01, ***p <.001, ****p <.0001

Table 17. Means and standard deviations for PVT performance metrics by ISI severity group

Performance Metric	No Clinical Symptoms (n = 39)		Subthreshold symptoms (n = 27)		Moderate Symptoms (n = 9)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Mean RT	288.10	66.73	280.94	36.18	311.06	55.07
Median RT	259.36	52.24	252.78	28.83	281.11	43.14
False Starts	.67	1.15	.89	1.12	.78	.83
Major Lapses	.10	.31	.11	.32	.00	.00
Minor Lapses	3.87	6.64	2.37	2.69	4.67	3.67
Mean 1/RT	3.86	.60	3.91	.42	3.68	.87
Lapse Probability	.04	.08	.03	.03	.05	.04
Performance Score	.95	.08	.97	.04	.94	.05
Fastest 10% RT	198.15	35.46	194.90	26.13	204.57	29.41
Slowest 10% 1/RT	2.18	.58	2.18	.53	1.86	.55
Lapses + False Starts	4.54	6.57	3.26	3.21	5.44	4.03

Note: *p <.05, **p <.01, ***p <.001, ****p <.0001

Relationships between PVT performance and self-reported sleep measures. Correlational analyses were performed to determine relationships between PVT performance metrics and self-reported measures of sleep quality. Aspects of self-reported sleep quality include daytime sleepiness (Epworth Sleepiness Scale; ESS), symptoms of insomnia (Insomnia Severity Index; ISI), and overall sleep quality (Pittsburgh Sleep Quality Index; Global PSQI). All participants fully completed the self-report measures resulting in no missing data for these analyses. Table 15 summarizes the Pearson correlations coefficients between PVT performance metrics and measures of sleep quality.

No significant relationships were found between PVT performance metrics and sleep measures for the overall sample or the group of good sleepers. In contrast, there was a single significant relationship between median reaction time (M = 258.71, SD = 36.40) and sleepiness (ESS; M = 8.47, SD = 3.22) in the group of poor sleepers, r = .29, n = 58, p = .03, 95% CI [.038, .513]. This relationship, although weak, suggests sleepiness is associated with greater median reaction times, especially in self-reported poor sleepers.

Additional correlational analyses were conducted to examine relationships between PVT performance metrics and individual component scores of the PSQI. Specifically, Spearman's rank order correlation coefficient (r_s) procedures were employed given the ordinal nature of the PSQI components and the linear, but not normal distribution of the variables. Component scores measure seven areas specifically contributing to overall sleep quality: sleep duration, sleep disturbance, sleep latency, sleep efficiency, sleep medication use, perceived daytime dysfunction, and subjective sleep quality rating. Higher scores (ranging from 0-3) on the PSQI components indicate greater maladaptive sleep behavior in that domain. Similarly, poorer performance on the PVT performance metrics corresponds to greater response times, false starts

(commission errors), and lapses (omission errors); however, higher PVT Performance Scores represent better performance. Table 19 shows the zero order correlations between PVT performance metrics and PSQI components scores for the overall sample. The majority of relationships were associated with the PSQI components of daytime dysfunction, sleep efficiency, and subjective quality of life. Self-reported daytime dysfunction was significantly and positively correlated with minor lapses (M = 3.43, SD = 5.23), r_s = .28, n = 75, p = .01, and lapse probability (M = .04, SD = .06), r_s = .29, n = 75, p = .01. The sleep efficiency component demonstrated significantly positive associations with PVT performance scores (M = .95, SD = .06), r_s = .23, n = 75, p = .05 and the slowest 10% 1/RT metric (M = 2.14, SD = .56), r_s = .25, n = 75, p = .03; however, there was a significant negative relationship between sleep efficiency and the combined number of lapses and false starts (M = 4.19, SD = 5.30), r_s = -.23, n = 75, p = .05. Lastly, self-reported quality of sleep demonstrated a significant positive relationships with the number of minor lapses, r_s = .23, n = 75, p = .05, and the lapse probability, r_s = .23, n = 75, p = .05, The slowest 10% reaction time metric was also correlated with self-reported sleep quality component scores, r_s = -.23, n = 75, p = .04. The majority of these findings were anticipated. For instance, it was thought that greater endorsement of daytime dysfunction and poorer sleep quality would be correlated with poorer PVT performance. As such, some of the current findings are somewhat unexpected, especially with regard to sleep efficiency. Sleep efficiency, which represents the ratio of time spent in bed versus actual time asleep in bed. Higher sleep efficiency ratios (>85% are considered good) reflect better overall sleep quality, in addition to being used to estimate the number of completed sleep cycles. Of note, however, higher scores on the PSQI Sleep Efficiency component represent poorer efficiency. Relationships between sleep efficiency and PVT performance metrics suggest that higher sleep

efficiency component scores (indicating poorer sleep efficiency) are associated with better PVT performance. The findings associated with the sleep efficiency component might better be explained by examining all the relationships together. For instance, poorer efficiency was associated with greater (slower) response speeds, which perhaps contributed to less errors and better performance.

Tables 20 and 21 show the correlations between PSQI component scores and PVT performance metrics for each designated sleep group (i.e., Poor Sleepers and Good Sleepers). When considering only poor sleepers, the majority of significant correlations were associated with the sleep efficiency component (M = 1.33, SD = 1.30) and subjective sleep quality rating (M = 1.43, SD = .68). Sleep efficiency demonstrated a significant and negative relationships with minor lapses (M = 3.10, SD = 3.43), r_s = -.30, n = 58, p = .02, lapse probability (M = .03, SD = .04, r_s = -.30, n = 58, p = .02, and combined false starts and lapse errors (M = 3.83, SD = 3.74), r_s = -.29, n = 58, p = .03. Significant positive relationships were noted between sleep efficiency and mean 1/RT (M = 3.84, SD = .53), r_s = .26, n = 58, p = .05, PVT performance score (M = .96, SD = .04), r_s = .29, p = .03, and slowest 10% RT metric (M = 2.15, SD = .56), r_s = .30, p = .02). Meanwhile, the PSQI overall subjective sleep quality component score was significantly positively correlated with PVT false starts (M = .72, SD = 1.09), r_s = .31, n = 17, p = .02 and combined errors (false starts and minor lapses), r_s = .28, n = 17, p = .04. In contrast, the overall subjective sleep quality component score was significantly negatively correlated with the PVT performance score r_s = -.28, n = 17, p = .03 and the slowest 10% RT metric, r_s = -.31, n = 17, p = .02. Much like the findings noted for the overall sample, these results suggest poorer sleep quality is associated with poorer PVT performance, whereas poorer sleep efficiency is associated with slower response speed and less errors.

In contrast, there were only two significant relationships between PSQI component scores and PVT performance metrics among good sleepers. For the good sleepers, daytime dysfunction component scores were significantly and positively correlated with mean RT (M = 288.94, SD = 81.15, r = .51, n = 17, p = .04, but negatively correlated with false starts (M = .88, SD = 1.17, r = -.54, n = 17, p = .03. These findings suggest that among self-identified good sleepers, greater self-reported daytime dysfunction was associated with slower response times and errors of commission.

Table 18. Zero-order correlations between PVT performance metrics and measures of sleep quality

Performance Metric	Overall sample (N = 75)			Good sleepers (n = 17)			Poor sleepers (n = 58)		
	ESS	ISI	PSQI	ESS	ISI	PSQI	ESS	ISI	PSQI
Mean RT	.08	.11	-.06	-.07	.36	.18	.14	.09	-.13
Median RT	.19	.13	-.09	-.03	.32	.15	.29*	.16	-.15
False Starts	-.15	.09	-.03	-.42	.04	-.24	-.08	.15	.03
Major Lapses	-.18	-.08	-.03	.05	.47	-.15	-.23	-.18	-.10
Minor Lapses	.04	.03	-.10	-.09	.23	.29	.13	.08	-.11
Mean 1/RT	-.14	-.10	.08	.08	-.36	-.12	-.22	-.05	.20
Lapse Probability	.04	.03	-.10	-.09	.23	.29	.13	.08	-.11
Performance Score	-.01	-.05	.11	.13	-.24	-.27	-.09	-.12	.10
Fastest 10% RT	.13	.11	-.08	-.04	.42	.14	.23	.10	-.11
Slowest 10% 1/RT	.02	-.18	.00	.34	-.30	-.18	-.06	-.20	.01
Lapses + False Starts	.01	.05	-.10	-.14	.24	.27	.10	.12	-.09
M	8.48	7.72	6.95	8.53	3.82	3.41	8.47	8.86	7.98
SD	3.09	4.93	2.80	2.70	2.30	.71	3.22	4.92	2.29

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: RT = response time in ms; Major Lapse = RT ≥ 3 seconds; Minor Lapse = RT ≥ 500 ms; Lapse probability = calculated as the number of lapses divided by the number of valid stimuli; Performance score = 1 minus the number of lapses and false starts divided by the number of valid stimuli (including false starts)

Table 19. Spearman's rho (r_s) Correlations between PSQI Component Scores and PVT Performance Metrics for the Overall Sample (N = 75)

PVT Performance Metric	Duration	Disturbance	Latency	Dysfunction	Sleep Efficiency	Overall Sleep Quality	Medication Use
Mean RT	.07	.03	.02	.16	-.18	.16	.05
Median RT	.13	.01	-.02	.14	-.11	.13	.01
False Starts	.04	.04	-.09	-.01	-.10	.15	.02
Major Lapses	-.02	-.06	-.09	.01	-.04	-.05	.21
Minor Lapses	.03	.10	.06	.28**	-.21	.23	.10
Mean 1/RT	-.09	.01	.02	-.18	.19	-.17	-.07
Lapse Probability	.03	.10	.06	.29**	-.21	.23*	.11
Performance Score	-.04	-.08	.03	-.20	.23*	-.21	-.08
Fastest 10% RT	.09	-.02	-.07	.13	-.09	.09	.08
Slowest 10% 1/RT	-.04	-.06	.04	-.15	.25*	-.23*	.01
#Lapses+ #False Starts	.04	.08	-.03	.21	-.23*	.21*	.08
M	.93	1.23	1.12	1.01	1.11	1.25	.29
SD	.78	.42	1.01	.73	1.24	.72	.67

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: RT = response time in ms; Major Lapse = RT ≥ 3 seconds; Minor Lapse = RT ≥ 500 ms; Lapse probability = calculated as the number of lapses divided by the number of valid stimuli; Performance score = 1 minus the number of lapses and false starts divided by the number of valid stimuli (including false starts)

Table 20. Spearman's rho (r_s) Correlations between PSQI Component Scores and PVT Performance Metrics for Poor Sleepers (n = 58)

PVT Performance Metric	Duration	Disturbance	Latency	Dysfunction	Sleep Efficiency	Overall Sleep Quality	Medication Use
Mean RT	.11	-.08	.01	.01	-.25	.10	.03
Median RT	.19	-.07	-.06	.04	-.16	.08	-.03
False Starts	.00	.11	-.09	.16	-.11	.31*	.05
Major Lapses	-.03	-.08	-.12	-.06	-.06	-.14	.22
Minor Lapses	.04	.02	.08	.17	-.30*	.20	.09
Mean 1/RT	-.13	.11	.05	-.08	.26*	-.13	-.05
Lapse Probability	.04	.02	.08	.18	-.30*	.21	.09
Performance Score	-.06	-.03	-.01	-.20	.29*	-.28*	-.09
Fastest 10% RT	.16	-.08	-.11	.06	-.12	.04	.07
Slowest 10% 1/RT	-.11	-.02	.01	-.11	.30*	-.31*	.01
#Lapses+ #False Starts	.06	.03	.01	.20	-.29*	.28*	.09
M	1.10	1.28	1.31	1.16	1.33	1.43	.38
SD	.77	.45	1.01	.72	1.30	0.68	.75

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: RT = response time in ms; Major Lapse = RT ≥ 3 seconds; Minor Lapse = RT ≥ 500 ms; Lapse probability = calculated as the number of lapses divided by the number of valid stimuli; Performance score = 1 minus the number of lapses and false starts divided by the number of valid stimuli (including false starts)

Table 21. Spearman's rho (r_s) Correlations between PSQI Component Scores and PVT Performance Metrics for Good Sleepers (n = 17)

PVT Performance Metric	Duration	Disturbance	Latency	Dysfunction	Sleep Efficiency	Overall Sleep Quality
Mean RT	-.38	.36	-.08	.51*	-.13	.15
Median RT	-.42	.36	.00	.37	-.13	.10
False Starts	.45	-.22	-.05	-.54*	.10	-.26
Major Lapses	-.18	-.06	-.18	.24	-.18	.18
Minor Lapses	-.26	.37	-.10	.48	-.01	.14
Mean 1/RT	.36	-.36	.03	-.39	.16	-.16
Lapse Probability	-.26	.37	-.10	.48	-.01	.14
Performance Score	.06	-.36	.17	-.27	.01	-.01
Fastest 10% RT	-.45	.28	.04	.31	-.20	.20
Slowest 10% 1/RT	.18	-.36	.08	-.36	.04	-.11
#Lapses+ #False Starts	-.06	.36	-.17	.27	-.01	.01
M	.35	1.06	.47	.53	.35	.65
SD	.49	.24	.72	.51	.49	.49

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: RT = response time in ms; Major Lapse = RT ≥ 3 seconds; Minor Lapse = RT ≥ 500 ms; Lapse probability = calculated as the number of lapses divided by the number of valid stimuli; Performance score = 1 minus the number of lapses and false starts divided by the number of valid stimuli (including false starts)

Note: PSQI Medication Use component scores are not included in the table as it was not endorsed aby any of the good sleepers.

Exploratory regression analyses investigating the predictive ability of PSQI components with PVT performance. Multiple regression analyses were conducted to examine how well PSQI components predicted PVT performance metrics. The predictors were the seven PSQI components, while the criterion variables were minor lapses and mean 1/RT as these two metrics were shown to be the most sensitive and valid measures of psychomotor vigilance (Basner & Dinges, 2011). Data for minor lapses were log transformed to address skewness. Neither of the regression analyses was statistically significant (see Table 22). The combination of PSQI components was not statistically related to minor lapses, $F(7, 67) = 1.37$, $p = .23$ or mean 1/RT, $F(7, 67) = .91$, $p = .51$. Based on these results, the PSQI components were not considered adequate predictors of PVT performance.

Table 22. Regression analysis predicting select PVT performance metrics for the overall sample ($N = 75$)

PSQI Component	Minor Lapses			Mean 1/RT		
	B	S.E. B	β	B	S.E. B	β
Duration	-0.03	0.14	-.03	0.09	0.10	.12
Disturbance	0.04	0.23	.02	0.13	0.17	.10
Latency	0.07	0.11	.09	0.03	0.08	.06
Daytime Dysfunction	0.26	0.15	.23	0.00	0.11	.00
Sleep Efficiency	-0.17	0.08	-.26*	0.09	0.06	.19
Subjective Sleep Quality	0.03	0.19	.03	-0.17	0.14	-.21
Medication Use	0.07	0.14	.06	-0.05	0.10	-.06
R^2		.12			.08	
F		1.37			.91	

*p <.05, **p <.01, ***p <.001, ****p <.0001
Note: Minor lapses was log transformed

Exploratory analyses investigating the relationship between personality and PVT performance. Correlational analyses were employed to explore the relationships between PVT performance metrics and aspects of personality, namely neuroticism, behavioral inhibition (BIS),

behavioral activation (BAS). These particular variables of personality were chosen in part due to their inherent relation to motivation and performance. Table 16 summarizes the means and standard deviations for measures of personality, in addition to their correlation coefficients associated PVT performance metrics.

In the overall sample, there was a significant positive correlation between Neuroticism and the slowest 10% 1/RT PVT performance metric. However, this relationship was not maintained when analyzing good and poor sleepers independently. In fact, there was no significant relationship indicated for the good sleepers and measures of personality. There were, however, several relationships identified for poor sleepers. The poor sleepers' self-reported scores of behavioral inhibition (M = 13.91, SD = 3.71) were significantly and positively correlated with PVT performance scores (M = .96, SD = .04), r = .27, n = 58, p = .04, 95% CI [.15, .496], but significantly negatively correlated with overall lapses and false starts (M = 3.83, SD = 3.74), r = -.28, n = 58, p = .04, 95%CI = [-.498, -.018]. Additionally, poor sleepers' behavioral activation (M = 23.29, SD = 5.30) scores were significantly and positively correlated with the slowest 10% 1/RT performance metric (M = 2.15, SD = .56), r = .30, n = 58, p = .02, 95% CI [.047, .519]. These relationships suggest the influence of behavioral inhibition and behavioral activation in attentional tasks such that higher levels of self-reported behavioral inhibition are associated with fewer errors and better overall performance, at least in poor sleepers. In contrast, poor sleepers endorsing higher levels of behavioral activation tended to have prolonged response times.

Table 23. Zero-order correlations between PVT performance metrics and measures of personality

Performance Metric	Overall sample (N = 75)			Good sleepers (n = 17)			Poor sleepers (n = 58)		
	N	BIS	BAS-Total	N	BIS	BAS-Total	N	BIS	BAS-Total
Mean RT	.19	-.18	-.06	.44	-.16	.13	.13	-.21	-.17
Median RT	.12	-.14	-.03	.41	-.17	.13	.05	-.15	-.12
False Starts	.04	-.10	-.02	-.23	.27	.26	.12	-.23	-.12
Major Lapses	.09	-.13	.04	.18	.01	.26	.06	-.15	-.02
Minor Lapses	.11	-.16	-.09	.31	-.20	-.03	.10	-.23	-.14
Mean 1/RT	-.12	.09	.02	-.44	.13	-.20	-.02	.07	.11
Lapse Probability	.10	-.15	-.09	.30	-.19	-.03	.10	-.22	-.14
Performance Score	-.11	.17	.09	-.28	.17	.00	-.12	.27*	.17
Fastest 10% RT	.08	-.03	.05	.20	-.07	.20	.07	-.02	-.05
Slowest 10% 1/RT	-.23*	.18	.18	-.41	.04	-.16	-.21	.23	.30*
Lapses + False Starts	.11	-.18	-.09	.28	-.17	.00	.13	-.28*	-.17
M	14.92	14.36	23.17	12.53	15.88	22.76	15.62	13.91	23.29
SD	4.66	3.77	5.50	3.48	3.67	6.30	4.75	3.71	5.30

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: RT = response time in ms; Major Lapse = RT ≥ 3 seconds; Minor Lapse = RT ≥ 500 ms; Lapse probability = calculated as the number of lapses divided by the number of valid stimuli; Performance score = 1 minus the number of lapses and false starts divided by the number of valid stimuli (including false starts)

Hypothesis Five: Dysfunctional Beliefs and Attitudes about Sleep and Subjective Sleep Quality

Means, standard deviations, and range of scores for the DBAS-16 can be found Table 17 for the overall sample (N = 75). Tables 18 and 19 provide descriptive data of DBAS-16 themes and items for PSQI good sleepers (n = 17) and poor sleepers (n = 58), respectively. Relevant univariate statistics including t-tests and Cohen's d calculations are also provided.

Univariate analyses were conducted to examine differences in mean scores across DBAS-16 items based on sleep classification (good versus poor sleepers). There was a significant difference between groups on the DBAS-16 total score indicating that poor sleepers (M = 4.40, SD = 1.49) did have significantly higher self-reported dysfunctional beliefs and attitudes about sleep than did the good sleepers (M = 3.62, SD = 1.33), t(28.70) = 2.02, p = .05, d = -.54. Among the four themes, poor sleepers' beliefs about the consequences of insomnia (M = 5.14, SD = 1.91) and worry about sleep (M = 3.64, SD = 1.85) were significantly stronger than their well-rested counterparts (M = 3.98, SD = 1.68; M = 2.59, SD = 1.61, respectively). However, good sleepers endorsed significantly stronger belief in sleep expectations (M = 7.44, SD = 1.62) than did the identified poor sleepers (M = 6.34, SD = 2.46).

With regard to specific items of the DBAS-16, independent samples t-tests identified four items in which the good and poor sleepers had significantly different means. Analyses revealed that individuals classified as being poor sleepers (M = 4.53, SD = 3.22) endorsed being significantly more concerned about effects of insomnia on health (Item 5) than good sleepers (M = 2.12, SD = 3.18), t(26.38) = 2.77, p = .01, d = -.77, in addition to being more concerned about the negative effects on daily functioning with poor sleepers on average endorsing a value of 6.72 (SD = 2.42) as compared to the good sleeper's average endorsement of 5.00 (SD = 3.00), t(22.45)

= 2.17, p = .04, d = -.68. Moreover, poor sleepers (M = 4.29, SD = 3.24) endorsed using sleeping pills to avoid poor sleep (Item 11) more than good sleepers (M = 2.53, SD = 2.96), t(28.26) = 2.11, p = .04, d = -.56. Mood disruption was also endorsed more by poor sleepers (Item 12) M = 5.84, SD = 2.67, t(30.03) = 2.99, p = .006, d = -.77.

Table 24. Means, standard deviations, and range of scores for DBAS-16 (N = 75)

Item	*M*	*SD*	*Range*
Dysfunctional Beliefs and Attitudes About Sleep Total Score	4.21	1.48	0-9
Theme 1: Consequences of Insomnia			
(10) Poor sleep affects my daily functioning	6.33	2.64	0-10
(12) Mood is disrupted by poor sleep	5.40	2.71	0-10
(18) Cannot function without a good night's sleep	4.29	2.90	0-10
(21) Lack of energy due to poor sleep	5.79	2.51	0-10
(30) Avoidance or cancellation of obligations due to poor sleep	2.48	2.82	0-10
Theme 2: Worry about Sleep			
(5) Concerned about effects of insomnia on health	4.00	3.35	0-10
(8) Worried about losing control over sleep	2.52	2.61	0-10
(17) One night of poor sleep disrupts entire week	3.11	2.89	0-10
(19) Sleep is unpredictable – cannot predict poor sleep	4.87	2.98	0-10
(20) Unable to manage negative consequences of disturbed sleep	4.09	2.75	0-10
(25) Insomnia is ruining ability to enjoy life	1.83	2.51	0-10
Theme 3: Sleep Expectations			
(1) Need eight hours of sleep	6.68	2.52	1-10
(2) Need to catch up on sleep loss	6.51	3.09	0-10
Theme 4: Medication Use			
(11) Using sleeping pills is better than poor sleep	3.89	3.25	0-10
(24) Insomnia is the result of a chemical imbalance	4.27	2.65	0-10
(27) Medication is only solution to insomnia	1.25	1.73	0-9

Note: Items have been arranged in themes. Themes were adapted from Morin, C. M., Vallières, A., & Ivers, H. (2007). Dysfunctional beliefs and attitudes about sleep (DBAS): Validation of a brief version (DBAS-16). *Sleep*, 30, 1547-1554. Numbers in parentheses represent the DBAS-16 question's location within the original DBAS-30 questionnaire.

Table 25. Means and standard deviations of DBAS-16 themes for good sleepers and poor sleepers

	Good sleepers (n = 17)		Poor sleepers (n = 58)		t Value	Degrees of Freedom	Cohen's d
DBAS-16 Theme	*M*	*SD*	*M*	*SD*	*t*	*df*	*d*
Theme 1: Consequences of Insomnia	3.89	1.68	5.14	1.91	2.61**	29.27	-0.68
Theme 2: Worry about Sleep	2.59	1.61	3.64	1.85	2.29*	29.47	-0.59
Theme 3: Sleep Expectations	7.44	1.62	6.34	2.46	2.16*	39.80	0.48
Theme 4: Medication Use	2.67	2.02	3.28	1.77	1.12	23.60	-0.34

*p <.05, **p <.01, ***p <.001, ****p <.0001

Table 26. Comparative analyses of the means and standard deviations of DBAS-16 items for good sleepers and poor sleepers

Themes and Items	Good sleepers (n = 17)		Poor sleepers (n = 58)		t Value	Degrees of freedom	Cohen's d
	M	*SD*	*M*	*SD*	*t*	*df*	*d*
Dysfunctional Beliefs and Attitudes About Sleep Total Score	3.62	1.33	4.40	1.49	2.02*	28.70	-.54
Theme 1: Consequences of Insomnia							
(10) Poor sleep affects my daily functioning	5.00	3.00	6.72	2.42	2.17*	22.45	-.68
(12) Mood is disrupted by poor sleep	3.88	2.29	5.84	2.67	2.99**	30.03	-.77
(18) Cannot function without a good night's sleep	4.06	3.09	4.36	2.86	.36	24.62	-.10
(21) Lack of energy due to poor sleep	4.94	2.54	6.03	2.46	1.57	25.52	-.45
(30) Avoidance or cancellation of obligations due to poor sleep	1.59	2.40	2.74	2.90	1.66	31.03	-.42
Theme 2: Worry About Sleep							
(5) Concerned about effects of insomnia on health	2.12	3.18	4.55	3.22	2.77**	26.38	-.77
(8) Worried about losing control over sleep	1.88	2.64	2.71	2.60	1.14	25.75	-.32
(17) One night of poor sleep disrupts entire week	2.59	2.67	3.26	2.95	.89	28.50	-.23
(19) Sleep is unpredictable – cannot predict poor sleep	4.06	3.09	5.10	2.94	1.24	25.09	-.35
(20) Unable to manage negative consequences of disturbed sleep	3.65	3.20	4.22	2.62	.68	22.67	-.21
(25) Insomnia is ruining ability to enjoy life	1.24	1.72	2.00	2.68	1.40	41.22	-.31
Theme 3: Sleep Expectations							
(1) Need eight hours of sleep	7.47	2.32	6.45	2.55	1.56	28.31	.41
(2) Need to catch up on sleep loss	7.41	2.27	6.24	3.27	1.68	37.54	.39
Theme 4: Medication Use							
(11) Using sleeping pills is better than poor sleep	2.53	2.96	4.29	3.24	2.11*	28.26	-.56
(24) Insomnia is the result of a chemical imbalance	4.47	2.40	4.21	2.73	.39	29.27	.10
(27) Medication is only solution to insomnia	1.00	1.62	1.33	1.76	.72	28.06	-.19

*p <.05, **p <.01, ***p <.001, ****p <.0001

Relationships among self-reported measures of personality, affect, and sleep. Correlational analyses were performed to determine relationships among self-reported measures of personality, affect, behavior, and sleep quality. Hypothesis one already explored several of these relationships (see Table 9). Previous correlational analyses revealed statistically significant positive relationships between measures of negative affect and personality (PANAS-N and N) in addition to relationships between negative affect, personality, and sleep quality (PANAS-N and N with PSQI self-reported). Significant negative correlations were identified between neurobehavioral measures of personality (BIS) with negative affect (PANAS-N), neuroticism (N), and sleep quality (PSQI).

Correlational analyses were conducted to consider the possible role and relationship of dysfunctional beliefs and attitudes about sleep in models of disordered sleep and poor sleep quality. Total scores obtained on the DBAS-16 were significantly correlated with several of the preceding measures of personality, affect, and sleep. DBAS-16 scores (M = 4.21, SD = 1.48) were significantly and positively correlated with Neuroticism (M = 14.92, SD = 4.66), r = .40, n = 75, p < .0004, 95% CI [0.191, 0.575] and sleep quality (PSQI; M = 6.95, SD = 2.80), r = .36, n = 75, p =.0013, 95% CI [0.150, 0.546], in addition to a measure of insomnia symptom severity (ISI; M = 7.72, SD = 4.93), r = .44, n = 75, p<.0001, 95% CI [0.241, 0.610]. In contrast, a significant negative relationship was found between DBAS-16 total scores and BIS (M = 14.92, SD = 4.66), r = -.43, n = 75, p = .0001, 95% CI [-0.598, -0.225]. These findings suggest dysfunctional beliefs and attitudes about sleep may be intimately related to poor sleep quality and/or disordered sleep.

Predicting sleep group classification from beliefs and attitudes about sleep. Logistic regression was conducted to determine whether the beliefs and attitudes about sleep significantly

predicted whether an individual was likely to be classified as a poor sleeper (according to the PSQI cutoff). A single predictor model considering only the DBAS-16 total score did significantly predict those individual classified as poor sleepers, $\chi^2(1, N = 75) = 3.85$, $p = .05$. The model correctly classified 86% of participants correctly as poor sleepers and 62% of participants as good sleepers. The model's overall success rate was 81%.

Next, the individual items of the DBAS-16 were considered in a model for predicting poor versus good sleepers. This model demonstrated a better success rate, 84%, at classifying participant sleep group membership, but was a slightly poorer statistical fit, $\chi^2(16, N = 75) = 50.90$, $p < .0001$. Whereas a reduced model consisting only of those significant DBAS-16 items, from the aforementioned logistic regression analysis, demonstrated the best statistical fit $\chi^2(5, N = 75) = 30.96$, $p < .0001$and had an adequate prediction success rate of 81%.

Tables 27, 28, and 29 show the logistic regression coefficients, Wald tests, and odds ratios for each of the predictors in a single predictor model (DBAS-16 total score), full model (DBAS-16 individual items), and reduced model (significant DBAS-16 items only) respectively. Item numbers (in parentheses) refer to the DBAS-16 question's location within the original DBAS-30 questionnaire. When employing a .05 criterion of statistical significance, the DBAS-16 Total score was a significant predictor of group membership indicating that an increase of one point on the total scale is associated with a 1.50-increased likelihood of being classified as a poor sleeper. Analysis of the full model, consisting of all DBAS-16 items revealed only items 1 (need for 8 hours of sleep), 2 (need to catch up on sleep loss), 5 (concerns about the ill-effects of insomnia on health), 10 (poor sleep affects my daily functioning), and 12 (disrupted mood from poor sleep), as significant predictors of sleep group membership. As such, these five items were considered in the development of a reduced model. The reduced model showed that every one-

point endorsement for the item referring to insomnia's ill-effects on health, there is a 1.5-increased likelihood that one would be grouped as a poor sleeper. Similarly, those endorsing greater belief in the DBAS-16 items regarding poor sleep as interfering with their next day's activities and mood disruption showed a 1.5- and a 1.6-increased likelihood of being a poor sleeper, respectively. In contrast, those endorsing the belief for needing 8 hours of sleep showed a 1.4-increased likelihood of being classified as a good sleeper; whereas greater belief in the need to catch up on sleep loss predicted better overall sleep quality with a 1.3-increased likelihood of being classified as a good sleeper.

Table 27. "DBAS-16" predictors of poor sleepers *(N = 75)*

Predictor	*B*	Wald χ^2	*p*	Odds Ratio
DBAS-16 Total Score	-.39	3.35	.08	1.50

Table 28. "DBAS-16" predictors of poor sleepers (*N* = 75)

Predictor	*B*	Wald χ^2	*p*	Odds Ratio
(1) Need eight hours of sleep	-0.36	4.49	.03	0.70
(2) Need to catch up on sleep loss	-0.31	4.41	.04	0.73
(5) Concerned about effects of insomnia on health	0.38	7.68	.006	1.46
(10) Poor sleep affects my daily functioning	0.36	5.67	.02	1.43
(12) Mood is disrupted by poor sleep	0.47	7.60	.003	1.60

Table 29. "DBAS-16" predictors of poor sleepers *(N = 75)*

Predictor	*B*	Wald χ^2	*p*	Odds Ratio
(1) Need eight hours of sleep	-1.06	5.15	.02	.34
(2) Need to catch up on sleep loss	-0.65	4.43	.04	.52
(5) Concerned about effects of insomnia on health	0.88	6.88	.009	2.42
(8) Worried about losing control over sleep	-0.49	1.24	.27	.61
(10) Poor sleep affects my daily functioning	0.74	5.40	.02	2.09
(11) Using sleeping pills is better than poor sleep	0.14	0.41	.52	1.15
(12) Mood is disrupted by poor sleep	1.01	5.28	.02	2.74
(17) One night of poor sleep disrupts entire week	-0.17	0.13	.72	.84
(18) Cannot function without a good night's sleep	-0.39	0.87	.35	.68
(19) Sleep is unpredictable – cannot predict poor sleep	0.42	2.59	.11	1.53
(20) Unable to manage negative consequences of disturbed sleep	0.28	1.04	.31	1.32
(21) Lack of energy due to poor sleep	0.48	3.02	.08	1.62
(24) Insomnia is the result of a chemical imbalance	-0.18	0.41	.52	.83
(25) Insomnia is ruining ability to enjoy life	-0.83	1.90	.17	.44
(27) Medication is only solution to insomnia	0.43	0.55	.46	1.53
(30) Avoidance or cancellation of obligations due to poor sleep	0.62	2.85	.09	1.86

Predicting overall subjective sleep quality from the endorsement of dysfunctional beliefs and attitudes about sleep. A multiple regression analysis was conducted to determine whether thematic means representing dysfunctional beliefs and attitudes about sleep could predict sleep quality. The full model was statistically significant, $F(4, 70) = 7.60$, $p < .0001$.

Multiple linear regression analysis was used to develop a model for predicting sleep quality from their endorsed beliefs and attitudes about sleep—specifically, the four thematic means from the DBAS-16. These include themes associated with the consequences of insomnia, worry about sleep, sleep expectations, and medication use. Basic descriptive statistics and regression coefficients are shown in Table 30. Three of the four predictor variables had a significant zero-order correlation with subjective sleep quality (PSQI), but only two themes (i.e., worry about sleep and sleep expectations) had significant partial effects in the full model. The four predictor model was able to account for 30% of the variance in subjective sleep quality, $F(4, 70) = 7.60$, $p < .001$, $R^2 = .30$. These results indicated that worry or perceived helplessness ($\beta = .33$, $p = .02$) was associated with an increase in PSQI scores, that is, poorer overall sleep quality. In contrast,

Table 30. Dysfunctional Beliefs and Attitudes about Sleep Related to Subjective Sleep Quality (N = 75)

	Zero-Order Correlations					β	b
	PSQI	Theme 4	Theme 3	Theme 2	Theme 1		
Theme 1						.25	.36
Theme 2					.58****	.33*	.50
Theme 3				.17	.47****	-.35**	-.42
Theme 4			.21	.48****	.40****	.08	.12
PSQI		.26*	-.16	.45****	.31***		
						Intercept =	5.89
M	6.95	3.14	6.59	3.40	4.86		
SD	2.80	1.83	2.33	1.84	1.92	R^2 =	.30****

*p <.05, **p <.01, ***p <.001, ****p <.0001

Note: Theme 1 = Consequences of insomnia; Theme 2 = Worry about sleep; Theme 3 = Sleep expectations; Theme 4 = Medication use; PSQI = Pittsburgh Sleep Quality Inventory

individuals endorsing particularly strong sleep expectations, which include the need to catch up on sleep loss and the need 8 hours of sleep nightly, was associated with better self-reported sleep quality (β = -.35, p =.003).

Exploratory mediation analysis investigating the role of beliefs and attitudes about sleep as a mediator for poor sleep quality. As expected, BIS was significantly correlated with PSQI, r = -.34, p = .0026, n = 75, 95%CI [-.0.529, -.126]. Sequential regression analyses, as seen in Table 24, were employed to investigate the involvement of dysfunctional attitudes and beliefs about sleep (DBAS) as a possible mediator of the relationship between personality (BIS) and subjective sleep quality (PSQI).

DBAS was found to be significantly negatively correlated to BIS, r = -.43, p = .0001, n = 75, 95% CI [-.598, -.225]. Sleep quality was related to a linear combination of BIS and DBAS, $F(2, 72) = 7.66$, p = .001, R = .42. BIS b = -.170, SE = .088, p = .058, 95% CI [-.346, .005], but failed to have a significant partial effect on PSQI; whereas DBAS b = .504, SE = .225, p = .03, 95% CI [.057, .952] was significant. Aroian's test of mediation indicated DBAS significantly mediated the relationship between BIS and PSQI, TS = -1.93, $p < .002$. Of note, the p-value was not obtained from the standard normal distribution but rather the table provided by MacKinnon, Lockwood, Hoffman, West, and Sheets (2002), which provides more accurate critical values for the test statistic obtained.

Table 31. Mediation analysis investigating the involvement of DBAS as a possible mediator of the relationship between BIS and PSQI *(N = 75)*

Model	Unstandardized Coefficients		Standardized Coefficient	*t*	*p*	*F*	*R*	R^2	Sobel Z
	B	S.E.	Beta						
Step 1 – Predicting DBAS-16 from BIS									
(constant)	6.629	.615	---	10.78	<.0001	16.54	.43	.19	---
BIS	-.169	.041	-.430	-4.07	.0001	---	---	---	---
Step 2 – Predicting PSQI from BIS and DBAS-16									
(constant)	7.265	1.900	---	3.82	.0003	7.66	.42	.18	-1.97
BIS	-.170	.088	-.229	-1.93	.06	---	---	---	---
DBAS-16	.504	.225	.266	2.25	.03	---	---	---	---

This simple mediation model is illustrated below in Figure 15. The indirect effect of BIS on PSQI, (-.430) (.266) = -.114, and its direct effect is -.229, yielding a total effect coefficient of -.229 - .114 = -.343 (which is equal to the zero-order correlation coefficient between BIS and PSQI). The indirect effect was tested using bootstrapping with 10000 samples. These results indicated the indirect effect was significant, b = -.170, SE = .088, p = .058, 95% CI [-.346, .005]. There is evidence to support that dysfunctional beliefs and attitudes about sleep mediate sleep quality when considering endorsement of behavioral inhibition.

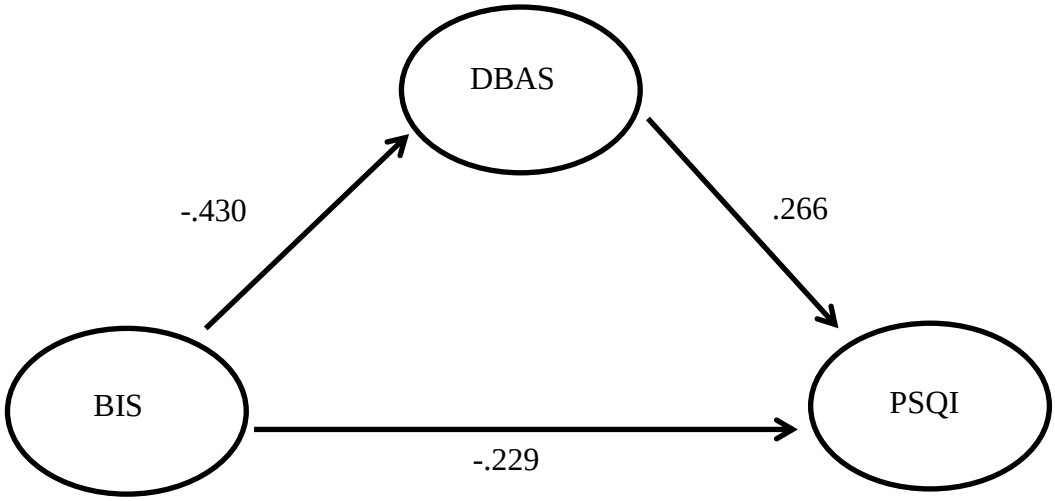


Figure 15. Standardized regression coefficients for the relationship between neurophysiological behavioral inhibition (BIS) and subjective sleep quality (PSQI).

Dysfunctional beliefs and attitudes about sleep partially mediate subjective sleep quality in college students experiencing psychological distress. Sequential correlational and multiple regression analyses were conducted to explore whether dysfunctional beliefs and attitudes about sleep (DBAS) mediated the relationship between psychological distress (PHQ-4; symptoms of depression and anxiety) and subjected sleep quality (PSQI). Data remained untransformed for correlational analyses; whereas, scores on the PHQ-4 were transformed (square root transformation) for regression analyses. As expected, all three variables were significantly positively correlated with each other. PHQ-4 was significantly positively correlated with subjective sleep quality (PSQI), $r = .48$, $p < .0001$, $n = 75$, 95% CI [.284, .638] and dysfunctional beliefs and attitudes about sleep (DBAS), $r = .50$, $p < .0001$, $n = 75$, 95% CI [.309, .653]. Moreover, DBAS was significantly positively correlated with PSQI, $r = .36$, $p = .001$, $n = 75$, 95% CI [.150, .546].

As seen in Table 32, regression analyses showed that PSQI was significantly related to the linear combination of PHQ-4 and DBAS, $F(2, 72) = 10.04$, $p = .0001$, $R = .47$. The relationship between psychological distress and subjective sleep quality was partially mediated by dysfunctional beliefs and attitudes about sleep. Figure 16 illustrates a significant partial effect of PHQ-4 on PSQI, $b = 1.179$, $SE = .42$, $p = .007$, 95% CI [.340, 2.017]. DBAS failed to show a significant partial effect on PSQI ($b = .363$, $SE = .230$, $p = .12$, 95% CI [-.095, .820]). However, Aroian's test of mediation indicated DBAS significantly mediated the relationship between BIS and PSQI, $TS = 1.51$, $p < .01$.

Table 32. Mediation analysis investigating the involvement of DBAS as a possible mediator of the relationship between PHQ-4 and PSQI (N = 75)

Model	Unstandardized Coefficients		Standardized Coefficient	t	p	F	R	R^2	Sobel Z
	B	S.E.	Beta						
Step 1 – Predicting DBAS-16 from PHQ-4									
(constant)	2.897	.298	---	9.71	< .0001	25.63	.51	.26	---
PHQ-4	.934	.185	.510	5.06	< .0001	---	---	---	---
Step 2 – Predicting PSQI from PHQ-4 and DBAS-16									
(constant)	3.765	.886	---	4.25	< .0001	10.04	.47	.22	1.51
PHQ-4	1.179	.421	.339	2.8	.0065	---	---	---	---
DBAS-16	.363	.230	.191	1.58	.1184	---	---	---	---

The mediation model (Figure 16) illustrates the relevant pathways in this exploratory investigation. The indirect effect of PHQ-4 on PSQI, (.510) (.339) = .173, and its direct effect is .339, which yields a total effect coefficient of .436. Therefore, .173/.364, 48% of the effect of psychological distress on subjective sleep quality is mediated through DBAS and .191/.364 = 53% is direct. The indirect effect was tested using bootstrapping approach of 10000 samples. These results indicated the indirect effect was not significant, *b* = .100, *SE* = .079, 95% CI [-.041, .274]. Of note, however, this direct effect likely includes the effects of mediators not accounted for in the model.

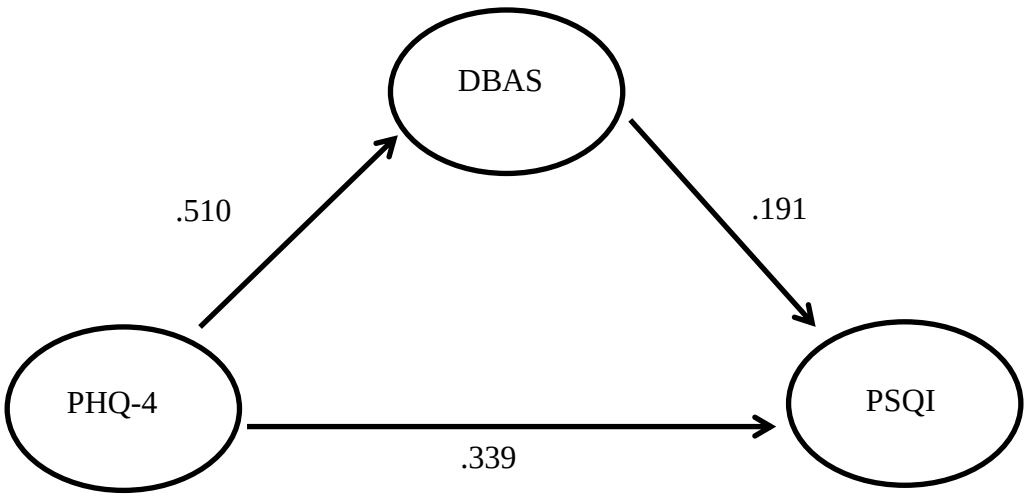


Figure 16. Standardized regression coefficients for the relationship between psychological distress (PHQ-4) and subjective sleep quality (PSQI).

CHAPTER V: DISCUSSION

Summary of Results and Relevant Implications

The broad aim of this study was to investigate the neuropsychological and neurophysiological correlates of subjective sleep quality in a population (university students) vulnerable to developing disrupted sleep behavior, due to the challenges presented in a socially and academically demanding setting, that could wreak havoc on sleep quality. Despite the wide scope of the present study, each aim and hypothesis were guided by presenting themes in the sleep literature. The five primary aims were: 1) to examine relationships among self-report measures of personality, affect, and behavior in relation to subjective sleep quality, 2) to investigate the N100, P200, and P300 ERP components as it relates to the information processing of positively- and negatively-valenced sleep-related images, 3) to replicate findings from previous research regarding resting asymmetry and the BIS/BAS measures, but also exploring possible relationships with subjective sleep quality, 4) to investigate the neuropsychological sequelae—namely psychomotor vigilance—associated with subjective sleep quality, 5) to explore the role of dysfunctional beliefs and attitudes about sleep with regard to subjective sleep quality.

Individual differences contributing to subjective sleep quality. The main findings of hypothesis one highlighted the contribution of individual differences in personality facets and affect in the prediction of subjective sleep quality. Subjective sleep quality was most associated with the five-factor model's constructs of neuroticism and agreeableness; however, when considering the influence of anxiety and depression on sleep quality, depressive symptoms significantly contributed to the predictive regression model.

There is a longstanding intimate relationship between neuroticism and sleep. The

literature is replete with studies highlighting the negative consequences associated with high levels of neuroticism which include decreased sleep quality; poor sleep hygiene, and reduced daytime functioning (Duggan, Friedman, McDevitt, & Mednick, 2014). The current study found that the personality facets of neuroticism and agreeableness were significant predictors of sleep quality. Individuals characterized by neuroticism are characterized as being prone to anxiety and depression, having a tendency to remain in negative emotional states for prolonged periods of time, and being emotionally reactive to a variety of situations (Lahey, 2009). Agreeable people, on the other hand, are characterized as trusting of others, valuing social harmony, and avoiding conflict. When considering these facets of personality separately, one can easily see how specific traits or behavioral tendencies might interfere with sleep, especially neuroticism; however, it is difficult to understand the positive association of agreeableness with poor sleep quality. At closer inspection, the data of the present study highlight a paradoxical or reversal effect (Simpson's Paradox; Blyth, 1972) resulting from the aggregation of data from two apparently different groups (poor sleepers versus good sleepers). While agreeableness was positively associated with subjective sleep quality in the overall sample, p

oor sleepers showed no significant relationship between agreeableness and sleep quality but good sleepers did. This paradoxical effect, seen in the correlational analyses, likely explains the directional impact (i.e., a decrease in PSQI scores which indicates better sleep quality) in the relationship between agreeableness and sleep quality in the regression analyses.

Nevertheless, it may be pertinent to consider the combination of neuroticism and agreeableness together, rather than as separate factors independently impacting sleep. For instance, the combination of high levels of neuroticism and high agreeableness promote the development of extreme emotional sensitivity, particularly to others, which contributes to increased demands of sacrificing the self (i.e., sleep) to manage the need for social connectedness or maintain high academic performance, especially within a collegiate setting. The results of the present study also underscore the importance of mood and effect on sleep quality. Psychological disorders, notably depression and anxiety, have diagnostic criteria acknowledging the disruptions in normal sleep patterns (American Psychiatric Association, 2013). Due to identified relationship of neuroticism to the mental health conditions, it may be argued that neuroticism is the driving force manifesting in the form of mood and anxiety disorders and resultant sleep difficulties.

Resting asymmetry, BIS/BAS, and subjective sleep quality. Research exploring Gray's (1990) Reinforcement Sensitivity Theory has consistently shown that the behavioral inhibition system (BIS) is predominantly associated with punishment sensitivity, avoidance

motivation, and negative affect; whereas the behavioral activation system (BAS) is associated with reward sensitivity, approach motivation, and positive affect. Moreover, the constructs underlying BIS have been shown to be associated with poor sleep quality. Consistent with previous research, the present study found self-reported BIS to be significantly correlated with self-reported poor sleep quality; however, this relationship was negative. This correlational finding was quite unexpected, as it was hypothesized that BIS would *positively* correlate with subjective sleep quality such that higher scores on BIS would be associated with poorer sleep quality.

Considering the population being studied might better explain these findings. Given the inherent stressors imposed onto students in a collegiate atmosphere (i.e., academic, social, and personal pressures), those students experiencing higher levels of BIS or aversion to punishment have likely developed adaptive coping strategies. For instance, studying course material, reaching out to others for support, and getting adequate sleep are strategies for avoiding punishment and negative consequences (e.g., bad grades). Another explanation for these correlational results might relate to a self-selection bias in which a certain subsection of the college population chose to participate in this research. Recruitment for the present study began toward the latter part of the spring semester and extended through the summer semesters. The college students willing to participate in a research study over the summer might represent a specific subsection of college students not entirely representative of the college population, but rather a group of participants characterized by failure avoidance and high achievement which is corroborated by the significant positive correlation between BIS and BAS-Reward Responsiveness. These particular explanations highlight two competing hypothesized methods in which to conceptualize BIS/BAS. The first is known as the separable systems hypothesis which

posits that BIS and BAS are activated independently by the presence of punishing stimuli or rewarding stimuli, respectively (Gomez, Cooper, McOrmond, & Tatlow, 2004). Alternatively, the joint subsystems hypothesis, suggests BIS and BAS are dependent and demonstrated combined effects in the presence of rewarding or punishing stimuli (Gomez et al., 2004). The extant literature has primarily examined BIS and BAS as separable systems, in part, due to limitations in available measurement tools. Nevertheless, given the current findings, it is prudent to consider the possible interdependent relationship between the two systems regarding reward and punishment sensitivity.

Electroencephalographic evidence for RST has consistently shown greater left (than right) resting baseline cortical activity for BIS; whereas BAS has demonstrated greater right (than left) baseline asymmetry (Sutton & Davidson, 1997). Another aim of this study was to examine subjective sleep quality within the RST framework, but results failed to show any significant relationships with EEG resting asymmetry data. Nevertheless, when examining the resting asymmetry data independent of sleep, there were findings consistent with the RST literature. The present study found that greater relative left (than right) cortical baseline activation was significantly positively related to BAS scores, specifically, the BAS-Reward Responsiveness subscale. As part of the greater Behavioral Activation System, BAS-Reward Responsiveness is thought to represent the ability to experience pleasure in the presence or anticipation of reward (Taubitz, Pedersen, & Larson, 2015). Together, these EEG findings lend support to prior research suggesting individuals with greater left than right cortical activation at baseline self-report greater sensitivity to reward and approach-related behaviors (Sutton & Davidson, 1997).

ERP amplitudes and latencies in relation to subjective sleep quality. Another aim of

the present study was to investigate the information processing of affective sleep-related imagery. Previous research by Yang and Lo (2007) examined ERP amplitudes and latencies in response to an auditory oddball tasks. They found that individuals with insomnia exhibited larger N100- and smaller P200-amplitudes to rare tones when compared to their non-sleep disordered counterparts. Contrary to these findings, the present study did not support these differences in ERP amplitudes and latencies in good and poor sleepers, although several results just fell short of statistical significance.

One explanation for our insignificant results pertains to power and sample size. The sample size for statistical tests analyzing ERP data was significantly reduced due to EEG artifact. The reduced sample had limited statistical power for multivariate analyses, particularly when controlling for familywise error. This analysis was further complicated when considering differences in group size such that there were 31 participants comprising the poor sleepers group and a mere 6 in the good sleepers group.

Another explanation for the lack of significant results might relate to the use of experimental stimuli. A growing literature has explored the role of mental imagery in specific psychological disorders. Individuals living with illness anxiety disorder experience more mental imagery about death and illness (Wells & Hackman, 1993), whereas people with insomnia experience imagery associated with sleep and intimate relationships more frequently but also with more intense emotional and physical distress (Harvey, 2000; Nelson & Harvey, 2003). The present study piloted the use of valenced sleep-related images to investigate these identified information processing differences between good and poor sleepers. Despite the apparent face validity and statistical findings (i.e., means and standard deviations for the domains of valence, arousal, and dominance), additional psychometric investigation is warranted.

While the primary analyses fell short of statistical significance, exploratory analyses found higher global PSQI scores to be associated with attenuated P300 amplitudes for positively-valenced target images and greater P300 amplitudes for negatively-valenced target images. Moreover, predictive modeling identified P300 ERP components to be attenuated as overall subjective sleep quality increased. These findings might best be understood within the context of attentional biases. Attentional biases are cognitive tendencies, such as thinking patterns, which shape our perception. They have been extensively studied in clinical research for psychiatric conditions such as anxiety (Bar-Haim et al., 2007) and depression (Ilardi et al., 2007). Moreover, condition-specific attentional biases have shown increased P300 amplitudes when confronted with condition-relevant stimuli. For instance, depressed individual have shown increased P300 amplitudes when presented negatively-valenced words associated with a depressed thinking style (i.e., "Loser", "Tired," and "Worthless"; Ilardi et al., 2007). However, study of attentional biases has more recently been applied to insomnia (Harris et al., 2015). Attentional biases coexisting with insomnia are hypothesized to create a tendency or pre-occupation with sleep and sleep-related information. Extrapolation of the previous research to the current study might explain the poor sleepers' larger P300 amplitudes in response to negatively-valenced sleep images. Of course, this assumption would need to be elucidated with a more focused follow-up study.

Neuropsychological sequelae in poor and good sleepers. A specific aim of this present study was to investigate whether self-reported sleep quality was sensitive to performance on a well-established measure of sustained attention. It was hypothesized that people endorsing poorer sleep quality would have worse performance on the PVT. This outcome, however, was not indicated in the present study. When considering performance on neuropsychological measures of psychomotor vigilance, there were no significant differences in PVT performance

metrics between poor sleepers and good sleepers (based on PSQI classification) or participants experiencing no clinical symptoms-, subthreshold symptoms-, or moderate symptoms of insomnia.

There are several possible explanations for the lack of significant findings which might relate to the sample size, study methodology, and operational definition and conceptualization of sleep quality. As previously noted, a larger sample size would increase the overall power of the statistical analyses conducted for this investigation. Although the overall sample size consisted of 75 participants and was considered adequate for obtaining robust findings, application of the grouping criteria formed grossly unbalanced groups. This likely affected the probability of obtaining statistical significance. In fact, findings from a statistical simulation study conducted by Rusticus and Lovato (2014) highlighted the detrimental influence of sample size on type I error rates of equivalence tests. Their recommendations to manage suboptimal data included 1) collecting as many data as possible, and 2) attempt to balance all group sizes. This limitation might be addressed by first administering the PSQI as a screening tool to identify poor sleeper and good sleeper status, and later inviting an equal number of good and poor sleepers to complete the remaining portion of the study. The present study's methodology also might have played a larger role—particularly regarding the psychomotor vigilance task. Typically PVTs are typically 10 minutes or longer in duration. to improve sensitivity to poor sleep and sleep deprivation; however, PVTs less than 10 minutes have also been found to be valid and reliable in identifying people affected by sleep loss (Loh, Lamond, Dorrian, Roach, & Dawson, 2004). In an attempt to reduce participant burden, the present study employed the use of a 5-minute PVT, which might have contributed to the lack of significant findings among PVT performance metrics and sleep variables. The vague operational definition of "sleep quality" was yet another

potentially limiting factor. Previous literature regarding sleep has demonstrated reduced performance on psychomotor tasks in people deprived of sleep (Basner & Dinges, 2011). In an attempt to better conceptualize "sleep quality," Harvey, Stinson, Whitaker, Moskovitz, and Virk (2008) conducted a detailed systematic investigation of the subjective meaning of "sleep quality" in a sample of normal sleepers and those diagnosed with clinical insomnia. They found that reported sleep quality reflected feeling rested upon waking, feeling restored upon waking, and having energy throughout the day. Psytchomotor Vigilence Tasks are most frequently used in the study of sleep deprivation. As sleep deprivaton was not the variable of interest in the present study, it might be unwise to assume that those individuals likely experiencing poor sleep quality (i.e., lack of alertness, lack of feeling restored, lack of feeling rested) may or may not be sleep deprived.

Exploratory analyses examining relationships between specific PSQI components scores and PVT performance showed weak but statistically significant relationships. Specifically, relationships between sleep efficiency and PVT performance metrics suggested that greater self-reported daytime dysfunction and sleep quality were associated with poorer PVT performance. These findings are consistent with the sleep literature regarding the deleterious effects of poor sleep on sustained attention. However, quite unexpected was the finding that higher sleep efficiency component scores (indicating poorer sleep efficiency) were associated with better PVT performance. One might assume that findings might better be explained by examining all the relationships together. For instance, poorer efficiency was associated with greater response times (slower), which perhaps contributed to less errors and better performance by allowing individuals more time to respond accurately.

Additional exploratory analyses of personality and neuropsychological performance

highlight an interesting association between PVT performance and the behavioral inhibition and activation systems. Findings showed that higher levels of behavioral inhibition were associated with better PVT performance (i.e., fewer errors), but only in those individuals endorsing poor sleep quality. This finding might best be understood when considering the behavioral inhibition system as being associated with failure avoidance. Individuals with higher levels of self-reported BIS perhaps were working hard to avoid mistakes, especially when aware of the fact they are poorly rested.

Dysfunctional beliefs and subjective sleep quality. The present study predicted poor and good sleepers (as per PSQI cutoffs) would differ in their beliefs and attitudes about sleep. Specifically, poor sleepers were expected to have more maladaptive beliefs and attitudes about sleep as compared to their better-rested counterparts. This hypothesis was driven by the work of Harvey (2002) and the neurocognitive model of disordered sleep which emphasize the significant contribution of dysfunctional beliefs about sleep (and the resultant cognitive arousal) in precipitating and perpetuating disordered sleep.

Consistent with previous research, the present study showed that dysfunctional beliefs and attitudes about sleep significantly contributed to subjective sleep quality. Poor sleepers, in general, held stronger maladaptive beliefs about sleep, especially sleep-related themes highlighting the negative consequences of insomnia and worry about sleep. In fact, items relating the health consequences of insomnia (item 5), reduced daily functioning (item 10), and disrupted mood (item 12) best discriminated poor sleepers from good sleepers. Whereas, stronger beliefs regarding sleep expectations (strongly agreeing with statements suggesting the need for eight hours of sleep nightly [item 1] and the need to catch up on sleep loss [item 2]) better identified good sleepers. Furthermore, the present study found that dysfunctional beliefs and attitudes about

sleep were at least a partial mediator contributing to poor sleep. These findings, when taken together, lend support to the cognitive and neurocognitive models of disordered sleep.

From a professional standpoint, the DBAS-16 demonstrates clinical utility in identifying at-risk individuals who will allow for the implementation of behavioral health treatment approaches. These interventions, aimed at teaching better sleep habits (behavioral therapy) or changing dysfunctional beliefs and attitudes about sleep (cognitive therapy), are extremely efficacious at treating disordered sleep (Harvey et al., 2014). However, combined cognitive behavioral therapy showed the most efficacy for treating insomnia due to the initiation fast-acting behavioral components (implementation of sleep hygiene, stimulus control, and standard sleep/wake times) in addition to the slow-acting but long-lasting cognitive components (changing maladaptive beliefs about sleep; Harvey et al., 2014). Plus, cognitive behavioral treatment has been validated in a group format, which allows for the provision of treatment services to a larger subset of people when individual therapy might not be feasible (Koffel, Koffel, & Gehrman, 2015).

General Strengths and Limitations of the Present Study

This study was an exploratory investigation of sleep quality among a non-clinical, university student population. One of the notable strengths of this study is the use of a university student population. Research has suggested that university students represent a vulnerable population, especially with regard to the risk of developing disordered sleep. The majority of university students are experiencing natural physiological changes related to late adolescence which predisposes them to a delayed sleep phase (Carskadon, Acebo, & Jenni, 2004). These biological changes coupled with the social and academic pressures associated with academia increase the risk for developing sleep difficulties in college. Moreover, this increased risk for

sleep difficulties has been associated with college performance (GPA) and persistence (good academic standing versus risk for probation or expulsion; Gaultney, 2010; Jenson, 2004). The present study was able to add to the extant sleep literature by extending our understanding of university students' sleep via exploration of neuropsychological and neurophysiological features associated with subjective sleep quality.

Despite its strengths, the present study is not without limitations—many of which were described previously. One such limitation was the variability in defining the construct of sleep quality. Many times the term "insomnia" is used interchangeably with other terms including "sleep quality" and "sleep impairment." Poor sleep quality was defined as endorsement of difficulties in any of the following areas of sleep behavior: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction. This definition is consistent with the primary measure—the Pittsburgh Sleep Qualtiy Index. The more self-reported or perceived difficulties endorsed on this measure coincided with poorer overall sleep quality (Buysse et al., 1989).

Relatedly, another issue to consider is how much of participants' poor sleep quality was contextually determined. With an undergraduate population, there might be a greater prevalence of external influences (e.g., noisy environment, large amount of coursework, and social pressures) that is limiting sleep quality whereas other samples might be limited by factors more closely tied to internal difficulties such as pre-sleep worry and neurophysiological disturbances. Unfortunately, external influences were not directly addressed or accounted for within the current study. Future research with university populations should consider external factors, especially those unique to the collegiate setting including shared living situations (dorm rooms and fraternity and sorority housing)

in addition to the amount of coursework.

Another limitation related to the classification of participants' level of sleep quality. The PSQI, used to assess this construct, provides specific cutoffs to dichotomize the variable of sleep quality into two groups: "good sleepers" and "poor sleepers" (Buysse, 1989). Consequently, a dichotomized variable contributes to a reduction in statistical power, loss of information about individual differences, and spurious statistical relationships (Altman & Royston, 2006; MacCallum, Zhang, Preacher, & Rucker, 2002). Because sleep quality is represented on a continuum, the total score obtained on the PSQI was treated as a continuous variable with higher scores indicating more disturbed sleep and poorer sleep quality. However, some analyses were dependent on group comparisons and thus were susceptible to reduced statistical power from dichotomizing.

The use of newly normed experimental stimuli presented as another limitation of the current study. Statistical analyses were quite limited due to participant attrition (approximately 52% of participant finished the pilot study in its entirety). The number of participant ratings for the experimental stimuli ranged from 85 to 163. Nevertheless, preference was given to those images a greater response rate would improve the psychometric properties.

Lastly, the sample size of a study greatly influences the amount of statistical power in the analysis process. Because of this study's purpose, time constraints, and non-clinical population (undergraduate participant pool within the departments of psychology and neuroscience), a larger sample was not feasible. Consequently, the reduced sample size posed the risk of increasing the probability of underpowered statistical analyses.

Concluding Remarks

This present investigation provides one of the first comprehensive exploratory analyses

of the neuropsychological and neurophysiological features associated with subjective sleep quality. Given that disordered sleep cannot always be measured objectively through extensive laboratory sleep studies (Harvey et al., 2008), enhancing our understanding of the overt impact of subjective sleep quality is essential to developing better treatments for addressing the cognitive, behavioral, and emotional features associated with disordered sleep. Key findings of the present study underscore the importance of individual differences associated with subjective sleep quality and those aspects which might be most amenable to change through cognitive and behavioral treatments.

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APPENDIX A: IRB DOCUMENTATION

East Carolina University

Informed Consent to Participate in Research
Information to consider before taking part in research
that has no more than minimal risk.

Title of Research Study: Affective Ratings of Sleep-Related Images
Principal Investigator: Eric Watson, MS
Faculty Supervisor: D. Erik Everhart, Ph.D., ABPP-CN, CBSM
Institution/Department or Division: East Carolina University
Address: 237 Rawl Building, Department of Psychology, East Carolina University
Telephone #: (252) 328-4138
Email: Watsone11@students.ecu.edu

Why is this research being done?
The neurocognitive model (also known as the "hyperarousal" model) posits that sleep impairment is the result of somatic and cortical arousal stimulated by objects, images, and sounds in the sleep environment. The current study proposes to investigate the self-reported affective components (i.e., valence, arousal, and dominance) underlying sleep-related images. The study will also examine the relationship between ratings of the sleep-related images to self-reported measures of personality, reward-sensitivity, and threat-sensitivity. The data from this study, namely the normed ratings of the sleep-related images, will then be used in a larger dissertation project examining the psychophysiological and electroencephalographic features of subjective sleep quality.

Additionally, due to the theorized relationship between sleep-related stimuli and subjective sleep quality, this study may identify evidence to support the neurocognitive model of sleep impairment, which ultimately provides greater insight into the development and maintenance of sleep impairment. Findings from this pilot investigation may lead to the development of improved cognitive and behavioral treatments for poor sleep.

Why am I being invited to take part in this research?
You are being invited to take part in this research because you are currently enrolled in a psychology or neuroscience course at East Carolina University. This study provides an opportunity for you to earn credit toward the research activity requirement (if applicable). If you volunteer to take part in this research, you will be one of about several hundred people to do so.

Are there reasons I should not take part in this research?
Participating in this study is voluntary. You may decide to withdraw from this study at any time without penalty.

What other choices do I have if I do not take part in this research?
You can choose not to participate.

Where is the research going to take place and how long will it last?
The research will be conducted in an online medium using an automated survey administrator (Qualtrics). By participating in this research study, you will be donating approximately 60 - 90 minutes of your time to complete the questionnaires.

What will I be asked to do?
You are being asked to do the following:

- Read this informed consent document.
- Complete a series of questionnaires presented to you online
- View and react/rate sleep-related images according to pleasure, arousal (cognitive/physical), and control

What possible harms or discomforts might I experience if I take part in the research?
There is a very slight chance that you may experience unwanted emotions from answering the questionnaires. Also, several of the images may depict or imply sexual content. For instance, various individuals and couples are shown in images related to sleep and other bedroom activities.

Nevertheless, it has been determined that the risks associated with this research are no more than what you would experience in everyday life.

What are the possible benefits I may experience from taking part in this research?
For your participation you will receive one participation credit toward your psychology or neuroscience course's research requirement (if applicable). If participating while enrolled in a Summer Session, you may be eligible for extra credit if your professor so chooses. Additionally, the information you provide in this study may be helpful in understanding sleep including sleep patterns and the relation of sleep quality with personality traits.

Will I be paid for taking part in this research?
We will not be able to pay you for the time you volunteer while being in this study.

What will it cost me to take part in this research?
It will not cost you any money to be part of the research.

Who will know that I took part in this research and learn personal information about me?
To do this research, ECU and the people and organizations listed below may know that you took part in this research and may see information about you that is normally kept private. With your permission, these people may use your private information to do this research:

- Any agency of the federal, state, or local government that regulates human research. This includes the Department of Health and Human Services (DHHS), the North Carolina Department of Health, and the Office for Human Research Protections.
- The University & Medical Center Institutional Review Board (UMCIRB) and its staff, who have responsibility for overseeing your welfare during this research, and other ECU staff

who oversee this research.

How will you keep the information you collect about me secure? How long will you keep it?
Your privacy and confidentiality will be maintained in the following ways. The records of this research will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a participant. Research records will be kept in a locked file, and access will be limited to the researchers, the University review board responsible for protecting human participants, and regulatory agencies. Additionally, identifying information (i.e., name, pirateID, and email) will be the only information linking you to your survey information. This information, as captured via the ExperimenTrak service when you signed up for study participation, will be used to send you a unique link to the study through the Qualtrics Survey Software distributor. This unique link will allow you to begin, save, and return to the survey on any computer at your convenience. This information will also be collected anonymously via a second survey link that is generated once you finish the primary set of surveys and image ratings. This is a Qualtrics autolink to a second survey, where you can enter your information, ensures that you are granted ExperimenTrak credits for you participation. Following the granting of your research participation credits all identifying information will be deleted at the end of the semester, as the research does not require any identifying information for the purposes of this study.

What if I decide I do not want to continue in this research?
If you decide you no longer want to be in this research after it has already started, you may stop at any time. You will not be penalized or criticized for stopping. You will not lose any benefits that you should normally receive (e.g., ExperimenTrak credit), that is, you will still get credit even if you do not complete all the surveys. However, credit offered will be equal to the amount of time and effort reflected in your particpation.

Who should I contact if I have questions?
The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator, Eric Watson by phone: (252) 328-4138 (8:30 am–5:00 pm) or Email: Watsone11@students.ecu.edu. There is no wrong time to ask questions, whether it is before, during, or even after the study, feel free to contact the principal investigator regarding any questions. If you have questions about your rights as someone taking part in research, you may call the Office for Human Research Integrity (OHRI) at phone number (252) 744-2914 (8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director of the OHRI, at (252) 744-1971.

I have decided I want to take part in this research. What should I do now?
Please read each of the following statements carefully and select "YES" or "NO" for each.

1. I have read all of the above information
□ YES
□ NO

2. I understand that I have the opportunity to ask questions (via email to the principal investigator) about things in this research I do not understand before or after completion.
 YES
 NO

3. I understand that I can stop taking part in this study at any time.
 YES
 NO

4. Do you voluntarily agree to take part in this study?
 YES, I voluntarily agree to take part in this study.
 NO, I do not wish to participate.

Thank you for taking the time to participate in my research.

Sincerely,

Eric Watson,
Principal Investigator

APPENDIX B: IRB Documentation (Present Study)

East Carolina University

Informed Consent to Participate in Research
Information to consider before taking part in research
that has no more than minimal risk.

Title of Study: An Investigative Study Of The Neuropsychological and Neurophysiological Features Of Subjective Sleep Quality
Principal Investigator: Eric Watson, MS
Faculty Supervisor: D. Erik Everhart, Ph.D., ABPP-CN, CBSM
Institution/Department or Division: East Carolina University
Address: 237 Rawl Building, Department of Psychology, East Carolina University
Telephone: (252) 328-4138
Email: Watsone11@students.ecu.edu

Why is this research being done?
The purpose of this research is to understand how a person's emotional responses to sleep-related images are associated with their reported sleep quality (i.e., good sleep or bad sleep). It is thought that problems falling asleep, staying asleep, and/or awakening too early from sleep are related to high levels of physical, emotional, or cognitive arousal or stimulation. This may include such things as holding muscle tension, being excited or angered, and worrying prior to bed. Specifically, it is suggested that individuals learn or develop these responses to sleep-related images or experiences.

The present study will also build upon previous studies investigating sleep quality in relation to personality, neuropsychological performance, and emotional and cognitive processing. Furthermore, the results of this study may have implications for further sleep research intended to improve upon identification, diagnosis, and intervention of symptoms related to poor sleep quality prior to the development of a potentially ch ronic sleep disorder. As such, there is particular emphasis on preventive care and overall health promotion.

Why am I being invited to take part in this research?
You are being invited to take part in this research because you are currently enrolled in an introductory psychology course at East Carolina. If you volunteer to take part in this research, you will be one of about 150 people to do so.

Are there reasons I should not take part in this research?
Participating in this study is voluntary. You may decide to withdraw from this study at any time without penalty.

What other choices do I have if I do not take part in this research?
You can choose not to participate.

Where is the research going to take place and how long will it last?
The research will be conducted in the Cognitive Neuroscience Lab, RAWL 237. By participating in this research study, you will be donating approximately 90-120 minutes of your time to complete the questionnaires, electroencephalographic (EEG) recordings, and relevant task.

What will I be asked to do?
You are being asked to do the following:

- Read, review (with principal investigator), and sign this informed consent document expressing your understanding of terms and conditions for your participation
- Complete a series of questionnaires
- Participate in a brief computer task while having EEG recording
- Engage in a Psychomotor Vigilance Task (i.e., reaction time task)

What possible harms or discomforts might I experience if I take part in the research?
There is a very slight chance that you may experience unwanted emotions from answering the questionnaires. Also, several of the images seen via participation in the EEG task may depict or imply sexual content. For instance, various individuals and couples are shown in images related to sleep and other bedroom activities.
Nevertheless, it has been determined that the risks associated with this research are no more than what you would experience in everyday life.

Additionally, some participants may feel fearful or anxious of the EEG component of the research study. As such, each participant will be introduced to the various parts and relevant procedures of EEG recording (e.g., wearing the Quick-Cap with embedded electrodes, allowing the tech to use a blunt syringe for applying conductive gel to the electrodes, sitting in a dark sealed room while performing the computer task etc.). During this time, or at any point during participation, you [the participant] are able to assert your concerns about either the questionnaires or EEG equipment and withdrawal their participation.

What are the possible benefits I may experience from taking part in this research?
The information obtained from this study may be helpful in understanding the development of disordered sleep and inform current intervention guidelines. Additionally, all participants who wish to participate during the Summer of 2015 will be eligible to win a $100 Amazon.com gift card (delivered via email). This is in part because summer participants, particularly students engaging in summer coursework, are not required to accrue research credits as part of their coursework. As such, these individuals will be provided the opportunity to win the aforementioned $100 Amazon.com gift card at the conclusion of the semester (8/03/2015). The winner will be chosen randomly via a random number generator in a statistical program.

Will I be paid for taking part in this research?
We will not be able to pay you for the time you volunteer while being in this study.

What will it cost me to take part in this research?

It will not cost you any money to be part of the research.

Who will know that I took part in this research and learn personal information about me?
To do this research, ECU and the people and organizations listed below may know that you took part in this research and may see information about you that is normally kept private. With your permission, these people may use your private information to do this research:

- Any agency of the federal, state, or local government that regulates human research. This includes the Department of Health and Human Services (DHHS), the North Carolina Department of Health, and the Office for Human Research Protections.
- The University & Medical Center Institutional Review Board (UMCIRB) and its staff, who have responsibility for overseeing your welfare during this research, and other ECU staff who oversee this research.

How will you keep the information you collect about me secure? How long is it kept?
Your privacy and confidentiality will be maintained in the following ways. The records of this research will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a participant. Research records will be kept in a locked file, and access will be limited to the researchers, the University review board responsible for protecting human participants, and regulatory agencies. Additionally, identifying information (i.e., name, pirateID, and email) will be the only information linking you to your survey information. This information will be captured only on this consent form (name and study identification number) and demographic questionnaire (for the purpose granting research credit in SONA ExperimenTrak).

What if I decide I do not want to continue in this research?
If you decide you no longer want to be in this research after it has already started, you may stop at any time. You will not be penalized or criticized for stopping. You will not lose any benefits that you should normally receive (e.g., ExperimenTrak credit), that is, you will still get credit even if you do not complete all the surveys or finish the EEG component. However, credit offered will be equal to the amount of time and effort reflected in your participation.

Who should I contact if I have questions?
The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator, Eric Watson by phone: (252) 328-4138 (8:30 am–5:00 pm) or Email: Watsone11@students.ecu.edu. There is no wrong time to ask questions, whether it is before, during, or even after the study, feel free to contact the principal investigator regarding any questions. If you have questions about your rights as someone taking part in research, you may call the Office for Human Research Integrity (OHRI) at phone number (252) 744-2914 (8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director of the OHRI, at (252) 744-1971.

Thank you for taking the time to participate in my research. Please continue to the next page to get started with your participation.

Sincerely,

Eric Watson,
Principal Investigator

I have decided I want to take part in this research. What should I do now?
Please read each of the following statements carefully and select "YES" or "NO" for each.

1. I have read all of the above information
□ YES
□ NO

2. I understand that I have the opportunity to ask questions (via email to the principal investigator) about things in this research I do not understand before or after completion.
□ YES
□ NO

3. I understand that I can stop taking part in this study at any time.
□ YES
□ NO

4. Do you voluntarily agree to take part in this study?
□ YES, I voluntarily agree to take part in this study.
□ NO, I do not wish to participate.

_____ _____
Participant Name (Print) Date

_____
Participant Signature

_____ _____
Name of Person Obtaining Consent Date

_____
Signature of Person Obtaining Consent

APPENDIX C: SUMMER RECRUITMENT SCRIPT

AN INVESTIGATIVE STUDY OF THE NEUROPSYCHOLOGICAL AND NEUROPHYSIOLOGICAL FEATURES OF SUBJECTIVE SLEEP QUALITY

Recruitment Script (Summer 2015)

Introduction:

"My name is Eric, and I am a fourth-year student in the Clinical Health Psychology Doctoral Program. I am interested in recruiting individuals for a brief survey study examining the psychological, behavioral, and emotional aspects of subjective sleep quality. Additionally, interested persons will have the opportunity to experience an EEG while performing a computer task."

Brief Description:

"The purpose of this research is to understand how a person's emotional responses to sleep-related images are associated with their reported sleep quality (i.e., good sleep or bad sleep). It is thought that problems falling asleep, staying asleep, and/or awakening too early from sleep are related to high levels of physical, emotional, or cognitive arousal or stimulation. This stimulation may include such things as holding muscle tension, being excited or angered, and worrying before bed. Specifically, it is suggested that individuals learn or develop these responses to sleep-related images or experiences.

The present study will also build upon previous studies investigating sleep quality relating to personality, neuropsychological performance, and emotional and cognitive processing. Furthermore, the results of this study may have implications for further sleep research intended to improve upon identification, diagnosis, and intervention of symptoms related to poor sleep quality before the development of a potentially chronic sleep disorder. As such, there is particular emphasis on preventive care and overall health promotion."

Participant Responsibilities:

"The study also examines the relationship of the many different measures (i.e., surveys/questionnaires) for these constructs. The surveys are administered online via a link to your email. It takes approximately 30-45 minutes to complete all surveys and additional 30-45 minutes for to complete the EEG.

Eligibility for Participation:

"To be eligible for this study you must be a student enrolled at East Carolina University or Pitt Community College that is: a) 18 years or older; b) Right handed, as to be consistent with EEG literature and to ensure brain anatomy is consistent (e.g., lateralization and localization of functioning) c) Not have history of head injury in the past 12 months; d) Not have a history of seizure disorder.

Participant Risks/Benefits:

"If you choose to participate, there are potential risks and benefits related to completing the research. For instance, participants may be at risk for unwanted or negative affect in response to the questionnaires or of the equipment used during the EEG process. The quiopment includes using a small blunt syringe to inject gel into the electrodes on the EEG cap and remaining seated

in a recliner in an EEG booth (i.e., a small sound proof booth with the lights off). However, there have been no reports of negative risks involved with the chosen questionnaires or EEG. While participants are not likely to benefit directly from participating in the survey, psychologists may benefit from better understanding the influence of personality, behavior, emotions, and neuropsychology of subjective sleep quality.

Additionally, all participants who wish to participate during the Summer of 2015 will be eligible to win a $100 Amazon.com gift card (delivered via email). This incentive is offered because summer participants, particularly students engaging in summer coursework, are not required to accrue research credits as part of their coursework. As such, these individuals will be provided the opportunity to win those above mentioned $100 Amazon.com gift card at the conclusion of the semester (8/03/2015). The winner will be chosen randomly via a random number generator in a statistical program.

Choosing to Participate:

"If you do wish to participate I will have you write down your name and email address on this signup sheet. From this point, you will be assigned a time slot of your choosing at which time you will arrive at RAWL 237 for your participation. You will be prompted to read the informed consent document, will review this with the researcher, and will sign in person designating your willingness to participate. At this point or any other point during the survey, you may decide to accept or withdrawal your participation. At the completion of the survey, please again provide the necessary information to receive your course credit/incentive."

APPENDIX D: STUDY ADVERTISEMENT

Volunteers Wanted for Research Study

Seeking: Right handed adults (18 years or older) with no history of head injury in the past year

More info: You will not be paid, but are eligible for an Amazon.com gift card raffle for $100.

About the Study:

- Approximately 90 minutes long
- Investigating the Psychology of Sleep Behavior
- Involves the completion of:
  - Electroencephalogram (EEG) & computer task
  - Brief surveys about behavior, emotion, and personality
  - Reaction speed test

Please contact Eric Watson if interested in participating

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APPENDIX E: DEMOGRAPHIC FORM

DEMOGRAPHICS & HISTORY

GENERAL INFORMATION

Age: _____ Year of Education (from 1st Grade): _____

Gender:
MALE_____ FEMALE_____ TRANSGENDER_____

What is your Race Ethinicity:
_____ White/Caucasian
_____ African American
_____ Hispanic
_____ Asian
_____ Native American
_____ Other

Handedness (hand you write with, eat with, throw a ball with):
RIGHT_____ LEFT_____

Do you have normal vision or are you wearing corrective lenses or glasses and can read this document and a computer screen without impairment?
YES_____ NO_____

Do you have normal color vision (not color-blind)?
YES_____ NO_____

Height (inches):
_____

Weight (pounds):
_____

Body Mass Index (BMI):

SLEEP HISTORY

In general, would you describe your sleep as: Refreshing_____ Not Refreshing_____

How would you rate your sleep?

Very Poor	Poor	Adequate	Good	Very Good
1	2	3	4	5

On average, how long does it usually take you to fall asleep?

_____

On average, how many hours do you usually spend in bed a night (asleep and just lying in bed)?

_____

On average, how many hours of sleep do you usually get in a night?

_____

Do you wake up during your sleep?
YES_____ NO_____

If yes, how many times per night?

_____

If awakened, do you have trouble returning to sleep?
YES_____ NO_____

Would you or others say you snore loudly?
YES_____ NO_____ DON'T KNOW_____

Would you say that you have other trouble breathing while you sleep – do you stop breathing, choke, gasp, or struggle for breath?
YES_____ NO_____ DON'T KNOW_____

Would you ever have described yourself as a "GOOD" Sleeper?
YES_____ NO_____

When do you have the highest energy level?
MORNING_____ AFTERNOON_____ EVENING_____

When do you have the lowest energy level?
MORNING_____ AFTERNOON_____ EVENING_____

Indicate which, if any, symptoms you've been having at least weekly during the past month:

☐ Wake up with dry mouth
☐ Problems controlling your blood pressure
☐ Morning headaches
☐ Difficulty concentrating
☐ Other
☐ Difficulty with memory
☐ Feeling Anxious
☐ Disturbing dreams or nightmares
☐ Feeling depressed/moody

Indicate which, if any, of the items listed below wake you up or keep you from sleeping:

☐ Restless legs or leg jerks
☐ Indigestion/Reflux
☐ Needing to use the bathroom
☐ Needing to care for a child, elder, roommate, pet
☐ Other
☐ Needing a drink of water
☐ Racing thoughts/ Can't turn off your mind
☐ Anxiety/ Worry/ Fear
☐ Pain

SLEEP HYGIENE

Please check all that apply:

☐ I watch TV in the bedroom
☐ I work on my computer in the bedroom
☐ I do house work until bedtime
☐ I exercise within 3 hours of bedtime
☐ I am on call at night (either for family or work)
☐ I watch TV until bedtime
☐ I work on my computer until bedtime
☐ I do work for school/job until bedtime
☐ My mind races when I go to bed
☐ I read novels until bedtime

DIETARY FACTORS AFFECTING YOUR SLEEP

I drink _____ ounces of caffeinated coffee before 10:00AM. After 10:00AM _____

I drink _____ ounces of caffeinated cola before 10:00AM. After 10:00AM _____

I drink _____ ounces of caffeinated tea before 10:00AM. After 10:00AM _____

I smoke _____ packs of cigarettes daily.

I drink _____ ounces of beer or _____ ounces of wine or _____ ounces of alcohol daily

I use street drugs or medications for any purposes
YES_____ NO_____

I have used medications to improve my sleep.
YES_____ NO_____

MEDICAL HISTORY

When was your last complete physical exam?
_____

Have you had an overnight sleep study or visited a sleep medicine doctor?
YES_____ NO_____

Have your tonsils and/ or adenoids been removed?
YES_____ NO_____

Have you had any sinus surgeries?

YES_____ NO_____

Do you have any problems with allergies?
YES, seasonal_____ YES, all year round_____ NO_____

Have you had problems with sinuses?
YES, seasonal_____ YES, all year round_____ NO_____

Have you had any sinus infections in the past three years?
YES_____ NO_____

Do you know if or have you ever been told that you grind or clench your teeth?
YES_____ NO_____

Do you have asthma or other lung disease?
YES_____ NO_____

Do you have any gastrointestinal issues (reflux, constipation, diarrhea...)?
YES_____ NO_____

History of head injury/trauma – lost consciousness or blacked out:
YES_____ NO_____

History of seizure disorder:
YES_____ NO_____

Do you have any chronic condition(s) or Disease(s)?
If yes, please list:

Are you taking any medications for your current medical concerns?
If yes, please list name and dosage of any medications:

Do you have a family history of any of the following?

☐ Diabetes
☐ Stroke
☐ Insomnia
☐ Anxiety
☐ Heart Disease
☐ Other
☐ Sleep Apnea
☐ Depression
☐ High Blood Pressure
☐ Restless Leg Syndrome
☐ Thyroid Disease

EMOTIONAL FUNCTIONING

Over the last two (2) weeks, how often have you been bothered by the following problems:

	Not at all	Several days	More than half the days	Nearly every day
Little interest or pleasure in doing things	0	1	2	3
Feeling down, depressed, or hopeless	0	1	2	3
Feeling nervous, Anxious, or on edge	0	1	2	3
Not being able to stop or control worrying	0	1	2	3

APPENDIX F: EXPERIMENTAL STIMULI MEANS AND STANDARD DEVIATIONS

Description	Slide	Valence		Arousal		Dominance		Sample
		M	*SD*	*M*	*SD*	*M*	*SD*	*N*
CPAP - Man	1	2.39	1.44	4.06	2.01	3.79	2.12	163
Crowded Bed – Family	2	6.46	1.77	4.23	2.06	5.43	2.02	161
Fluffy Bed	3	7.15	1.93	4.05	2.66	6.10	2.22	161
Sleep Study - Man	4	3.33	1.54	4.75	1.67	3.50	1.93	160
Older Couple	5	7.80	1.56	5.35	2.31	6.08	1.77	160
Sleeping Children	6	7.24	1.66	4.13	2.11	5.90	1.68	159
Hospital Bed - Man	7	2.58	1.43	4.19	1.92	3.53	1.85	158
Older Couple	8	7.57	1.57	4.53	2.27	5.97	1.78	158
Hospital Bed - Man	9	5.80	1.84	4.91	1.67	5.28	1.75	158
Hospital Bed – Man	10	4.04	1.64	4.46	1.36	4.31	1.63	158
Sleep Mask	11	6.06	1.91	4.30	2.11	5.78	1.90	158
Bedtime Story – Man And Girl	12	6.98	1.73	4.74	2.02	5.72	1.74	158
Couple	13	7.45	1.49	4.69	2.47	6.31	1.71	158
Sleeping Pills	14	3.36	1.58	4.67	1.86	3.81	1.88	158
Comfy Bed	15	7.58	1.48	4.59	2.69	6.57	1.77	157
Comfy Bed	16	7.20	1.56	4.72	2.37	6.31	1.88	157
CPAP – Woman	17	3.00	1.63	4.81	1.80	3.67	1.97	156
Hospital Bed – Man With Infant	18	5.66	2.40	4.71	1.85	4.66	1.98	156
Dog With Owner In Bed - Man	19	7.66	1.42	5.17	2.39	6.39	1.58	156
Sofa Bed	20	4.92	1.99	4.54	1.58	5.01	1.64	156
CPAP – Man	21	3.97	1.63	4.52	1.53	4.29	1.59	155
Texting In Bed – Couple	22	5.52	1.90	4.80	1.73	5.39	1.72	155
Cot	23	4.64	1.96	4.57	1.68	4.75	1.79	155
Fetal Position In Bed – Woman	24	2.38	1.53	4.99	2.09	3.21	2.11	155
Napping Kitten And Puppy	25	8.23	1.09	5.47	2.97	7.02	1.83	155
Distractions In Bed - Family	26	4.95	1.75	4.83	1.57	4.95	1.59	155
Dog At Foot Of Bed	27	6.54	1.82	4.97	2.02	5.69	1.74	155
Food In Bed – Woman	28	5.94	1.73	4.92	1.84	5.63	1.69	155
Food In Bed – Man	29	5.01	1.74	5.05	1.49	5.08	1.75	155
Food In Bed – Woman	30	5.29	1.90	4.95	1.72	5.25	1.76	155
Sleeping Pills	31	3.27	1.65	4.54	1.72	3.77	1.88	153
Awake In Bed – Woman	32	4.59	1.51	4.59	1.47	4.80	1.57	152
Asleep While Studying - Woman	33	3.43	1.54	4.49	1.97	3.98	1.98	149
Child Scared In Bed - Girl	34	3.33	1.77	4.84	1.72	4.09	1.89	149
Dog With Owner In Bed – Man	35	6.80	1.81	4.98	2.15	6.01	1.73	149
CPAP - Man	36	2.65	1.44	4.49	1.84	3.51	1.86	149
Crying Baby With Parents	37	4.00	1.74	5.67	1.80	4.08	1.84	149
Sofa Bed	38	4.82	2.05	4.54	1.68	5.04	1.71	149
Sleeping Pills	39	3.00	1.43	4.88	1.83	3.53	1.85	149
Family In Bed	40	7.16	1.70	4.72	2.30	6.11	1.91	149
Napping Baby	41	7.73	1.58	4.94	2.69	6.46	1.94	149
Sleep Study – Man	42	2.78	1.46	4.71	2.02	3.51	1.99	149

Sleep Study – Woman	43	2.35	1.31	4.60	2.15	3.20	1.97	148
Dog With Owner In Bed - Woman	44	7.07	1.70	4.78	2.33	6.30	1.77	147
Napping Baby	45	7.49	1.51	4.99	2.53	6.38	1.75	147
Hospital Bed	46	4.31	2.11	4.83	1.73	4.66	1.79	146
Working In Bed - Woman	47	6.76	1.77	5.67	1.92	6.18	1.69	144
Asleep With Headphones – Woman	48	6.80	1.64	3.86	2.17	6.25	1.75	144
Breakfast In Bed - Woman	49	7.33	1.49	5.25	2.33	6.49	1.74	144
Hospital Bed – Woman	50	7.07	1.65	5.29	2.35	6.33	1.74	144
Breakfast In Bed – Woman	51	6.64	1.58	5.03	1.92	6.13	1.74	144
Disheveled Bed	52	2.92	1.72	4.77	1.92	4.03	1.85	144
Asleep With Music	53	6.72	1.64	4.25	2.04	6.01	1.77	143
Unhappy Couple	54	2.94	1.52	4.77	1.77	3.75	1.91	143
Asleep With Remote Control	55	5.26	1.62	4.28	1.45	5.17	1.55	142
Asleep At Desk	56	2.84	1.39	5.04	1.85	3.65	1.93	142
Nightmares	57	2.32	1.38	5.59	2.28	3.13	1.95	142
Yawning While Driving	58	3.24	1.39	4.73	1.74	3.79	1.68	142
Comfy Bed	59	6.86	1.78	4.57	2.33	6.22	1.81	142
Computer In Bed	60	4.25	1.69	4.89	1.62	4.51	1.78	142
Tablet In Bed	61	5.09	1.61	4.84	1.60	4.99	1.54	141
TV In Bed	62	4.44	1.54	4.64	1.51	4.76	1.48	141
Asleep On Books	63	3.91	1.50	3.98	1.58	4.37	1.67	139
Asleep On Bench	64	5.11	1.68	4.53	1.43	4.84	1.39	138
Sound Sleep – Woman	65	6.52	1.62	3.96	1.90	6.13	1.63	138
Alcohol In Bed - Woman	66	3.25	1.55	4.93	1.72	3.89	1.81	138
Sore Neck – Woman	67	3.15	1.35	4.84	1.67	4.00	1.60	136
Tablet In Bed – Woman	68	5.34	1.50	4.85	1.34	5.12	1.49	135
Asleep At The Wheel - Man	69	2.56	1.35	5.74	2.05	3.52	1.98	135
Napping Baby	70	7.64	1.49	4.65	2.54	6.14	1.99	135
Distressed Woman	71	3.43	1.44	6.00	1.78	4.36	1.84	135
Drowsy Man	72	3.80	1.46	4.50	1.41	4.26	1.58	135
Relaxing Outdoors – Man	73	7.35	1.57	4.24	2.40	6.75	1.75	135
Frustrated Couple	74	3.59	1.41	5.09	1.50	4.51	1.68	135
Drowsy Driving – Man	75	2.68	1.39	5.19	2.01	3.70	1.89	135
Exhausted Man	76	4.15	1.58	4.50	1.62	4.52	1.40	133
Watching Clock – Woman	77	4.22	1.46	4.52	1.47	4.41	1.52	133
Sound Sleep – Woman	78	6.59	1.76	3.87	1.92	5.94	1.80	133
Watching Clock – Woman	79	3.99	1.35	5.00	1.47	4.57	1.42	133
Children Napping In Car	80	6.34	1.65	4.31	1.74	5.65	1.47	131
Children Napping In Bed	81	6.88	1.62	4.26	1.97	6.02	1.61	131
Napping Toddler	82	7.21	1.55	4.08	2.23	6.27	1.77	131
Yawning – Woman	83	3.96	1.42	4.23	1.33	4.34	1.37	131
Sound Sleep – Couple	84	6.74	1.74	3.99	2.02	6.18	1.73	131
Bed With Mosquito Net	85	5.78	1.97	4.47	2.03	5.51	1.84	131
Hospital Bed – Man	86	3.19	1.49	4.75	1.71	3.82	1.74	131

Asleep On Couch – Man	87	6.47	1.65	4.03	1.82	5.98	1.61	131
Stretching In Bed - Man	88	6.75	1.61	5.13	1.96	6.38	1.66	131
Dorm Bed	89	6.07	1.80	5.05	1.73	5.74	1.76	131
Dorm Bed	90	4.97	1.87	5.00	1.60	5.01	1.74	131
Sound Sleep – Pregnant Woman	91	6.93	1.78	5.27	2.31	6.07	1.84	131
Cell Phone In Bed - Child	92	4.48	1.47	4.82	1.23	4.83	1.49	131
Stretching In Bed – Woman	93	7.01	1.50	5.24	2.09	6.54	1.51	130
Newspaper In Bed- Man	94	5.92	1.47	4.49	1.42	5.89	1.42	129
Snoring In Bed – Couple	95	3.64	1.53	5.21	1.55	4.23	1.70	129
Drowsy Physician – Woman	96	3.91	1.44	4.82	1.42	4.38	1.65	129
Frustrated In Bed – Woman	97	3.30	1.42	4.82	1.42	4.09	1.60	129
Sleep Mask – Woman	98	5.76	1.54	4.15	1.52	5.28	1.43	128
Sound Sleep – Couple	99	5.04	1.69	4.35	1.52	5.48	1.56	128
Asleep In Class – Woman	100	4.06	1.39	4.24	1.37	4.42	1.60	127
Asleep On Couch – Woman	101	4.03	1.54	4.68	1.48	4.25	1.56	127
Asleep On Couch – Man	102	4.33	1.47	4.55	1.26	4.55	1.52	127
Sleeping Child – Boy	103	6.35	1.74	3.93	1.78	5.79	1.72	127
Texting In Bed – Man	104	3.89	1.57	4.93	1.40	4.50	1.59	126
Covered In Blankets – Person	105	5.50	1.82	4.28	1.66	5.41	1.55	126
Sleeping Student – Man	106	4.63	1.59	4.55	1.36	4.77	1.39	126
Studying In Bed – Women	107	5.32	1.46	5.01	1.22	5.05	1.40	126
Disheveled Bed	108	6.21	1.82	4.80	2.20	5.98	1.77	125
Sleeping Student - Woman	109	4.26	1.47	4.63	1.38	4.38	1.44	125
Sore Neck – Woman	110	4.39	1.46	4.70	1.28	4.78	1.42	125
Yawning At Work – Man	111	4.05	1.33	4.39	1.34	4.32	1.33	124
Frustrated In Bed – Man	112	3.51	1.33	4.57	1.52	4.08	1.42	124
Scared In Bed – Boy	113	2.56	1.52	6.40	2.09	3.54	2.03	123
Frustrated In Bed – Woman	114	3.02	1.46	4.92	1.79	3.85	1.74	123
Scared In Bed – Woman	115	2.65	1.52	5.70	2.17	3.43	1.94	123
Scared In Bed – Woman	116	2.89	1.48	5.60	2.18	3.60	1.78	123
Scared In Bed – Woman	117	2.82	1.42	5.67	2.03	3.50	1.71	123
Scared In Bed – Girl	118	2.99	1.45	5.37	1.84	3.75	1.65	123
Scared In Bed – Boy	119	2.31	1.40	6.12	2.36	3.18	2.08	123
Stretching In Bed – Woman	120	6.61	1.62	4.38	1.99	6.15	1.77	122
Stretching In Bed – Woman	121	6.95	1.45	4.68	2.03	6.38	1.65	122
Stretching In Bed – Woman	122	7.06	1.46	4.88	2.15	6.58	1.64	122
Happy Awakening – Woman	123	6.84	1.39	4.53	2.03	6.36	1.60	121
Frustrated In Bed – Woman	124	3.14	1.37	5.08	1.67	4.00	1.71	120
Napping Toddler	125	6.63	1.83	3.99	1.98	6.04	1.72	120
Napping Toddler	126	7.22	1.53	3.99	2.22	6.28	1.77	119
Sound Sleep – Couple	127	6.50	1.71	4.27	2.00	6.21	1.71	118
Sleeping Kitten	128	7.26	1.60	4.77	2.41	6.35	1.80	118
Sleeping Kitten	129	7.33	1.61	4.81	2.47	6.38	1.78	117
Exhausted With Coffee Cup – Man	130	3.38	1.65	4.62	1.59	4.11	1.72	116
Asleep At Work – Woman	131	3.67	1.47	4.59	1.40	4.08	1.62	115

Asleep In Meeting – Men	132	3.97	1.67	4.25	1.53	4.29	1.67	115
Yawning In Class – Man	133	3.75	1.48	4.42	1.50	4.28	1.60	115
Asleep On Subway – Woman	134	3.61	1.46	4.26	1.41	4.42	1.68	115
Watching Clock – Woman	135	4.10	1.35	4.63	1.27	4.44	1.45	115
Working In Bed – Woman	136	4.10	1.54	4.41	1.43	4.44	1.52	115
Computer In Bed – Woman	137	4.18	1.36	4.94	1.26	4.58	1.55	115
Computer In Bed – Man	138	4.61	1.37	4.82	1.16	4.81	1.33	114
Computer In Bed – Woman	139	4.54	1.16	4.69	1.14	4.71	1.38	114
Computer – Woman	140	4.00	1.27	4.83	1.37	4.59	1.56	112
Working In Bed – Man	141	4.12	1.30	4.77	1.37	4.49	1.57	112
Computer In Bed – Woman	142	3.82	1.34	4.41	1.41	4.45	1.62	112
Frustrated In Bed – Woman	143	3.24	1.35	5.06	1.51	4.07	1.64	112
Awake In Bed – Couple	144	3.69	1.31	5.08	1.39	4.17	1.56	112
Frustrated In Bed – Woman	145	3.24	1.25	4.94	1.52	3.99	1.60	111
Frustrated In Bed – Man	146	3.57	1.27	4.80	1.44	4.12	1.47	111
Awake In Bed – Woman	147	3.80	1.46	4.71	1.39	4.21	1.47	110
TV In Bed – Couple	148	5.02	1.42	4.48	1.27	5.09	1.49	110
Frustrated In Bed – Man	149	3.50	1.48	4.84	1.63	4.02	1.50	109
Frustrated In Bed – Man	150	3.84	1.26	4.72	1.32	4.29	1.34	108
Frustrated In Bed – Woman	151	3.66	1.28	4.73	1.46	4.11	1.37	108
Frustrated In Bed Woman	152	3.67	1.29	4.67	1.49	4.21	1.33	108
Resting In Grass – Man	153	5.42	1.78	4.40	1.55	5.49	1.55	108
Asleep On Subway – Man	154	3.96	1.46	4.60	1.37	4.47	1.45	108
Dog With Owners In Bed	155	6.58	1.67	4.50	1.92	6.09	1.61	108
Frustrated In Bed – Man	156	3.43	1.39	4.79	1.43	4.11	1.51	107
Frustrated In Bed – Man	157	4.01	1.48	4.56	1.27	4.56	1.39	105
Puppy Sleeping	158	6.85	1.68	4.75	2.07	5.98	1.76	105
Puppy Sleeping	159	6.90	1.56	4.69	2.12	6.14	1.76	105
Puppy Sleeping	160	7.17	1.71	4.80	2.45	6.26	1.90	105
Happy Awakening – Woman	161	6.88	1.37	4.93	2.11	6.37	1.67	105
Studying In Bed – Woman	162	5.25	1.18	4.86	1.06	5.37	1.41	105
Sleep Mask – Man	163	5.12	1.23	4.59	1.32	5.22	1.36	104
Asleep In Work Clothes – Man	164	5.64	1.47	4.55	1.44	5.40	1.46	104
Yawning – Woman	165	4.33	1.15	4.57	1.14	4.85	1.20	104
Asleep In Class – Man	166	3.92	1.34	4.64	1.28	4.58	1.53	104
Asleep At Lunch – Man	167	4.05	1.38	4.68	1.34	4.51	1.46	104
Alarm Clock – Man	168	4.28	1.31	4.94	1.37	4.56	1.56	104
Snoring – Upset Woman	169	3.52	1.44	5.02	1.63	4.20	1.54	104
Snoring – Upset Woman	170	4.10	1.44	5.02	1.39	4.58	1.51	103
Snoring – Upset Woman	171	4.27	1.53	5.02	1.40	4.60	1.49	103
Frustrated In Bed – Woman	172	4.08	1.30	4.66	1.20	4.49	1.45	103
Asleep From Studying – Man	173	3.60	1.52	4.75	1.64	4.32	1.69	103
Snoring – Upset Woman	174	4.01	1.52	4.72	1.47	4.70	1.66	103
TV In Bed – Woman	175	4.65	1.14	4.70	1.27	4.81	1.26	103
TV In Bed – Woman	176	4.45	1.34	4.77	1.22	4.77	1.36	103
Alarm Clock – Man	177	4.06	1.39	4.76	1.42	4.47	1.60	103

Alarm Clock – Man	178	3.97	1.27	4.92	1.38	4.41	1.50	103
Stretching In Bed – Woman	179	6.03	1.32	4.68	1.54	5.81	1.41	103
Asleep With Book In Bed – Woman	180	4.85	1.46	4.40	1.36	5.17	1.49	102
Frustrated In Bed – Couple	181	3.83	1.54	4.81	1.34	4.28	1.65	101
Asleep With Book In Bed – Woman	182	5.32	1.39	4.59	1.43	5.43	1.34	100
Alarm Clock – Woman	183	5.34	1.34	4.56	1.38	5.50	1.45	100
Asleep At Work – Man	184	3.91	1.40	4.68	1.61	4.43	1.67	100
Asleep At Desk* - Man	185	3.52	1.50	4.90	1.60	4.21	1.68	98
Asleep With Remote* - Woman	186	4.80	1.24	4.60	1.25	4.91	1.45	98
Asleep In Grass – Woman	187	6.88	1.45	4.24	1.99	6.41	1.62	98
Snoring – Upset Woman	188	3.62	1.47	5.21	1.54	4.19	1.63	98
Snoring – Upset Woman	189	3.26	1.55	5.37	1.79	4.16	1.93	98
Sleep Mask – Woman	190	6.24	1.61	3.87	1.93	5.89	1.72	98
Hospital – Woman	191	3.32	1.55	4.91	1.72	3.89	1.60	97
Checking Phone In Bed* - Woman	192	3.92	1.30	4.90	1.45	4.45	1.62	96
Studying – Man	193	3.81	1.43	4.92	1.46	4.40	1.53	96
Alarm Clock – Woman	194	3.68	1.49	4.89	1.56	4.18	1.62	94
Sleeping Baby	195	7.23	1.75	4.30	2.39	6.55	1.70	93
CPAP – Man	196	3.25	1.42	4.81	1.76	3.69	1.54	93
Sleeping Kitten	197	7.41	1.54	4.68	2.51	6.50	1.74	93
Physician Sleeping – Man	198	3.82	1.51	4.72	1.50	4.56	1.57	93
Asleep At Work – Man	199	3.73	1.54	4.67	1.52	4.26	1.59	93
Student Sleeping – Boy	200	4.13	1.56	4.59	1.42	4.46	1.54	93
Exhausted In Bed – Man	201	3.56	1.32	4.94	1.30	4.25	1.47	93
Yawning – Woman	202	4.36	1.43	4.71	1.27	4.72	1.24	93
Alarm Clock – Man	203	4.14	1.34	4.78	1.32	4.52	1.50	93
Asleep In Class – Man	204	3.77	1.40	4.81	1.43	4.29	1.62	93
Alarm Clock – Woman	205	3.98	1.53	4.80	1.56	4.31	1.49	93
Exhausted Mother With Child	206	4.86	1.68	5.13	1.39	4.81	1.54	93
Stretching In Bed – Woman	207	6.35	1.40	4.86	1.70	6.20	1.42	92
Stretching In Bed – Woman	208	6.69	1.39	5.00	1.99	6.37	1.44	92
Snoring – Upset Woman	209	3.88	1.72	5.21	1.60	4.30	1.64	92
Awake In Bed – Man	210	3.17	1.37	5.39	1.91	3.99	1.72	92
Frustrated In Bed – Woman	211	3.93	1.42	4.81	1.38	4.38	1.50	92
Sound Sleep – Woman	212	6.20	1.55	4.20	1.81	5.93	1.55	92
Rubbing Face – Woman	213	4.85	1.41	4.71	1.30	4.91	1.22	92
Drowsy Driving – Man	214	3.79	1.35	5.05	1.45	4.26	1.54	92
Sound Sleep – Woman	215	5.68	1.41	4.27	1.36	5.38	1.39	92
Sound Sleep – Woman	216	6.32	1.46	4.24	1.69	6.13	1.52	92
Drowsy Driving – Man	217	3.42	1.64	5.21	1.72	3.96	1.65	92
Asleep On Beach – Man	218	6.85	1.71	4.17	2.09	6.40	1.76	92
Frustrated In Bed – Man	219	3.75	1.41	4.98	1.57	4.28	1.59	92
Snoring – Man	220	5.31	1.55	4.46	1.51	5.17	1.42	92

Snoring – Woman	221	6.42	1.44	4.26	1.65	6.09	1.44	92
Sleeping Cat	222	7.11	1.76	4.49	2.23	6.53	1.74	92
Sleeping Physician – Man	223	4.02	1.57	4.97	1.52	4.38	1.53	92
Tired – Man	224	3.97	1.39	4.81	1.44	4.52	1.61	92
Sleeping Baby	225	7.13	1.61	4.19	2.17	6.23	1.81	92
Sleeping Toddler	226	7.01	1.56	4.30	2.12	6.22	1.79	92
Stretching In Bed – Woman	227	5.59	1.25	4.71	1.31	5.58	1.21	92
Exhausted With Coffee Cup – Man	228	3.67	1.44	4.99	1.44	4.11	1.54	92
Sleeping At Work – Man	229	3.59	1.55	4.78	1.48	4.09	1.58	92
Asleep In Library – Woman	230	4.06	1.65	4.47	1.49	4.56	1.55	92
Asleep At Work – Woman	231	4.11	1.48	4.30	1.40	4.53	1.48	92
Child Sleeping	232	6.54	1.65	4.26	1.76	5.94	1.61	92
Sound Sleep – Older Couple	233	6.39	1.49	4.32	1.85	6.20	1.53	91
Fetal Position In Bed – Man	234	5.91	1.53	4.48	1.74	5.92	1.55	91
Sleeping Kitten	235	7.44	1.60	5.11	2.61	6.64	1.80	91
Sound Sleep – Woman	236	6.93	1.57	4.53	2.16	6.51	1.62	91
Sleeping Cat	237	7.24	1.74	5.02	2.36	6.54	1.85	91
Alarm Clock – Woman	238	6.78	1.49	4.66	2.06	6.45	1.66	91
Sound Sleep – Woman	239	6.73	1.63	4.72	2.04	6.46	1.58	91
Sound Sleep – Man	240	6.32	1.41	4.35	1.67	6.13	1.53	91
Sound Sleep – Couple	241	6.66	1.47	4.37	1.99	6.26	1.67	91
Sound Sleep – Woman	242	6.93	1.42	4.43	2.07	6.39	1.60	91
Asleep In Airport	243	3.74	1.65	4.98	1.56	4.19	1.67	91
Yawning At Work – Man	244	4.42	1.44	4.85	1.28	4.73	1.35	91
Snoring – Upset Man	245	4.03	1.51	5.14	1.41	4.51	1.52	91
Sleeping Rat	246	7.08	1.84	4.95	2.34	6.54	1.76	91
Sleeping Toddler* - Boy	247	6.98	1.61	4.63	2.29	6.50	1.63	90
Child Sleeping In Car – Girl	248	5.66	1.45	4.77	1.58	5.49	1.40	90
Asleep In Tight Quarters	249	4.19	1.55	5.10	1.31	4.60	1.59	89
Child Sleeping In Car – Girl	250	4.61	1.41	4.64	1.28	4.85	1.59	89
Exhausted After Work – Man	251	4.28	1.37	4.75	1.37	4.60	1.39	89
Yawning – Man	252	4.34	1.34	4.80	1.27	4.55	1.32	89
Bear Sleeping In Tree	253	6.85	1.56	4.71	2.00	6.19	1.61	89
Cell Phone In Bed – Man	254	4.55	1.37	4.86	1.10	4.94	1.37	89
Sleeping Toddler – Girl	255	6.83	1.56	4.53	2.11	6.23	1.63	89
Stretching In Bed – Woman	256	6.57	1.46	4.87	1.82	6.20	1.41	89
Sound Sleep – Couple	257	6.80	1.47	4.71	1.98	6.42	1.45	88
Frustrated In Bed – Man	258	3.71	1.27	4.90	1.45	4.41	1.43	88
Asleep On Bench – Man	259	4.00	1.54	4.98	1.37	4.77	1.56	88
Awake In Bed – Woman	260	3.77	1.37	5.38	1.47	4.10	1.40	88
Asleep In Chair – Woman	261	4.33	1.49	4.58	1.33	4.69	1.47	88
Yawning*- Man	262	3.95	1.28	4.71	1.39	4.32	1.30	88
Asleep From Studying – Man	263	4.58	1.51	4.62	1.38	4.78	1.57	88
Snoring – Upset Woman	264	3.68	1.40	4.78	1.52	4.29	1.64	88
Alarm Clock – Woman	265	3.93	1.41	5.00	1.40	4.20	1.54	88

Drowsy Driving – Man	266	3.53	1.53	4.85	1.63	4.16	1.77	88
Red Eye – Man	267	3.59	1.71	5.23	1.73	4.13	1.71	88
CPAP – Man	268	3.06	1.35	4.63	1.86	3.61	1.73	88
Video Games – Man	269	3.41	1.76	4.96	1.69	3.90	1.74	88
Asleep In Class – Man	270	3.66	1.51	4.63	1.51	4.10	1.67	88
Stretching In Bed – Woman	271	6.67	1.50	4.69	2.00	6.37	1.62	88
Asleep In Public – Man	272	3.34	1.53	4.89	1.69	3.99	1.74	88
Sleeping Baby	273	7.20	1.70	4.48	2.37	6.42	1.88	88
Cell Phone In Bed – Man	274	4.37	1.45	4.75	1.39	4.73	1.55	88
Uncomfortable Sleeping Position – Man And Dog	275	5.13	1.89	5.17	1.59	5.01	1.63	88
Stretching In Bed – Woman	276	6.64	1.35	4.66	1.84	6.25	1.37	88
Asleep At Table – Girl	277	5.47	1.75	4.77	1.54	5.24	1.64	87
Child With Electronics In Bed	278	4.55	1.45	4.95	1.34	4.75	1.44	87
Asleep While Studying – Man	279	4.39	1.35	4.72	1.36	4.73	1.46	87
Computer In Bed* - Woman	280	3.98	1.47	5.03	1.43	4.47	1.75	87
Snoring – Man	281	4.81	1.51	4.81	1.39	5.02	1.45	87
Exhausted In Bed – Man	282	4.41	1.40	4.73	1.35	4.68	1.45	87
Alarm Clock – Woman	283	4.18	1.32	4.92	1.33	4.50	1.52	86
Asleep While Studying – Woman	284	3.90	1.53	4.74	1.49	4.53	1.75	86
Exhausted In Bed – Woman	285	4.11	1.63	4.73	1.43	4.32	1.70	86
Asleep While Studying – Boy	286	4.05	1.46	4.60	1.38	4.34	1.63	86
Frustrated In Bed – Woman	287	3.89	1.51	4.82	1.39	4.12	1.42	86
Asleep At Work – Woman	288	3.73	1.38	4.76	1.52	4.37	1.60	86
Sleeping Dog	289	7.17	1.72	5.04	2.42	6.50	1.81	86
Sound Sleep – Woman	290	6.56	1.46	4.55	1.86	6.15	1.56	86
Asleep While Studying – Woman	291	3.97	1.51	4.81	1.40	4.54	1.59	86
Sound Sleep – Woman	292	6.73	1.55	4.52	1.82	6.35	1.60	86
Sound Sleep – Woman	293	6.94	1.50	4.45	2.08	6.58	1.64	86
Alarm Clock	294	5.57	2.03	4.99	1.90	5.81	1.94	86
Asleep In Airport – Man	295	4.06	1.49	4.76	1.36	4.62	1.46	86
Asleep In Airport – Man	296	4.01	1.49	4.76	1.35	4.53	1.59	86
Asleep In Hammock – Man	297	6.44	1.56	4.21	1.83	6.26	1.41	86
Asleep At Work – Man	298	4.18	1.76	4.81	1.59	4.67	1.80	86
Sound Sleep – Woman	299	6.62	1.34	4.32	1.77	6.26	1.39	86
Sound Sleep – Woman	300	6.52	1.39	4.62	1.79	6.21	1.38	85
Asleep With Alcohol – Man	301	3.92	1.80	5.04	1.53	4.24	1.77	85
Asleep On Plane – Man	302	4.82	1.45	4.82	1.30	5.18	1.44	85
Frustrated In Bed – Woman	303	3.20	1.57	5.24	1.86	3.84	1.79	85
Stretching In Bed – Woman	304	6.95	1.57	4.95	2.12	6.51	1.55	85
Sleep Mask And Neck Pillow – Woman	305	5.91	1.52	4.51	1.59	6.10	1.32	85
Frustrated In Bed – Woman	306	3.91	1.56	5.07	1.49	4.27	1.59	85
Yawning Child – Boy	307	4.49	1.36	4.97	1.31	4.58	1.37	85
Sleeping Pills	308	4.17	1.63	5.06	1.55	4.46	1.96	85
Frustrated In Bed – Girl	309	4.49	1.51	4.85	1.39	5.08	1.52	85

Asleep While Studying In Bed* - Woman	310	4.26	1.51	4.62	1.51	4.53	1.69	85
Yawning At Table – Man	311	4.36	1.52	4.71	1.30	4.76	1.64	85
Opening Blinds – Woman	312	6.67	1.34	4.96	1.89	6.38	1.34	85
Stretching At Window – Woman	313	6.82	1.42	5.00	1.98	6.52	1.49	85
Stretching In Bed – Man	314	6.78	1.39	4.89	2.03	6.53	1.40	85
Asleep In Public – Man	315	3.15	1.59	4.73	1.87	3.85	1.84	85
Frustrated In Bed – Woman	316	3.54	1.37	4.94	1.58	4.11	1.66	85
Sound Sleep – Woman	317	6.41	1.45	4.24	1.63	6.05	1.48	85
Asleep At Work – Man	318	3.85	1.51	4.62	1.47	4.33	1.40	85
Disheveled In Bed – Woman	319	4.27	1.58	4.62	1.23	4.91	1.37	85
Asleep In Snow – Man	320	3.56	1.70	4.80	1.62	4.34	1.75	85
Asleep On Subway – Man	321	3.99	1.43	4.61	1.38	4.55	1.41	85
CPAP Masks	322	3.38	1.45	4.96	1.80	4.02	1.68	85
Exhausted In Bed – Man	323	4.81	1.50	4.46	1.30	5.10	1.36	85
Asleep While Studying – Man	324	3.86	1.49	4.64	1.53	4.59	1.66	85
Sound Sleep – Woman	325	6.51	1.66	4.34	1.86	6.08	1.59	85
CPAP – Man	326	2.80	1.60	5.00	2.07	3.68	1.91	85
Asleep With Cellphone – Woman	327	4.21	1.34	4.67	1.23	4.43	1.35	85
Asleep In Grass – Woman	328	6.86	1.63	4.48	2.19	6.53	1.67	85
Asleep On Plane – Man	329	4.68	1.26	4.71	1.25	5.01	1.46	85
Asleep In Bunkbeds	330	3.42	1.74	5.01	1.72	4.20	1.70	85
Frustrated In Bed – Man	331	3.12	1.38	5.01	1.82	3.88	1.70	85
Crowded Sleeping	332	3.79	1.86	4.89	1.66	4.17	1.72	85
Crowded Sleeping	333	2.64	1.57	5.06	2.18	3.35	1.89	85
Scared In Bed – Boy	334	3.46	1.42	5.19	1.67	3.97	1.66	85
Asleep In Hammock At Beach – Woman	335	7.09	1.67	4.38	2.30	6.67	1.68	85
Feet Outside Of Blanket	336	5.37	1.55	4.71	1.52	5.59	1.56	85
Sound Sleep – Boy	337	6.47	1.62	4.31	1.80	6.22	1.54	85
Napping Toddler*	338	7.06	1.67	4.32	2.30	6.37	1.85	85
Yawning – Man	339	4.70	1.49	4.88	1.49	4.99	1.55	85
Asleep While Studying – Woman	340	3.77	1.44	4.77	1.53	4.47	1.77	85
Sound Sleep* - Woman	341	6.95	1.59	4.19	2.12	6.32	1.72	85
Sound Sleep – Woman	342	6.83	1.43	4.22	1.91	6.52	1.47	85
Exhausted With Alcohol – Woman	343	3.54	1.64	5.00	1.60	4.06	1.89	85
Sleep Mask And Neck Pillow – Man	344	4.30	1.51	4.66	1.44	4.65	1.67	85
Asleep With Beer Mug – Woman	345	3.49	1.70	4.80	1.66	4.10	1.91	85
Yawning – Boy	346	4.01	1.33	4.83	1.42	4.54	1.57	85
Disheveled In Bed – Woman	347	4.08	1.58	4.74	1.49	4.74	1.60	85
Freshly Made Bed	348	7.02	1.46	4.55	2.37	6.31	1.90	85
Computer In Bed – Woman	349	4.91	1.63	4.51	1.41	5.31	1.54	85
Asleep On Bench – Couple	350	4.32	1.64	4.60	1.38	4.83	1.57	85
Asleep On Couch – Man	351	4.02	1.55	4.49	1.43	4.81	1.84	85

Yawning – Man	352	4.63	1.31	4.66	1.30	4.85	1.43	85
Asleep At Work – Man	353	3.50	1.53	4.90	1.62	4.27	1.82	85
Clutching Blanket – Man	354	5.64	1.61	4.32	1.65	5.75	1.62	85
Asleep In Chair – Man	355	4.16	1.54	4.58	1.48	4.70	1.69	85
Asleep On Couch – Woman	356	4.55	1.47	4.23	1.29	5.15	1.56	85
Hospital Bed	357	4.07	1.66	4.55	1.49	4.53	1.70	85
Asleep On Couch – Man	358	5.88	1.47	4.04	1.51	5.85	1.49	85
Contorted Body Position – Man	359	4.31	1.64	4.65	1.54	4.74	1.68	85
Happy Awakening – Man	360	6.59	1.93	5.08	2.16	6.57	1.51	85
Sleeping Baby	361	7.45	1.68	4.74	2.60	6.60	2.04	85
Sleeping Mother And Baby	362	7.08	1.76	4.41	2.40	6.45	1.87	85
Sleeping Mother And Baby	363	6.74	1.77	4.53	2.18	6.45	1.79	85
Sleeping Mother And Baby	364	7.19	1.63	4.42	2.41	6.66	1.82	85
Sleeping Baby	365	6.20	1.91	4.91	1.84	5.81	1.69	85
Sound Sleeping – Woman	366	5.40	1.89	4.35	1.54	5.23	1.71	85
Drinking Milk In Bed – Girl	367	6.29	1.50	4.37	1.58	6.00	1.64	85
Drinking Water In Bed – Woman	368	6.11	1.52	4.69	1.59	6.01	1.55	85
Drinking Water In Bed – Woman	369	6.26	1.52	4.78	1.83	6.01	1.58	85
Reading In Bed – Woman	370	6.37	1.47	4.57	1.76	6.36	1.46	85
Reading On Couch – Man	371	6.01	1.40	4.40	1.59	5.92	1.54	85
Reading In Bed – Man	372	6.48	1.42	4.44	1.79	6.26	1.63	85
Sweating In Bed – Woman	373	3.46	1.48	5.29	1.66	4.17	1.82	85
Bed With Mosquito Net	374	6.58	1.65	4.48	2.04	6.10	1.67	85
Freshly Made Bed	375	7.11	1.52	4.71	2.31	6.68	1.50	85

APPENDIX G: PVT INSTRUCTIONS

Psychomotor Vigilance Task (PVT) Script

"The test will begin once you press the up button. During the test, as soon as you see the target on the screen, press and release the button using your preferred hand, that is, the hand you typically write with. The numbers in the display show how fast you responded each time – the smaller the number, the faster you pressed it. This number is your reaction time in hundredths of a second. Your task is to pay close attention to the stimulus window for the full 5 minutes of the task and respond by pressing the button as quickly as possible when you see the target stimulus. Again, the lower the number, the faster your reaction. However, don't try to guess or anticipate the stimulus by hitting the button too soon –in which case you will see an error message, "FALSE START!" You will also see the "FALSE START!" message if you forget to release the button. If you press the incorrect button, the device will neither not register the button push nor will it tell you to use this button. Try to do your best and get the lowest number you possibly can avoiding "false starts." At the end of the reaction time test you will see your average response time. The device will save data and then shut down automatically. Any questions? Let's begin."

APPENDIX H: EEG INSTRUCTIONS

Baseline Instructions (Eyes Open, Eyes Closed)

"Thank you again for your participation in this experiment. Now that you are all hooked up and the EEG software is recording, the very first thing we are going to do is establish a baseline. The purpose of establishing a baseline is to allow us to compare your EEG brain activity when you are relaxed and at rest to when you are engaging in the task. To get this baseline, I will be asking you to remain comfortably seated in the recliner keeping your gaze forward. Over the next several minutes, you'll hear my voice over the intercom to ask you to either open your eyes or close your eyes."

"When I ask you to open your eyes, you will continue to face forward gazing at the blank computer screen in front of you. You are allowed to blink naturally, but I do ask you refrain from squinting, clenching your jaw, or making any strong or sudden movements, as this will disrupt the recording."

"When I ask you to close your eyes, I would like you to continue facing forward keeping your eyes naturally closed. Again, please refrain from squinting, clenching your jaw, or making any strong or sudden movements. I will ask you to do this several times, alternating between having your eyes open and closed. Each time you will hear me tell you to either open your eyes or close your eyes on this intercom on this table behind your chair. Do you have any questions? Let's begin."

ERP Oddball Paradigm Task Instructions

[Walk into the participant booth to see if there are any questions and provide directions for test; *these directions assume positive target block precedes the negative*]

Positive Target Block: "Now you are going to do the exact same thing you did in the practice, except this block will be a bit longer. A series of positive and negative sleep images will appear on the screen. Your goal is to press the buttons numbered one and four quickly and accurately as possible as soon as you think you see a positive sleep image. Do not press anything for the negative sleep images, only the positive. Any questions? Let's begin."

Negative Target Block: [*over the intercom*] "Ok. You are almost done. You only have one more block left. You are going to do the exact same thing you did for the practice, except this block will be a bit longer. A series of positive and negative sleep images will appear on the screen. Your goal is to press the buttons numbered one and four quickly and accurately as possible as soon as you think you see a negative sleep image. Do not press anything for the positive sleep images, only the negative. Any questions? Let's begin."

APPENDIX I: IRB APPROVAL (PILOT STUDY)

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · **www.ecu.edu/irb**

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB
To: Eric Watson
CC: Daniel Everhart
Date: 12/8/2014
Re: UMCIRB 14-001890
Affective Ratings of Sleep-Related Images

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 12/8/2014 to 12/7/2015. The research study is eligible for review under expedited category #7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
Affective.Sleep.Pictures.compressed.pdf	Surveys and Questionnaires
BIS.BAS_DISSERTATION.docx	Surveys and Questionnaires
Demographics & History.docx	Surveys and Questionnaires
Epworth Sleepiness Scale_DISSERTATION.doc	Surveys and Questionnaires
Informed Consent_Dissertation.Pilot.Revision	Consent Forms
ISS_DISSERTATION	Surveys and Questionnaires
Mini-IPIP_DISSERTATION	Surveys and Questionnaires
PANAS_DISSERTATION	Surveys and Questionnaires
PSQI_DISSERTATION.docx	Surveys and Questionnaires
Rating Manikins.pdf	Surveys and Questionnaires
Watson_Dissertation.Proposal.pdf	Study Protocol or Grant Application

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

APPENDIX J: IRB APPROVAL (PRESENT STUDY)

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building · Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · www.ecu.edu/irb

Notification of Initial Approval: Expedited

From: Biomedical IRB
To: Eric Watson
CC: Daniel Everhart
Date: 2/4/2015
Re: UMCIRB 14-002062
AN INVESTIGATIVE STUDY OF THE NEUROPSYCHOLOGICAL AND NEUROPHYSIOLOGICAL FEATURES OF SUBJECTIVE SLEEP QUALITY

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 2/3/2015 to 2/2/2016. The research study is eligible for review under expedited category # 4,6,7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
BIS/BAS Scales	Surveys and Questionnaires
Demographics & History	Surveys and Questionnaires
Dissertation Pics- Affective Sleep Images.pptx	Surveys and Questionnaires
Dysfunctional Beliefs About Sleep Scale	Surveys and Questionnaires
Epworth Sleepiness Scale	Surveys and Questionnaires
ICF_1.26.2015 .docx	Consent Forms
Insomnia Severity Index	Surveys and Questionnaires
Medical Outcome Study Sleep Questinnaire	Surveys and Questionnaires
Mini IPIP	Surveys and Questionnaires
Positive and Negative Affect Scale	Surveys and Questionnaires
Short Form (12) Health Survey	Surveys and Questionnaires
Subjective Happiness Scale	Surveys and Questionnaires
Watson_Dissertation.Proposal.pdf	Study Protocol or Grant Application

The Chairperson (or designee) does not have a potential for conflict of interest on this study.
