

A Randomized Controlled Trial of Sleep Schedule Regularization: Sleep Regularization Results
in Quicker Reaction Times on a Dot-Probe Task



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A Randomized Controlled Trial of Sleep Schedule Regularization: Sleep Regularization Results
in Quicker Reaction Times on a Dot-Probe Task

A Senior Comprehensive Project

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Abstract

The effects of sleep regulation, sleep quality, and chronotype on attentional bias were studied in generally healthy college students. Participants were randomly assigned to either a sleep-as-usual group or a sleep regulation group (7 hours each night for five nights over a weekend). Participants completed a demographics questionnaire, the Pittsburgh Sleep Quality Index (PSQI) and the Chronotype Questionnaire (Oginska, 1996). Actigraphs recorded sleep efficiency for each of the five nights. Participants returned to the lab after five nights and completed a dot-probe task. It was hypothesized that participants in the sleep-as-usual group would have a greater attentional bias towards threatening stimuli. Attentional bias refers to reaction time and number of probes correctly identified in either the threatening or neutral position. In addition, it was hypothesized that participants with an evening chronotype, low sleep efficiency (<85%) and poor sleep quality (PSQI score >5) would have greater attentional bias towards threatening stimuli. Participants in the sleep-as-usual group responded slower to threatening stimuli ($M=542.13$, $SD=120.28$) than the sleep regulation group ($M=452.14$, $SD=68.49$), $t(29)=2.48$, $p=.02$. In addition, sleep-as-usual participants responded slower to neutral stimuli ($M=531.97$, $SD=107.22$) than the sleep regulation group ($M=451.61$, $SD=60.99$), $t(29)=2.49$, $p=.02$. There were no significant differences between sleep groups and number of correctly identified probes overall or number of threatening probes identified. Chronotype and sleep quality were not significantly associated with attentional bias. As predicted, participants with low sleep efficiency, correctly identified more probes in the threat position ($M=46.27$, $SD=1.75$) than participants with high sleep efficiency ($M=43.31$, $SD=4.19$), $t(20.35)=-2.59$, $p=.02$ showing a greater attentional bias towards threatening stimuli.

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A randomized controlled trial of sleep schedule regularization: Sleep Regularization Results in Quicker Reaction Times on a Dot-Probe Task

Depression is the leading cause of disability in the United States and increases severity of many other diseases (World Health Organization, 2012). Worldwide, more than 350 million people suffer from depression (World Health Organization, 2012) and increasing evidence finds depression and poor sleep highly comorbid (Chang et al., 2014, Buysse et al., 2008, Roane & Taylor, 2008, Nutt et al., 2008). From 2005 to 2008, 37% of adults reported a short sleep duration (less than the recommended 7-9 hours/night), which can affect daily activities (CDC, 2014). Not only is poor sleep associated with depression, but there is also evidence linking depression with cardiovascular morbidity (Elderon & Whooley, 2013, Bivanco-Lima et al., 2006, World Health Organization, 2012).

Cardiovascular disease is the leading cause of death among men and women in the United States and has many risk factors associated with it (Murphy et al., 2013). For example, poor sleep increases risk for hypertension and other cardiovascular disease risk factors, such as high cholesterol, BMI (Narang et al., 2012, Martikainen et al., 2011) and also proinflammatory and procoagulant changes that could lead to an increased risk of cardiovascular disease (von Kanel et al., 2006). Increased risk can be seen especially in settings of high stress (von Kanel et al., 2006).

There is a strong correlation between sleep quality, cardiovascular disease and mood. There is also evidence of an association between irregular sleep (variations between 2-4 hours nightly) and depression severity (Taub, 1978). It has been suggested that regularizing sleep patterns by having the same sleep/wake time daily can enhance mood (Trochel et al., 2011) since sleep-regularization increases alertness and sleep efficiency (Manber et al., 2006).

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Since aspects of sleep such as quality, efficiency and regularity affect multiple domains of physiological functioning, having quality sleep hygiene is of the utmost importance. Specifically, regularizing sleep has the potential to increase mood, alertness, and sleep efficiency. Risk of depression and cardiovascular disease may decrease with proper sleep practices and have widespread benefits for public health.

Literature Review

Sleep as a Restorative Function

Sleep is a restorative function necessary to regulate metabolism and balance energy (Garcia-Garcia et al., 2013, Pejovic et al., 2010), and is crucial for homeostasis. After one night of sleep deprivation, leptin levels, a hormone that inhibits appetite, decrease (Pejovic et al., 2010). In addition to leptin, ghrelin, an amino acid associated with hunger, increases after sleep deprivation. Since both leptin and ghrelin are affected by sleep loss, it is suggested that these changes may be associated with an increased risk of obesity (Garcia-Garcia et al., 2013). Ghrelin may regulate the secretion of growth hormone (GH).

In addition to fueling childhood growth and maintaining tissues and organs throughout life (Mayo Clinic, 2014), GH also plays a major role in metabolic homeostasis such as appetite regulation and energy balance. During slow-wave sleep, GH secretion peaks. It is thought that GH plays a role in the sleep-wake cycle because altering its secretion can cause sleep disturbances (Garcia-Garcia et al., 2013). Growth hormone is also needed to stabilize blood-glucose levels over a period of time without food (Garcia-Garcia et al., 2013). Low blood glucose levels are characteristic of diabetes mellitus (Lee, S.H., 2006). In order to keep the body in homeostatic equilibrium, these hormones and amino acids must be regulated by sleep.

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In addition to metabolic homeostasis, sleep also plays a significant role in immune function (Majde & Krueger, 2005). Studies have shown that sleep deprivation can significantly affect antibody response (Majde & Krueger, 2005). For example, after one night without sleep, subjects that received a hepatitis A vaccination had a suppressed antibody response 28 days later compared to normal-sleeping controls. In addition, participants that were inoculated with the flu virus and partially sleep deprived for six nights also showed antibody level decreases 10 days after inoculation (Majde & Krueger, 2005). Also, chronic sleep restriction (<6 hours/night) showed a slowed response to the influenza vaccine. This suggests that sleeping can help improve immune defenses such as antibody production (Faraut et al., 2012). These studies show that sleep plays a crucial role in maintaining immune system health and function (Faraut et al., 2012).

Sleep has also been shown to affect immune response in animal research. Prolonged sleep deprivation in rodents inoculated with opportunistic infections showed an increased rate of mortality than regularly sleeping control animals (Faraut et al., 2012). On the other hand, enhanced sleep in rabbits inoculated with *Escherichia coli*, *Staphylococcus aureus*, or *Candida albicans* showed less severe symptoms of disease and ultimately led to a better prognosis of survival than sleep deprived animals (Faraut et al., 2012, Toth et al., 2003). Immune reactions to disease in rodents shows that the effects of sleep are not limited to humans.

Sleep, Cognitive Function and Mood

While sleep is associated with restorative functions of the body, it is also associated with mood and cognitive function. A meta-analysis reports that sleep deprivation strongly impairs human functioning (Pilcher & Huffcutt, 1996). After studying 143 study coefficients, it was found that mood was more impacted by sleep deprivation than cognitive or motor performance.

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In addition, partial sleep deprivation has more of an impact on physiological functioning than short-term or long-term sleep deprivation (Pilcher & Huffcutt, 1996).

Williamson and Feyer (2000) found that sleep deprivation (28 hours without sleep) led to decreased performance and self-rated alertness. These results were similar to tests that were taken after alcohol was consumed. Performance deficits were found with increasing sleep deprivation in the reaction time task (simple response speed), the dual task (a divided attention task combining reaction time and tracking), tracking task (low-level, hand-eye coordination task) and Mackworth clock tasks (passive vigilance test). Scores from participants with 17 hours of sleep deprivation were equivalent to that of a person with a .05% BAC. These decreases in cognitive task performance were measured by comparing the results after sleep deprivation and after alcohol consumption (Williamson & Feyer, 2000).

Persistent sleep restriction to 5 hours and alcohol consumption up to a BAC of 0.8% resulted in similar results on a tracking task and a reaction time task (Elmenhorst, 2009). After one night of restoring sleep to eight hours, performance levels increased and returned to their values before sleep deprivation (Elmenhorst, 2009).

Sleep restriction also affects functions that are needed for academic and occupational success such as memory, verbal creativity, problem solving and attention/response inhibition (Cassoff et al., 2014, Lockley et al., 2004). Reducing sleep by one hour each night can have negative impacts on cognitive performance (Sadeh et al., 2003). Decreased measures of vigilance and decreased performance on the Block design subtest of an IQ test are characteristic of people who have short sleep duration (Touchette et al., 2007).

Sleep restriction is also associated with mood instability (Bowen et al., 2013) and lower optimism, and sociability scores (Haack & Mullington, 2005). Haack and Mullington (2005)

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found that over the course of 16 days of sleep restriction (four hours of sleep per night), optimism and sociability scores significantly decreased (Haack & Mullington, 2005) meaning that sleep restriction may lead to negative personality states.

Other sleep impairments such as insomnia, sleep quality and short sleep duration have been tied to decreased mood (Johnson et al., 2006). A recent study found that people with insomnia are 40% more likely to develop anxiety, depression, and have suicide attempts due to impaired judgment (Johnson et al., 2006). Johnson et al. (2006) conducted extensive interviews to assess DSM-IV diagnoses. Strong associations were observed over a lifetime between insomnia, anxiety disorders and depression. The majority of comorbid cases (73%) revealed that anxiety occurred prior to insomnia, but insomnia came before the onset of depression 63% of the time (Johnson et al., 2006). Studies in adults with insomnia found that there was an increased risk of mood and anxiety disorders, in addition to suicide, compared to those who did not have insomnia (Ohayon, 2002, Benca & Peterson, 2008, Breslau et al., 1996, Paffenbarger et al., 1994, Weissman et al., 1997).

Sleep Regulation

There is research suggesting that sleep regularization and sleep adequacy have positive affects on adolescents (Wolfson & Carskadon, 1998). Positive affects include self-reported improved daytime alertness, reduced daytime sleepiness and improved sleep efficiency (Manber et al., 1996).

Sleep schedule during the school week has a significant effect on students. Subjective academic success is associated with earlier, longer sleep time (Wolfson & Carskadon, 1998). Students with parent-set bedtimes resulted in longer sleep duration and less daytime sleepiness (Short et al., 2011, Wolfson & Carskadon, 1998). In addition, short sleep duration (<6 hours 45

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minutes) (Wolfson & Carskadon, 1998), later regular bedtimes (midnight and later) (Gangwisch et al., 2010) and poor sleep quality (Short et al., 2013) are associated with greater depressed mood compared to participants who had a longer sleep duration (>8 hours 15 minutes), earlier bedtimes of 10pm and higher sleep quality.

Since sleep quality, restriction and chronotype are known to have an affect on mood (Short et al., 2013, van der Helm et al., 2010, Hidalgo et al., 2009, Baert et al., 2010, Yoo et al., 2009), it is important to understand the potential affects of sleep regularization on mood and attentional bias as well (Trockel et al., 2009)

Measures of Sleep

Actigraphy, polysomnography, and self-report are three common methods to examine sleep hygiene and EEG architecture. Actigraphy records relative movement of an individual with accelerometry in order to examine sleep disturbances and sleep efficiency in their everyday environment. An actigraph can be worn on the wrist or the ankle and measures motor activity. This is an inexpensive and noninvasive way to measure sleep patterns (Kushida et al., 2001). On the other hand, in the laboratory, polysomnography can also be used to measure the amount of time in REM or NREM sleep, respiration, EMG, EOG, EKG and EEG (Bear et al., 2006).

Kushida et al. (2001) compared three different techniques for measuring sleep: actigraphy, polysomnography and self-reported sleep. All three measures showed similar accuracy in terms of number of awakenings, sleep efficiency and sleep time. While actigraphy and self-report seemed to have overestimated amount of sleep time, post hoc analysis showed that their data was not significantly different from polysomnography. While polysomnography may have a reputation of being more accurate, this was found to be untrue.

Actigraphy does have some advantages over polysomnography. For example, it is cost efficient and allows participants to sleep in their own environment (Wang, 2012). Since participants are able to sleep in the comfort of their own bed, actigraphy has higher external validity over polysomnography. Actigraphy is also useful for detecting brief periods of awakening during the night that may not be explained during self-report (Wang, 2012). The measure of movement during sleep allows for sleep efficiency to be calculated which is the percentage of time spent sleeping as a proportion of the total time in bed. Actigraphy is sensitive to movement; therefore, it is a reliable measure for detecting sleep disorders that involve frequent movement during the night such as sleep apnea (Wang, 2012). This supports the idea that actigraphy is a safe, reliable way to measure sleep efficiency.

The Pittsburgh Sleep Quality Index (PSQI) has been widely accepted as an index of sleep quality and sleep duration (Buysse et al., 1989), with scores of >5 suggestive of poor sleep quality and clinically significant sleep dysfunction (Buysse et al., 1989). This 19-item questionnaire inquires about sleep habits in the past month. It asks about how easily participants have been able to sleep in addition to things such as how hard has it been to stay awake while taking part in activities like driving or engaging in social activity (Buysse et al., 1989).

Chronotype

Chronotype refers to an individual's preferences to the 24-hour circadian rhythm. This can be seen in how active and alert people feel at certain times of the day (Roenneberg et al., 2004). For example, some people identify as "night owls" or "early birds", although most people fall somewhere in between (Roenneberg et al. 2004, Short et al., 2013). Genetic and environmental factors affect chronotype. Children typically have early chronotypes and as they

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develop, the chronotype shifts. Around the age of 20, people tend to start moving toward an earlier chronotype once again (Roenneberg et al., 2004).

There is evidence that evening chronotypes in adolescents is correlated with poor sleep quality and diminished daytime alertness (Short et al., 2013). In addition, adolescents with evening chronotypes showed more symptoms of depressed mood (Short et al., 2013, Hidalgo et al., 2009). Since adolescents' sleep schedule is heavily based off of school, maintaining a regular sleep schedule throughout the week and weekends may help increase daytime alertness, sleep quality and may prevent depressive symptoms (Short et al., 2013). This holds importance because people with evening chronotypes may be predisposed to more depressive symptoms than morning or intermediate chronotypes and regularizing sleep schedules may show mood improvements. There is evidence supporting the idea that chronotype may be a biological characteristic that could contribute to affective disorders (Hidalgo et al., 2009).

Attentional bias

Attentional bias refers to attention that is allocated towards positive, neutral or negative stimuli (Cisler & Koster, 2010). Attentional bias to negative stimuli has been observed in participants with mild to severe depressive symptoms (Baert et al., 2010). In addition, attentional bias towards threatening stimuli has been seen in numerous anxious populations (Cisler & Koster, 2010), subjects with eating disorders (Ehrhardt et al., 2003), chronic pain (Dehghani et al., 2003), or smokers (Hogarth et al., 2003). Other conditions for attentional bias are also being observed in populations that consume alcohol and populations with certain phobias (Cooper & Langton, 2006).

Since attentional bias determines the allocation of attention, there may be a link between poor sleep habits and negative attentional bias. There is evidence that lack of sleep is related to

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inaccurate judgments of emotional stimuli (Baert et al., 2010). A study by van der Helm et al. (2010) found that after 31 hours without sleep, participants tended to overestimate negative stimuli through examining the results of an emotional face recognition task (Baert et al., 2010). Yoo et al. (2007) studied amygdala activation in participants who were sleep deprived. They found that after one night of sleep deprivation, there was 60% more amygdala activity in response to negative picture stimuli.

It has been suggested that sleep regulation and mood may be related (Trockel et al., 2011). In a study comparing naturally regular and irregular sleepers, participants were awoken four times. During these instances, negative affects such as depression, were seen significantly more in irregular sleepers (Taub1978). Since 35.3% of adults studied reported less than seven hours of sleep each night (CDC, 2014), people may be at greater risk for depressive symptoms, decreased daytime alertness and increased attention towards negative stimuli (Short et al., 2013, van der Helm et al., 2010, Hidalgo et al., 2009).

Dot-probe task

Attentional bias can be assessed with the Modified Stroop task (Segerstrom, 2001), Visual Search Task (Avery, 1968), Exogenous Cueing Task (Koster et al., 2005) and the Dot-Probe Task (MacLeod et al., 1986). The dot-probe task is used to examine attentional bias towards emotional cues. Classically, the Dot-Probe task includes pairs of visual stimuli of different valences (positive, negative or neutral) on a screen followed by a probe (a cross or dot) in the location of one of the stimuli. Participants are asked to locate the probe as quickly as possible by either clicking on the probe or pressing the corresponding key on a keyboard (Cooper & Langton, 2006). This task typically takes 5-10 minutes to complete. Attentional bias is measured by the mean reaction time (RT) for locating a probe that replaces a threatening

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stimulus compared to the RT for a neutral stimulus (Cisler & Koster, 2010). The Dot-Probe task was originally used to measure bias to threat in anxious populations, but it since has expanded to other areas in which there may be attentional bias (Cooper & Langton, 2006).

The aim of the current study was to examine the influence of sleep regulation, sleep quality, sleep efficiency and chronotype on attentional bias. A two-part study was utilized. For part one, it was hypothesized that cross-sectional analysis would show attentional bias to negative emotional stimuli on the dot probe task in participants in the Sleep-as-Usual. It was also hypothesized that acute regularization (5 nights of sleep) would be associated with less negative bias in morning but not evening chronotypes because evening chronotypes are associated with depressive symptoms and may also be associated with other affective disorders (Hidalgo et al., 2009). Finally, it is hypothesized that participants with low sleep efficiency and poor sleep quality will have greater attentional bias towards negative emotional stimuli.

Methods

Participants

The Allegheny College Institutional Review Board granted ethics approval for this study. Participants ($N=35$, 85% female, $M=19.67$, $SD=1.01$) included generally healthy undergraduate students. Upon arrival to the lab, they provided informed consent (Appendix A), and completed a demographics questionnaire (Appendix B), the Chronotype Questionnaire (Oginska, 1996) (Appendix C), and the Pittsburgh Sleep Quality Index (Buysse et al., 1989) (Appendix D) to determine sleep quality. Participants were randomly assigned to either a regular sleep/wake schedule or a sleep-as-usual group for six days and five nights. Participants who were assigned the regulation group were instructed to go to sleep at night and wake up in the morning at the same general time (within 30 minutes) for the subsequent five nights and try to sleep for seven

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hours (National Sleep Foundation, 2013). Participants in the sleep-as-usual group continued their own sleeping patterns as usual during the study period. Participants recorded their sleep wake times over the course of the study in a paper sleep diary provided by the researcher (Appendix E). All participants completed a dot-probe task at the end of the study on day six and were provided with a debriefing form (Appendix F).

Actigraphy

Participants wore an actigraphy bracelet (GT3X ActiGraph, Pensacola, FL) on the wrist for six days and five nights. Sleep efficiency (the percentage of time spent sleeping as a proportion of the total time in bed), latency to sleep onset (amount of time it takes to fall asleep, reported in minutes) and total sleep time (total amount of time in minutes the participant spent sleeping) were calculated by ActiLife5 software. Data were analyzed as epochs of 60 seconds. Participants with sleep efficiency greater than 85% were considered as sleeping efficiently while participants with a score of less than 85% were considered as not efficiently sleeping (Javaheri et al., 2008). A sleep diary provided by the researcher was also kept in order to determine sleep duration and sleep onset latency. Participants were instructed to record the date, time in bed and time of awakening in the sleep diary.

Dot-Probe Task

Participants completed a dot-probe task on day six of the study. The Dot-Probe task was downloaded from Millisecond Software and Inquisit 4 lab (<http://www.millisecond.com>). Ninety-six word pairs that convey emotional content (threatening or neutral) were displayed on the computer screen for 500ms (Appendix G). The same 96 pairs of stimuli were used for each participant and were generated from the computer program. After 500ms, a cross shape appeared in the middle of the screen. After the cross shape disappeared, a symbol (< or >)

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appeared in place of either the threatening or neutral word. The participants were instructed to strike the corresponding key on the keyboard as quickly as possible (Cooper & Langton, 2006). The task was approximately five minutes and participants sat about two feet away from the computer screen. Faster reaction times reflect attentional bias (MacLeod et al., 1986, Bradley et al., 2010).

Scoring

The PSQI was used to assess sleep quality. A score of greater than five is suggestive of poor sleep quality (Buysse et al., 1989).

The Chronotype Questionnaire has two scales: the morningness-eveningness (ME) scale and the distinctness (DI) scale (Oginska, 1996). Scores of 8-15 on the ME scale indicate morning preference, scores of 16-26 indicate an intermediate preference and scores of 27-40 are indicative of evening preference (Oginska, 1996). On the DI scale, scores of 6-15 are poorly marked, meaning that the time-of-day preferences are not very strong. Scores of 16-22 are moderately marked and scores of 23-30 are strongly marked. As people enter their twenties, chronotype often shifts from evening to morning preference (Roenneberg et al., 2004).

Data Analysis

Actigraphy (MacLeod et al., 1986) and the dot-probe task (MacLeod et al., 2007) data were analyzed to test the hypotheses. Independent samples t-tests were used to test the hypotheses that the sleep-as-usual group, participants with low sleep efficiency and participants with low sleep quality would have greater attentional bias towards threatening stimuli. A one-way ANOVA was used to test the hypothesis that participants with an evening chronotype would have greater attentional bias towards threatening stimuli.

Results

Among 35 participants enrolled in the study ($N=35$, 85% female, $M=19.67$, $SD=1.01$), 31 participants' data was used (14 sleep-regulated, 17 sleep-as-usual) (Table 1). The sleep regulation and sleep-as-usual groups were similar in terms of age and class year. Four participants were excluded due to non-compliance. Participants assigned to the sleep regulation group were counted as non-compliant if they did not sleep for 7 hours each night throughout the study.

An independent samples t-test showed that the sleep-as-usual group ($M=382.15$, $SD=55.52$) and the sleep regulation group ($M=352.66$, $SD=34.85$), $t(29)=1.73$, $p=.10$, $d=-.67$, did not differ significantly in terms of sleep duration (Figure 1). The sleep-as-usual group slept significantly more ($M=428.53$, $SD=107.89$) than the sleep regulation group ($M=360.79$, $SD=59.07$), $t(29)=2.49$, $p=.02$, $d=.92$, only on Saturday; Thursday, Friday, Sunday and Monday nights were not significantly different (Figure 2).

Independent samples t-tests compared the sleep regulation and sleep-as-usual group. Participants in the sleep regulation group had quicker reactions to both threatening and neutral stimuli (Figure 3). Participants in the sleep-as-usual group reacted more slowly to neutral probes ($M=531.97$, $SD=107.22$) compared to the regulated sleep group ($M=451.61$, $SD=60.99$), $t(29)=2.49$, $p=.02$, $d=.92$.

The sleep-as-usual group also responded more slowly to threatening stimuli ($M=542.13$, $SD=120.28$) compared to the regulated sleep group ($M=452.14$, $SD=68.49$), $t(29)=2.48$, $p=.02$, $d=.91$. The number of correctly identified probes in the threatening or the neutral position did not differ significantly between the sleep regulation group and the sleep-as-usual group (Table 2).

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Chronotype was not significantly associated to reaction time or number of probes in the threat or neutral position correctly identified (Table 3). A one-way between subjects ANOVA was conducted to compare the effect of chronotype (morning, intermediate and evening) on attentional bias. Morning chronotypes, intermediate chronotypes, and evening chronotypes did not differ in their reaction time to threatening stimuli, $F(2, 28)=.10$, $p=.91$, partial eta squared=.007, or neutral stimuli $F(2,28)=.06$, $p=.94$, partial eta squared=.004. In addition, there was no significant difference between chronotypes in terms of the number of threatening probes correctly identified, $F(2, 28)=.31$, $p=.74$, partial eta squared=.021 or overall probes correctly identified, $F(2, 28)=.44$, $p=.65$, partial eta squared=.03 (Table 3).

Participants with high sleep efficiency were not significantly different in terms of reaction time compared to less efficient sleepers (Table 4). As predicted, participants with low sleep efficiency ($M=46.27$, $SD= 1.75$) correctly identified more probes in the threat position than those with high sleep efficiency ($M=43.31$, $SD=4.19$), $t(20.35)=-2.59$, $p=.02$, $d=.92$ (Figure 4).

Higher PSQI scores (>5), indicative of poor sleep quality, were not significantly associated with the reaction time to the threatening or neutral probes (Table 5). Participants that had a PSQI >5 , did not have a slower reaction time to threatening stimuli ($M=525.46$, $SD=123.49$) compared to participants with a PSQI score ≤ 5 ($M=475.92$, $SD=87.36$), $t(29)=-1.28$, $p=.21$, $d=.46$. In addition, PSQI score was not associated with the number of correctly identified probes overall or in the threatening position (Table 5).

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Table 1

Demographics of Regularization Group and Sleep-as-Usual Group

Measure	Regularization Group (n=14) M(SD)	Sleep-as-Usual Group (n=17) M(SD)	Sample (n=31) M(SD)
Sex	100% Female	76% Female	87% Female
Age	19.79(1.12)	19.59(.94)	19.68(1.01)
Class year	2.71(.99)	2.41(1.12)	2.55(1.06)
Credits	16.43(4.24)	17.53(2.96)	17.03(3.57)
Chronotype	42.86%	70.59%	58.06%

Notes: SD= Standard Deviation

Class Year indicates First Year (1), Sophomore (2), Junior (3), Senior (4)

Chronotype % indicates percent of participants with evening chronotype

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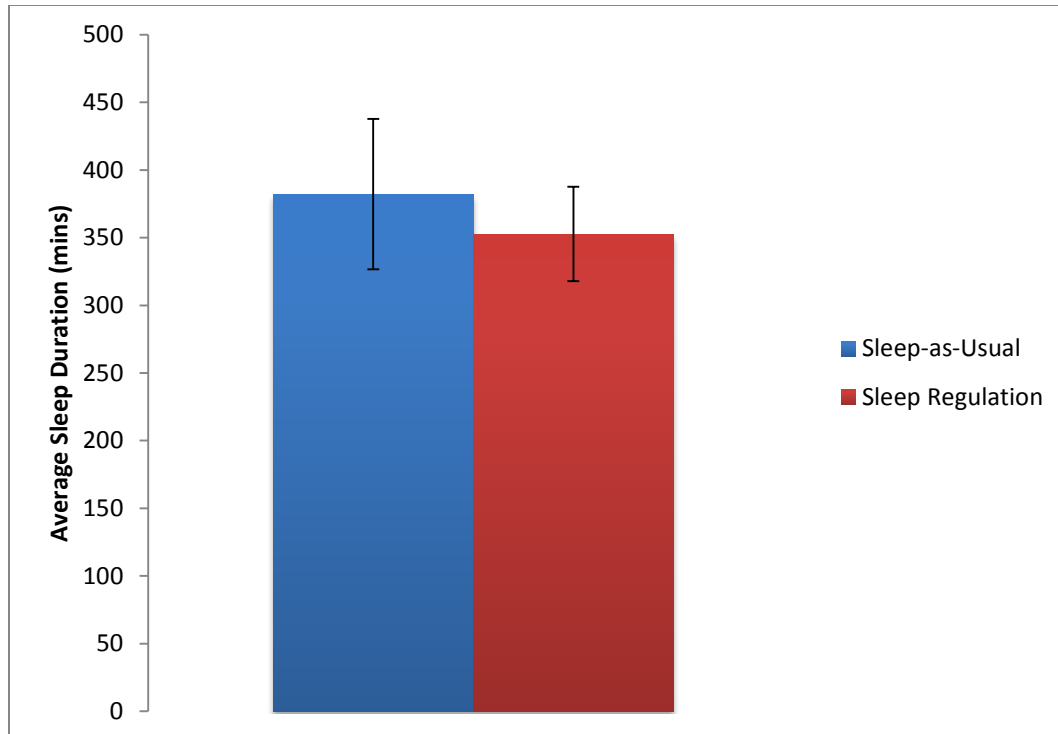


Figure 1. Overall average sleep duration for the sleep-as-usual group and sleep regulation group shows no significant difference in the amount of time spent sleeping

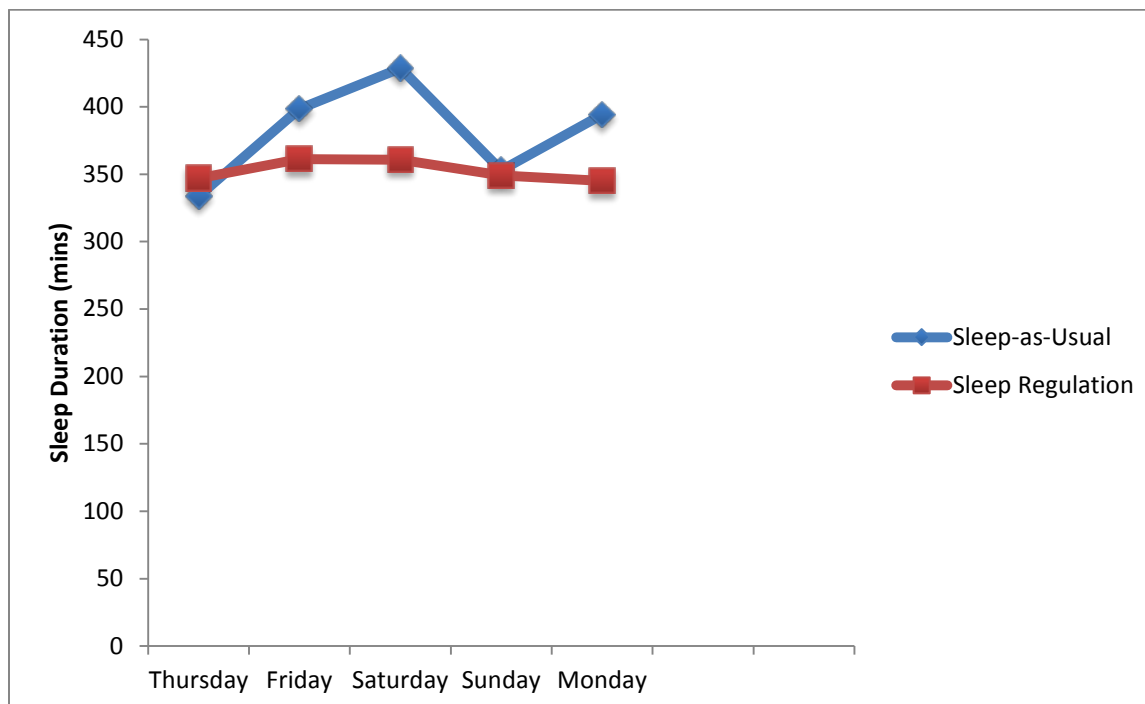


Figure 2. Average sleep duration each night throughout the study shows that the sleep-as-usual group and the sleep regulation group did not significantly differ in the amount of time spent sleeping

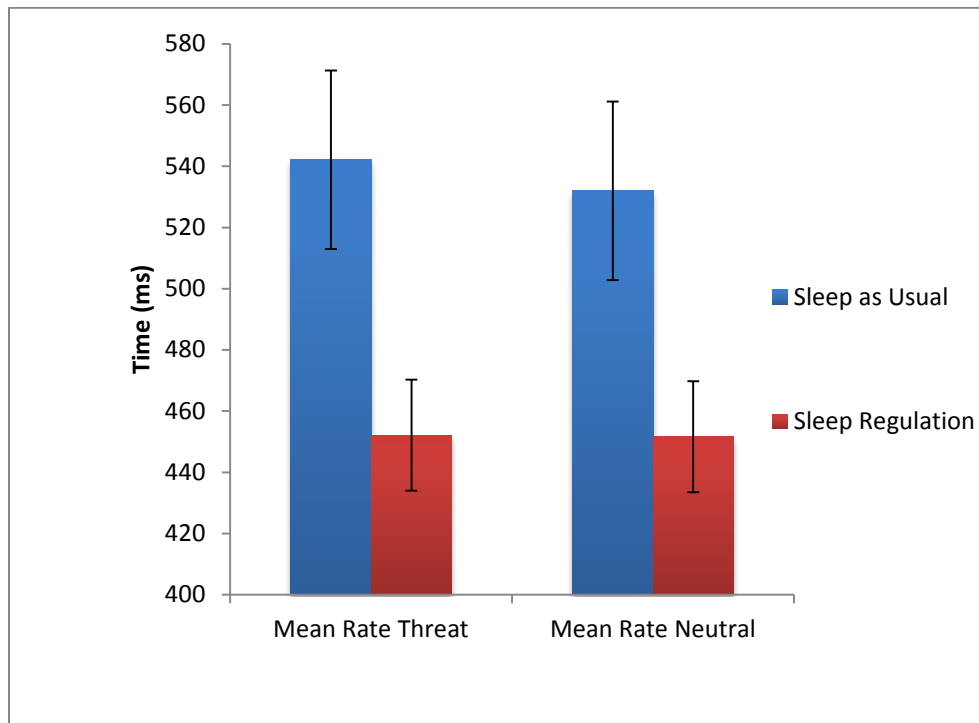


Figure 3. The Sleep Regulation group had faster reaction times to both threatening and neutral probes compared to the Sleep-as-Usual Group

Table 2

Attentional Bias of Participants in the Sleep-as-Usual Group and Sleep Regulation Group

Measure	Regularization Group (n=14) M(SD)	Sleep-as-Usual Group (n=17) M(SD)	p value
Mean Threat Rate	452.14(68.49)	542.13(120.28)	.02*
Mean Neutral Rate	451.61(60.99)	531.97(107.21)	.02*
Total Probes Correct	88.79(6.93)	90.41(5.83)	.48
Total Threat Correct	44.36(3.75)	45.06(3.42)	.59
Average Sleep Duration	352.66(34.85)	382.15(55.52)	.10
Sleep Quality	5.21(2.26)	6.71(3.63)	1.49
Sleep Efficiency	83.49%(7.66)	84.04%(5.21)	.55

Notes: SD=Standard Deviation

Mean Threat and Mean Neutral Rates are measured in milliseconds

Total Probes Correct is out of 96 pairs (48 threat and 48 Neutral probes)

*Indicates significance between the Regularization group and the Sleep-as-Usual Group

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Table 3

Attentional Bias of Morning, Intermediate and Evening Chronotypes

Measure	Morning Chronotype (n=6) M(SE)	Intermediate Chronotype (n=8) M(SE)	Evening Chronotype (n=21) M(SE)	<i>p</i> value
Mean Threat Rate	484.51(44.20)	522.14(38.27)	503.95(23.63)	.91
Mean Neutral Rate	482.91(39.86)	513.18(34.52)	497.75(21.31)	.94
Total Probes Correct	89.33(2.50)	88.63(2.16)	90.76(1.34)	.74
Total Threat Correct	44.67(1.22)	44.25(1.22)	45.29(.75)	.65

Notes: SE=Standard Error

Mean Threat and Mean Neutral Rates are measured in milliseconds

Total Probes Correct is out of 96 pairs (48 threat and 48 Neutral)

Table 4

Attentional Bias of Participants with High Sleep Efficiency and Low Sleep Efficiency

Measure	High Sleep Efficiency (n=16) M(SD)	Low Sleep Efficiency (n=15) M(SD)	p value
Mean Threat Rate	495.83(124.48)	507.52(93.01)	.77
Mean Neutral Rate	494.59(109.96)	496.84(84.71)	.95
Total Probes Correct	87.63(7.73)	91.87(3.31)	.06
Total Threat Correct	43.31(4.19)	46.27(1.75)	.02*

Notes: SD= Standard Deviation

Mean Threat and Mean Neutral Rates are measured in milliseconds

Total Probes Correct is out of 96 pairs (48 threat and 48 Neutral)

*Indicates significance difference between participants with high sleep efficiency and participants with low sleep efficiency

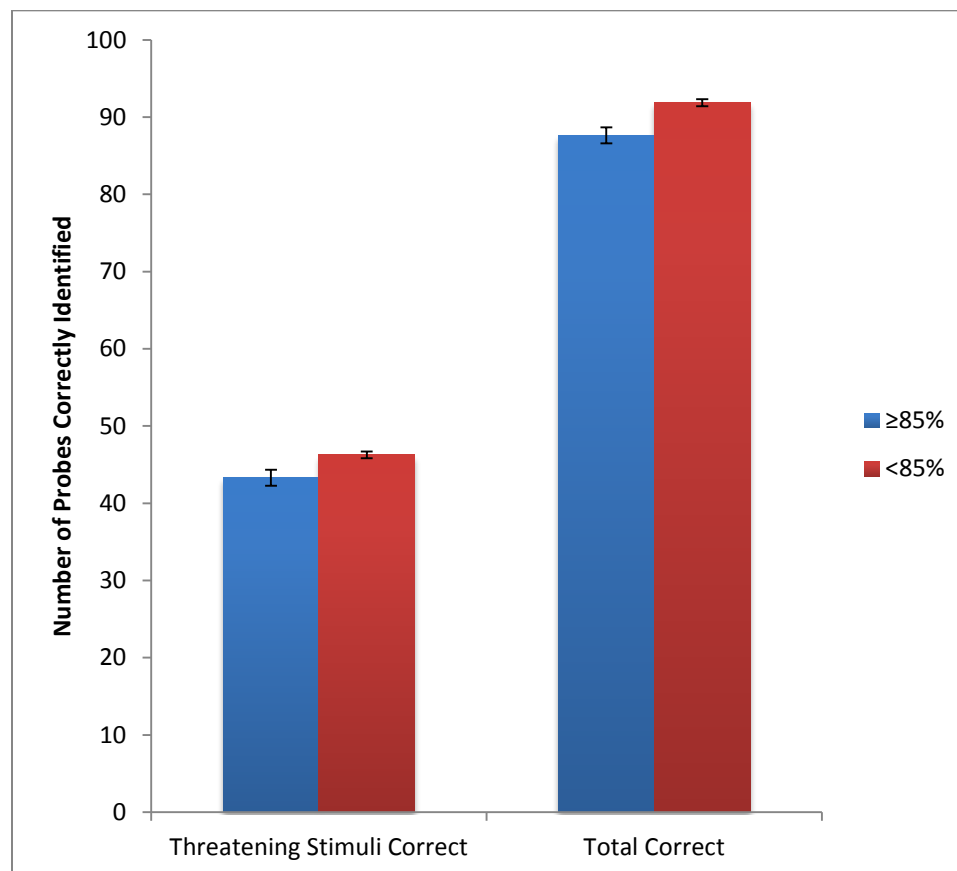


Figure 4. Participants with low sleep efficiency correctly identified more probes in the threatening position compared to participants with high sleep efficiency

Table 5

SLEEPWAKE CYCLE REGULARITY AND ATTENTIONAL BIAS

Attentional Bias of Low (PSQI >5) and High (PSQI ≤5) Quality Sleepers

Measure	PSQI >5 (n=16) M(SD)	PSQI ≤5 (n=15) M(SD)	p value
Mean Threat Rate	525.46(23.49)	475.92(87.36)	.21
Mean Neutral Rate	514.93(111.12)	475.92(87.36)	.26
Total Probes Correct	90.50(5.35)	88.80(7.25)	.46
Total Threat Correct	44.93(3.17)	44.53(3.98)	.75

Notes: SD= Standard Deviation

Mean Threat and Mean Neutral Rates are measured in milliseconds

Total Probes Correct is out of 96 pairs (48 threatening and 48 neutral)

Discussion

SLEEPWAKE CYCLE REGULARITY AND ATTENTIONAL BIAS

The aim of this study was to examine the effects of sleep schedule on attentional bias. In addition, the effects of sleep quality, sleep efficiency and chronotype on attentional bias were also examined.

It was hypothesized that participants in the sleep-as-usual group would have a greater attentional bias towards negative emotional stimuli. Also, it was predicted that participants with poor sleep quality, low sleep efficiency and an evening chronotype would also have an attentional bias towards negative stimuli.

There is evidence that stress and tension are key causes of poor sleep quality in college students (Lundel et al., 2010). College lifestyles create many instances in which stress and tension can arise such as finals and variable schedules. In addition, some students may not be accustomed to the stress level college creates as compared to high school. For these reasons, stress-induced sleep difficulties are to be expected (Lundel et al., 2010, Buboltz et al., 2014). High quality sleep is essential for mental and physical health. A number of sleep impairments such as insomnia, sleep restriction and sleep quality have been known to contribute to decreased mood (Johnson et al., 2006).

Naturally irregular sleepers (defined as varying sleep/wake times by 2-4 hours) compared to naturally regular sleepers showed significantly lower levels of pulse rate and body temperature, but significantly longer reaction times (Taub, 1978). This study also provides evidence that subjective mood is associated with chronic irregular sleep patterns (Taub, 1978). For this reason, it was hypothesized that irregular sleepers would show an attentional bias towards threatening stimuli and that acute regularization of the sleep schedule could reverse negative attentional bias.

The current study found that participants in the sleep-as-usual group responded slower to both threatening and neutral stimuli. This finding was contrary to the hypothesis, however, it is

SLEEPWAKE CYCLE REGULARITY AND ATTENTIONAL BIAS

in line with the evidence provided by previous studies (Taub, 1978) which found that irregular sleepers had longer reaction times.

Chronotype was not associated with reaction time or number of correctly identified probes in the threat position.

As predicted, participants with low sleep efficiency correctly identified significantly more probes in the threatening position than participants with high sleep efficiency. However, sleep efficiency was not associated with reaction time. Sleep quality was also unrelated to reaction time and number of correctly identified probes.

College students were an ideal population to study because there is evidence showing that they generally have poor sleep habits including sleep restriction, sleep deprivation, poor sleep quality and erratic sleep schedules (Lundel et al., 2010, Buboltz et al., 2001). This was optimal for the current study because it was hypothesized that acute regularization would reverse the effects of poor sleep on attentional bias. Also, because participants were instructed to sleep 7 hours each night, which is the suggested amount by the National Sleep Foundation, participants in the sleep regulation group should not have experienced sleep restriction.

There is evidence supporting the theory poor sleep habits contribute to reaction time (Cain et al., 2011, Taub, 1978). After 40 hours of sleep deprivation, it was found that response time in the Stroop Color Task significantly increased (Cain et al., 2011). Sleep, when restricted to 4 hours/night in children ages 8-15 years old resulted in increases in daytime sleeping, subjective sleepiness, and inattentiveness (Fallone et al., 2001). Inattentiveness could be a possible cause for slower reaction time, which would explain the delay in reactions among the sleep-as-usual group.

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In addition, there is evidence that shows individuals with insomnia have slower reaction times than matched controls (Hauri, 1997). In 26 pairs of insomniacs and controls, insomniacs performed worse in terms of reaction time in an auditory vigilance task (Hauri, 1997). Since poor sleeping habits such as sleep deprivation, sleep restriction and insomnia have been associated with slower reaction time, could explain why participants in the sleep-as-usual group had slower response times to all stimuli.

This study did have limitations. A major limitation was that the sleep-as-usual group ($M=382.15$, $SD=55.52$) and the sleep regulation group ($M=352.66$, $SD=34.85$), $t(29)=1.73$, $p=.10$, did not receive significantly different amounts of sleep. This suggests that participants did not adhere to the study instructions, making them non-compliant. While the standard deviation shows that the sleep-as-usual group did vary more than the sleep regulation group, this variation was not significant. Additionally, standard deviation calculations for sleep regulation, PSQI and chronotype were very large showing that individual data was not close to the overall mean.

A strength of this study was that it took place over a weekend, a time that sleep schedules are at their most irregular, especially for college students. In a study researching college student sleep patterns, analyses showed that sleep schedules were erratic and restricted during the week. During the weekends, bedtimes tend to be extended and rise times are delayed (Lund et al., 2010). In addition, 20% of students reported staying up all night at least once in the last month and 35% reported staying up til 3a.m. at least once each week (Lundel et al., 2010).

For future research, the effects of naturally sleeping irregularly or regularly on attentional bias could be studied. The benefits of this would be that since the groups naturally sleep one way or the other, participants would not be inconvenienced to change their sleeping habits. With

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college students having schedules that vary often (Lundel et al., 2010, Buboltz et al., 2014), compliance was a major issue in this study and could potentially be avoided if natural sleep patterns were observed instead. This would also show long-term effects as opposed to acute effects of regularization.

In addition, future studies could use different emotional stimuli. The list of words (Appendix G) used for this study may not have contained strong enough threatening stimuli. Future studies could possibly use pictures as opposed to words in order to see if the intensity of emotional stimuli has an effect on attentional bias.

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Appendix A

Informed Consent

This study is being conducted because poor sleep is becoming increasingly prominent in the United States and regulating sleep may be an easy solution to this problem.

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This study will last six days and five nights. On the first day, participants will report to the lab in Carnegie to fill out a demographics questionnaire, a chronotype questionnaire and a sleep questionnaire. This should take about ten minutes. They will be instructed on how to use an actigraph and will use it for five nights. Participants will be randomly assigned to either a regular sleep pattern or irregular sleep pattern for those five nights. The regularized sleep group will need to sleep for 7 hours each night, laying down for bed and waking up at the same time. The irregular group will be continuing their regular sleep habits.

On the sixth day, participants will return to the lab and take part in a dot-probe task. This task measures attentional bias to emotional stimuli. This task should take around 20 minutes.

Emails will be sent out to participants reminding them of appointments. There will be a record of participant's names and actigraph number, but these will be kept separate from any recorded data.

By signing this consent form, you agree that you are at least 18 years of age. Participation in this research is voluntary. There can be no consequences for either failure to participate or termination of participation. If participants decide to discontinue the study, actigraphs must be returned to the experimenter. There are no foreseeable risks or potential discomforts from participating in this research study. In addition, no benefits are acquired by partaking in this experiment. All information collected throughout the study will remain confidential. Only group average data will be reported.

If you have any inquiries regarding participants' rights, please contact one of the following people:

Haylee Andrews (412)-527-0500, andrewsh@allegheny.edu

Sarah Conklin (814)-332-2392, sconklin@allegheny.edu

Rich Bowden (814)-332-2869, rbowden@allegheny.edu

Participant's name (please print) _____

Participant's signature _____

Date _____

Appendix B Demographics

Sex:

____ Male ____ Female

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Age:

Class Year:

_____Freshman _____Sophomore _____Junior _____Senior

Credit hours currently enrolled in:

Housing:

_____Dorm building _____House _____Other

Do you have a job?

_____Yes _____No

If yes, how many hours/week?

Do you share a bed during sleep regularly?

_____Yes _____No

How much exercise do you get in one week (minutes)?

How many drinks containing caffeine do you consume in one week?

Appendix F
Debriefing Form

Research has suggested that regulating sleep/wake patterns may enhance mood. This study is being conducted because depression is becoming an increasingly prominent force in the

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United States and regulating sleep may be an easy way to combat the manifestation of this disorder.

There were no deceptions in this study. It has been hypothesized that participants with short, irregular and poor quality of sleep will have a faster reaction time to negative emotional stimuli. If you would like to be kept up to date on the findings of this study, you can contact Haylee Andrews at andrewsh@allegheny.edu.

If this research study causes any concerns, feel free to contact Professor Sarah Conklin (sconklin@allegheny.edu), the chair of the Ethics Review Board, Rich Bowden (rbowden@allegheny.edu), or the principal researcher, Haylee Andrews.

If this study causes any psychological concerns, contact the counseling center to schedule a free appointment (814-332-4368). Any sleep-related problems may also be directed to the National Sleep Foundation's hotline, 888-time4sleep from 6pm to 1am. For information regarding this topic, you can reference the following articles:

Trockel, M., Manber, R., Chang, V., Thurston, A., and Taylor, C. B. (2011). An e-mail delivered CBT for sleep-health program for college students: effects on sleep quality and depression symptoms. *Journal of Clinical Sleep Medicine*, 7, 276-281.

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Appendix G

Word List

Coffin/Edited	Assault/Bottles	on
Tense/Backs	Sinister/Integral	Fatigue/Avocado
Unfortunate/Commodities	Misunderstood/Manifestati	Disease/Remarks

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Discontented/Households	Fright/Sipped
Deserted/Marching	Edgy/Rink
Confused/Arranged	Defeat/Museum
Miserable/Statewide	Cautious/Editions
Useless/Flowing	Ignored/Lighted
Fail/Ears	Cringing/necklace
Inform/Depots	Lonely/Jersey
Brooding/Proteins	Grieving/Hallmark
Defensive/Geometric	Pointless/Lunchroom
Unhappy/Bridges	Apprehension/Instrumental
Tragedy/Request	Inferior/Shearing
Sluggish/Textured	Emergency/Listening
Ambulance/Momentary	Trauma/Enjoin
Despised/tomatoes	Strangled/Signature
Desperate/Variables	Danger/League
Embarrassed/Microscopic	Hazard/Ballot
Nausea/Confer	Forlorn/Keyhole
Unsettled/Advocated	Touchy/Tinted
Mistake/Quarter	Suffocating/Constituent
Awful/Tract	Incurable/Reclaimed
Worried/Context	Glum/Kite
Lost/Read	Inadequate/Transition
Attack/Season	Suicide/summers
Tease/Aisle	Insecure/Fetching
Rejected/Quantity	Dismal/Midway
Dull/Flew	Quaking/Anagram
Mutilated/Decanting	Wary/Fold
Worthless/Batteries	Powerless/Multitude
Deathbed/Softener	Scared/Planet
Mourn/Scans	Agitation/Fireplace
Alarmed/Shelves	Hopeless/Feathers
Lethal/Racket	Timid/Satin
Devastated/Stagecoach	Dreadful/Computer
Gloomy/Pastel	Harm/Noon
Nervous/Outcome	Intimidated/Coefficient
Hostile/Rolling	Jumpy/Lotus
Catastrophe/Approximate	Panicky/Clarets
Sad/Pat	Coronary/receipts
Futile/Attire	Groan/Flute
Cancer/Saddle	Sickly/Tokens
Tormented/Mythology	Discouraged/connections
Horror/Wagons	Unpopular/Shoreline
Funeral/Hunting	
Humiliated/Waterproof	
Distress/Creature	
Pathetic/Cleaners	