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DEPARTMENT OF BIOBEHAVIORAL HEALTH

MOTIVATION AS A COVARIATE FOR CHANGES IN NEUROCOGNITIVE PERFORMANCE DURING SLEEP RESTRICTION

DAVID BAILEY
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Reviewed and approved* by the following:

Orfeu M. Buxton, PhD
Associate Professor of Biobehavioral Health
Thesis Supervisor

Lori Francis
Associate Professor of Biobehavioral Health
Honors Advisor

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

Today, people do not view sleep as a top priority. Oftentimes sleep takes a secondary role in people's lives with negative health outcomes as a result. In experimental studies sleep restriction is imposed on study participants by limiting sleep opportunity over multiple days. As sleep duration is restricted, neurocognitive performance is decreased. However, laboratory models of sleep restriction require participants to undergo prolonged periods of time in the lab undergoing repeated, boring tests of neurocognitive performance. The participants experience can be mentally strenuous and lead to a decrease in motivation to continue participation with the same vigor as at the beginning of the study period. A decline in motivation has been implicated in decreasing neurocognitive performance similar to the decline in performance attributed to increased levels of sleepiness. Consequently, this thesis sought to examine the effects of motivation on neurocognitive performance during sleep restriction. The goals of the present study are to examine whether or not a decline in motivation causes a decrease in neurocognitive performance independent of the decline attributed to perceived sleepiness. We collected data within a larger 11-day inpatient study conducted at The Pennsylvania State University Clinical Research Center. Study participants were submitted to three conditions; baseline, restriction, and recovery. The baseline and recovery periods were defined as ten hours in bed for three and two nights respectively while restriction allowed for five hours in bed across five nights. Cognitive batteries were administered throughout each day followed by a survey that evaluated levels of motivation and sleepiness. The results of this study were that at the test level an increase in self-reported levels of sleepiness predicted a higher incidence of psychomotor vigilance task (PVT) lapses. The level of unmotivation was not significantly related to an increase in the number of PVT lapses.

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Chapter 1

Introduction

This study seeks to better understand the influence of participant motivation as a covariate for the cognitive decline seen during a period of sleep restriction. It is believed that a loss of participant motivation during sleep restriction would have a negative impact on the performance of tasks measuring cognition relative to a rested baseline which would act as a covariate to the primary relationship between sleepiness and cognitive performance. This study tests the hypothesis that motivation will have a negative effect on cognitive performance that is independent of self-reported sleepiness.

Data were collected using a within-subject technique for an 11-day inpatient sleep restriction study. Measures of cognition and motivation were collected across three conditions, baseline (10h/night TIB), restriction (5h/night TIB), and recovery (10h/night TIB). Subject sleepiness and motivation levels were collected via self-report survey following a cognitive battery that lasted approximately twenty minutes. Cognitive battery and subsequent surveys were administered approximately every two hours during subject wake-time.

Sleep restriction and its effect on cognition

Sleep restriction is defined as a decrease in sleep duration below the habitual level (8). Previous research has shown that sleep restriction causes deficits in cognitive and motor performance (2). This decline in performance has been attributed to increased participant

sleepiness due to restriction. Subjective levels of sleepiness have been observed to increase after the first night of restriction relative to baseline. This level of sleepiness has been observed to plateau and remain constant throughout the restricted period (4).

Previous research has shown that increased levels of sleepiness is predictive of a decline in performance (1). Initially it was believed that sleepiness decreased neurocognitive performance by causing lapses of attention which led to the observed effect as opposed to an overall decline in cognitive ability (2). Further research determined that the decline in performance was not due to lapses in attention but a lessening of ability on average (2). This lessening of ability while restricted was hypothesized to be an adaptive change to maintain a stable level of performance despite a lack of adequate sleep (2).

The decline in performance has been observed across periods of sleep restriction during controlled laboratory studies (2). Previous research has found that performance decline continues to increase throughout restriction which would indicate a dose-response relationship between the degree of sleep restriction and neurocognitive performance (9). A greater amount of restriction was associated with a more extreme decrease in neurocognitive ability relative to baseline.

An alternative hypothesis suggests that the decline in neurocognitive performance reaches a peak and plateaus during restriction. It has been hypothesized that this plateau is a result of a neuro-modulatory response to keep performance levels consistent when sleep restricted. This theory suggests that the brain undergoes adaptive changes to stabilize performance decline (2).

Motivation as a possible covariate

Previous sleep restriction studies have observed a decline in participant mood throughout the duration of the study. As opposed to sleep deprivation where a subject is kept awake for an extended period of time, sleep restriction requires lessening of sleep across many days. The benefit of using a sleep restriction design is that it better mimics the incidence of poor sleep habits in a real-world population (10). This restriction design requires a prolonged length of inpatient study which has been observed to negatively influence participant mood and their level of motivation to perform required tasks (11). Previous research notes that participants have reported feeling unenthusiastic about continuing and that they have trouble focusing due to the monotony of tasks (5). This lack of focus has also been mentioned to possibly impact cognitive performance.

Similar studies have observed that tests of neurocognitive ability become more sensitive to the effects of sleep restriction depending on the order in which tasks are taken and how long the assay takes to complete (12). The later the tasks are taken in a cognitive battery is predictive of increased sensitivity to the decline in neurocognitive performance. It has also been observed that performance towards the ends of a lengthy test, such as the psychomotor vigilance task, is lower than participant performance at the beginning (12). These observations suggest that motivation may serve as a covariate for the cognitive decline observed during sleep restriction which has been attributed to sleepiness levels. The decline in participant motivation towards the end of a battery of tests or at the end of a certain task could be associated with the increased sensitivity observed in those instances.

Motivation has been shown to have an impact on cognitive performance in studies outside of sleep restriction as well (7). Motivated participants have increased performance relative to other equally competent but less motivated individuals (6). These findings have been explained by

breaking performance down into two aspects, competence and motivation. Possessing both qualities is important to perform at ones highest capability. Despite being competent, an unmotivated individual will not perform as well as an equally capable person who is motivated (7).

This study seeks to examine the effect this second aspect, motivation, has on cognitive performance. Through a sleep restriction model controlling for competence, defined as level of sleepiness, it will be possible to visualize how much of an effect motivation has on cognitive performance.

Tests of neurocognitive performance

Neurocognitive performance was measured using a Joggle cognitive battery (Version 2.5.0.412, Joggle, Seattle Washington). The psychomotor vigilance tasks (PVT) will be used as a measure of attention and reaction speed (13). This task has been demonstrated to have minimal learning effects that may lead to bias in results after repeated administration of the measure (13). A decline in reaction time and an increase in lapses was indicative of a decline in neurocognitive performance.

Previous research has demonstrated that neurocognitive performance declines during a period of sleep restriction. The decline in neurocognitive performance has been attributed to increased “objective” sleepiness and is associated with self-reported sleepiness. While this relationship between sleepiness and performance has been well documented, the effect that participant motivation has on neurocognitive performance has not been as closely examined. A decline in participant motivation throughout a period of prolonged sleep restriction could moderate

the relationship between neurocognitive performance and sleepiness. The current study examines the effect of participant motivation on neurocognitive performance independent of sleepiness. By collecting measures of self-report sleepiness and motivation, it is possible to compare this self-rating of sleepiness and motivation to an objective measure of neurocognitive performance in the psychomotor vigilance task. The goal of this research is to better understand the sources of neurocognitive decline during sleep restriction, specifically motivation.

Chapter 2

Methods

1. Subject Recruitment

1.1 Subjects were recruited via online advertisement and flyering in State College, Pennsylvania. They were required to be healthy, non-smoking men between the ages of 20-35 who were right hand dominant (due to imaging aims beyond the scope of this report). Compensation for participation was $2,250 upon completion of all procedures. Health was determined by evaluation of medical and psychiatric history, medical examination, serum chemistry, and hematology. Participants were required to be free of any acute or chronic medical conditions.

2. Inclusion and Exclusion Criteria

2.1 Participants were chosen if they fulfilled the criteria of a healthy, non-smoking young male between the age of 20-35. Healthy status was verified by a physical exam including medical history and laboratory testing by CRC clinical staff. Volunteers were required to be free of any acute or chronic medical conditions. Participants were required to meet certain metabolic criteria such as cholesterol and BMI. Failure to meet all of these criteria led to exclusion.

2.2 A psychiatric evaluation was conducted to determine mental health status. A psychologist administered and scored a Structured Clinical Interview (SCID) for each subject. Any evidence of psychopathology was exclusionary. Also, a history of psychiatric illness or the past prescription of medication treating psychological illness was exclusionary. Evidence for Axis II

personality types was also grounds for exclusion due to potential interference with protocol compliance.

2.3 Three weeks prior to the start of the in-lab period participants were also asked to give up alcohol, caffeine, nicotine, and non-prescription drugs including supplements. This compliance was verified by a toxicology screen prior to and upon admission. Participants who required prescription medication were excluded. Any history of anti-hypertensive drugs, lipid modifying drugs, or fish oil supplementation of >100mg/day were excluded (for metabolic testing components of the protocol outside of the scope of the current analysis). Participants were excluded if they had dietary restrictions that obstructed the dietician-designed diet necessary for procedures outside the scope of this paper.

2.4 Participants were excluded if they had a history of night-work in the last 3 years. Also, travel across > 2-time zones in the previous 3-months would lead to participant exclusion. Before beginning the study, participants were asked to spend 10 hours in bed for at least one week which was verified by wrist actigraphy data and sleep diaries.

2.5 fMRI was used for procedures outside of the scope of this paper. However, due to this protocol study participants were excluded if they were colorblind, had metallic implants, or did not comply with the Social, Life, and Engineering Center for 3T MRI Safety.

3. Sleep Restriction Study

3.1 Data for motivation, sleepiness, and cognitive performance were collected within a larger 11-day inpatient study by the Sleep, Health, and Society Lab at The Pennsylvania State University Clinical Research Center. Data were collected from 12 subjects (n=12). The 11 days were split into 3 days of baseline (10 hours/night), followed by five nights of restriction (5 hours/night), and concluding with two nights of recovery (10 hours/night). Subject remained in a

light controlled, sound proof room for the majority of the study. Several procedures not included in this thesis occurred outside of the room. The participant was monitored throughout the day to ensure sleep was only allowed at the designated time.

4. Cognitive Battery

4.1 The Psychomotor Vigilance Task (PVT) is a test of visual reaction time to a single stimulus. Delivered on an iPad, (Version 2, Apple, Cupertino, CA) participants are asked to maintain attention on a box inside of which a stimulus will appear. The stimulus is a millisecond counter that upon appearance begins to count up. Participants are to tap the screen as soon as they see this stimulus. Upon tapping the screen the counter stops and the reaction time is shown in milliseconds. The stimulus then disappears and the process repeats. This continues for 10 minutes.

4.1.1 Number of lapses per test session were counted. A lapse was defined as a reaction time that is longer than 500 milliseconds. ***Lapse.***

4.1.2 Reaction time was measured for each stimulus and a per test mean was then determined. Reaction time was measured in milliseconds. ***Mean RT. Milliseconds.***

5. Motivation and Sleepiness Surveys

5.1 Surveys were administered on an iPad 2 following Joggle cognitive battery using the survey tool RedCap. The cognitive battery included multiple cognitive tasks lasting for a total of

approximately twenty minutes. Joggle battery and RedCap surveys were administered in a quiet environment free of all distractions.

5.2 The visual analogue scale (VAS) survey was given to determine how motivated the participant was during performance of the cognitive battery as well as a measure of sleepiness. This survey was administered on a sliding scale from 0-100.

5.2.1 Alertness was measured from “sleepy” to “alert”. A score of 0 corresponded to max level of sleepy while a score of 100 indicated maximum alertness. ***Alertness (0-100).***

5.2.2 Motivation was measured on a sliding scale from “motivated” to “unmotivated”. Motivation was measured on a scale from 0-100. A score of 0 corresponded to maximum amount of motivation. A score of 100 was determined as the minimum amount of motivation, or unmotivation. ***Unmotivated (0-100***).

5.3 PEERS survey was used to determine self-report of performance and motivation. This survey asked subjects to rate their belief in being able to perform better on the previous cognitive tasks. ***Potential Improvement. 1-3.***

5.4 Sleepiness was measured by the Karolinska Sleep Scale which allows participants to self-report by checking a box that corresponded to their feelings. The options ranged from alert to extremely sleepy. ***Sleepiness. 1-9***

6. Statistical analysis

6.1 The survey data for VAS, KSS and PEERS were visualized by taking the average of the daily mean for each subject (n=11). Restriction and recovery periods were normalized to

baseline by subtracting the average daily mean of the baseline period from the daily mean for each subject during restriction and recovery.

6.2 PVT data were visualized by the daily mean for lapses and daily median for mean RT. PVT mean RT was shown as the average of the daily median for each subject (n=11). Data were normalized by subtracting the mean of baseline median from the daily median for days of restriction and recovery for each subject. PVT lapse data were shown as the average of each subject's daily mean (n=11). Data were normalized by taking the baseline mean and subtracting it from the daily mean for restriction and recovery time for each subject.

6.3 Correlations were run on the test level for each subject. Survey data and PVT performance within the same test period were used for a within-subject correlation. Significance was determined with a p value that was less than >.05. Correlations for number of PVT lapses x VAS Unmotivation, VAS Unmotivation x Karolinska sleep scale, and number of PVT lapses x Karolinska sleep scale were obtained.

6.4 Statistics were run using a mixed model, controlling for random effects with the outcome variable being number of PVT lapses. Self-reported levels of sleepiness as determined by KSS as well as self-reported level of unmotivation determined by VAS survey were used as predictor variables. Sleepiness and motivation were run simultaneously. Day within study as well as time of day were not used in statistical analysis.

Chapter 3

Results

Subjects (n=11) were evaluated via cognitive battery over a period of 11 days. Cognitive batteries were administered approximately every two hours followed by a survey to determine the participants self-reported motivation and sleepiness level. Data were plotted with the first four days constituting baseline condition (10h/night TIB) followed by five days of sleep restriction (5h/night TIB). The final two days served as the recovery condition (10h/night TIB).

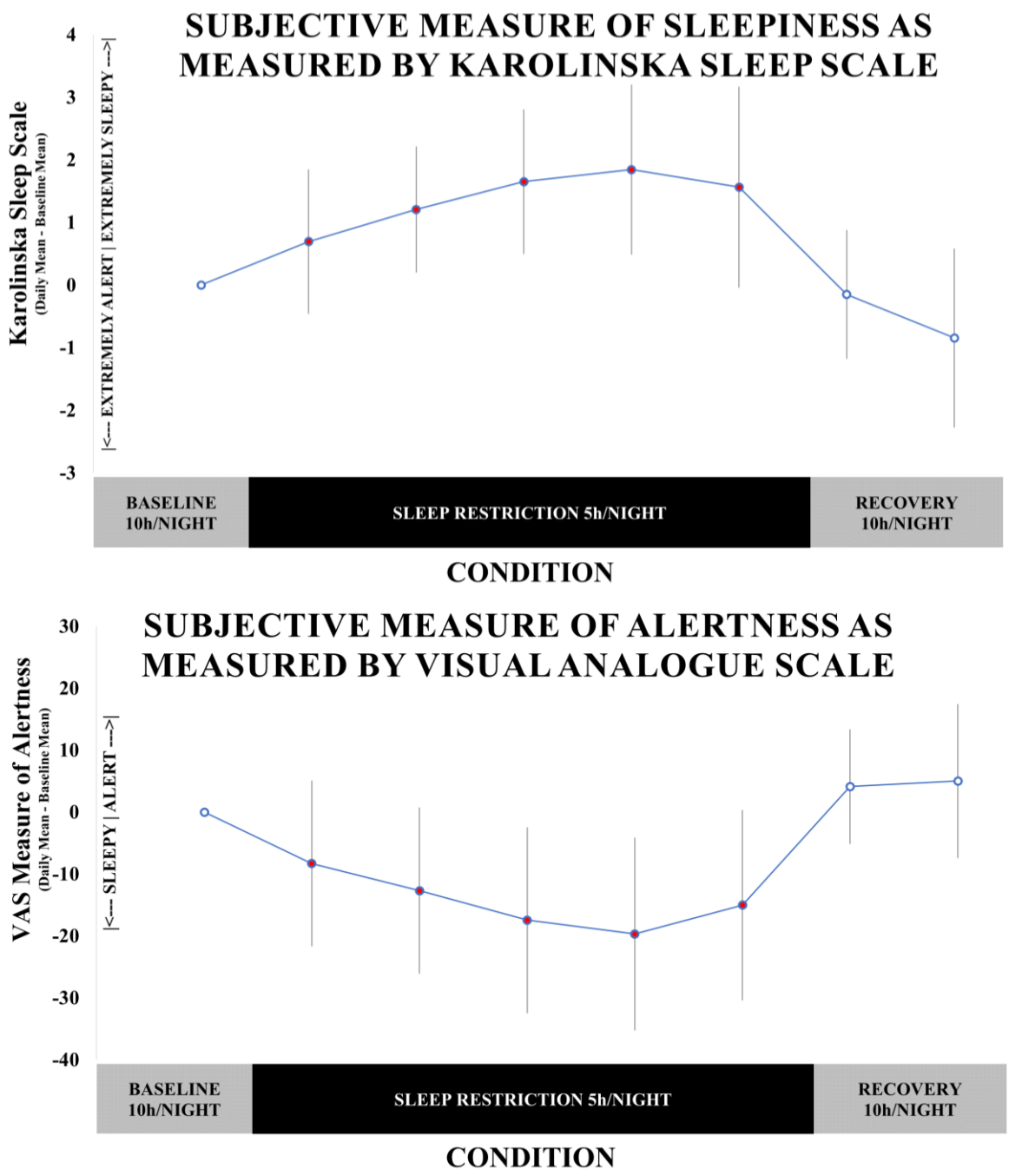
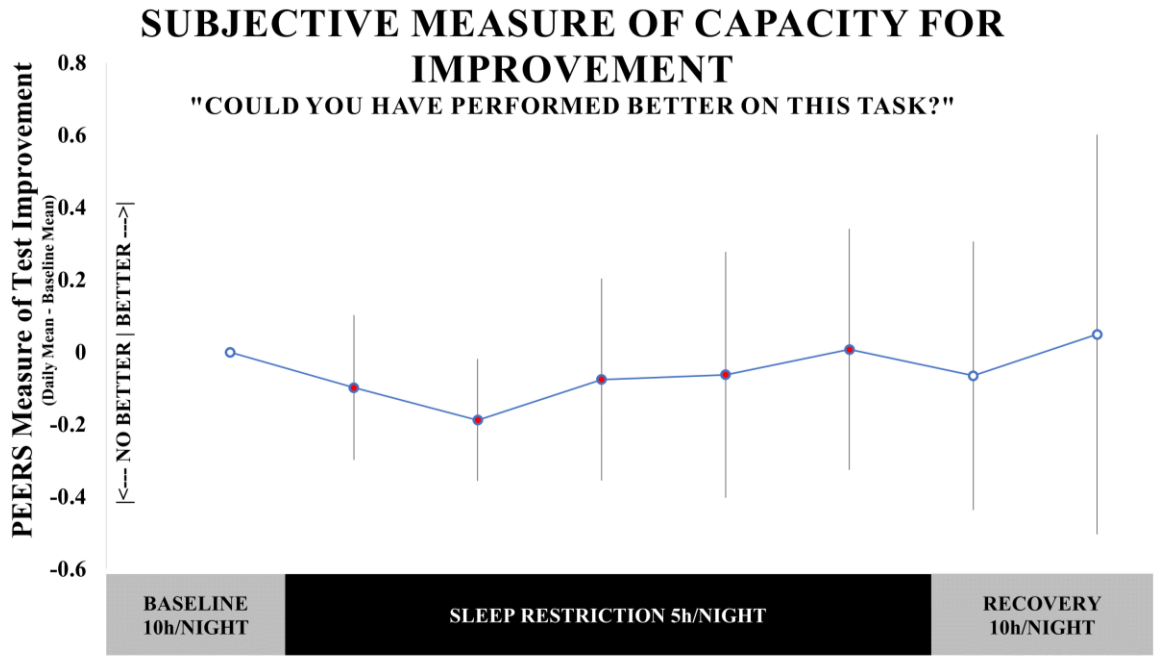


Figure 1 Measure of daily mean (n=11) for subjective sleepiness and alertness as measured by VAS and KSS survey following cognitive battery. Data were normalized by subtracting the baseline mean from the daily mean for each day of restriction and recovery. Subjective sleepiness was measured during baseline (10h/night TIB), sleep restriction (5h/night TIB), and during recovery (10h/night TIB).

Subjective measures of sleepiness/alertness. As the amount of time in sleep restriction increased so did participant self-reported sleepiness as reflected in figure 1. Sleepiness increased for each subsequent day of restriction relative to baseline before again returning to baseline levels after one night of recovery (Fig. 1). Levels of alertness shared a similar trend. Across sleep restriction, levels of alertness decreased relative to baseline. Following one night of recovery, a return to baseline level of alertness was observed (Fig. 1).



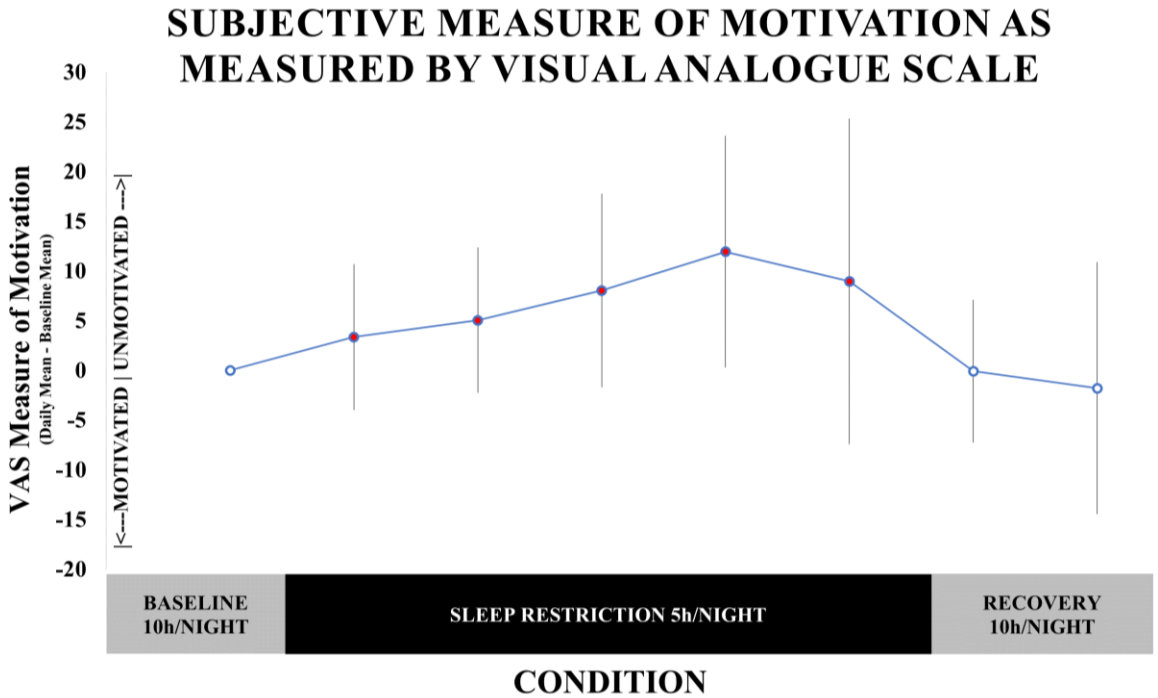


Figure 2 Measures of subjective motivation (n=11) as measured through survey following cognitive battery. Data were normalized by subtracting the baseline mean from the daily mean for each day of restriction and recovery. Motivation was measured during baseline period (10h/night TIB, 4 days), restriction period (5h/night TIB, 5 days), and recovery period (10h/night TIB, 2 days).

Subjective measures of motivation. The VAS measure of motivation demonstrates that the further into restriction participants progress, the more unmotivated they became (Fig. 2). Relative to baseline, level of unmotivation increases for each subsequent day of restriction. After one night of recovery, motivation levels return to that of baseline (Fig 2.). The PEERS measure of self-reported potential improvement remained relatively level across all conditions. This reflects that participants believed an increase in effort would not improve their objective performance (Fig. 2)

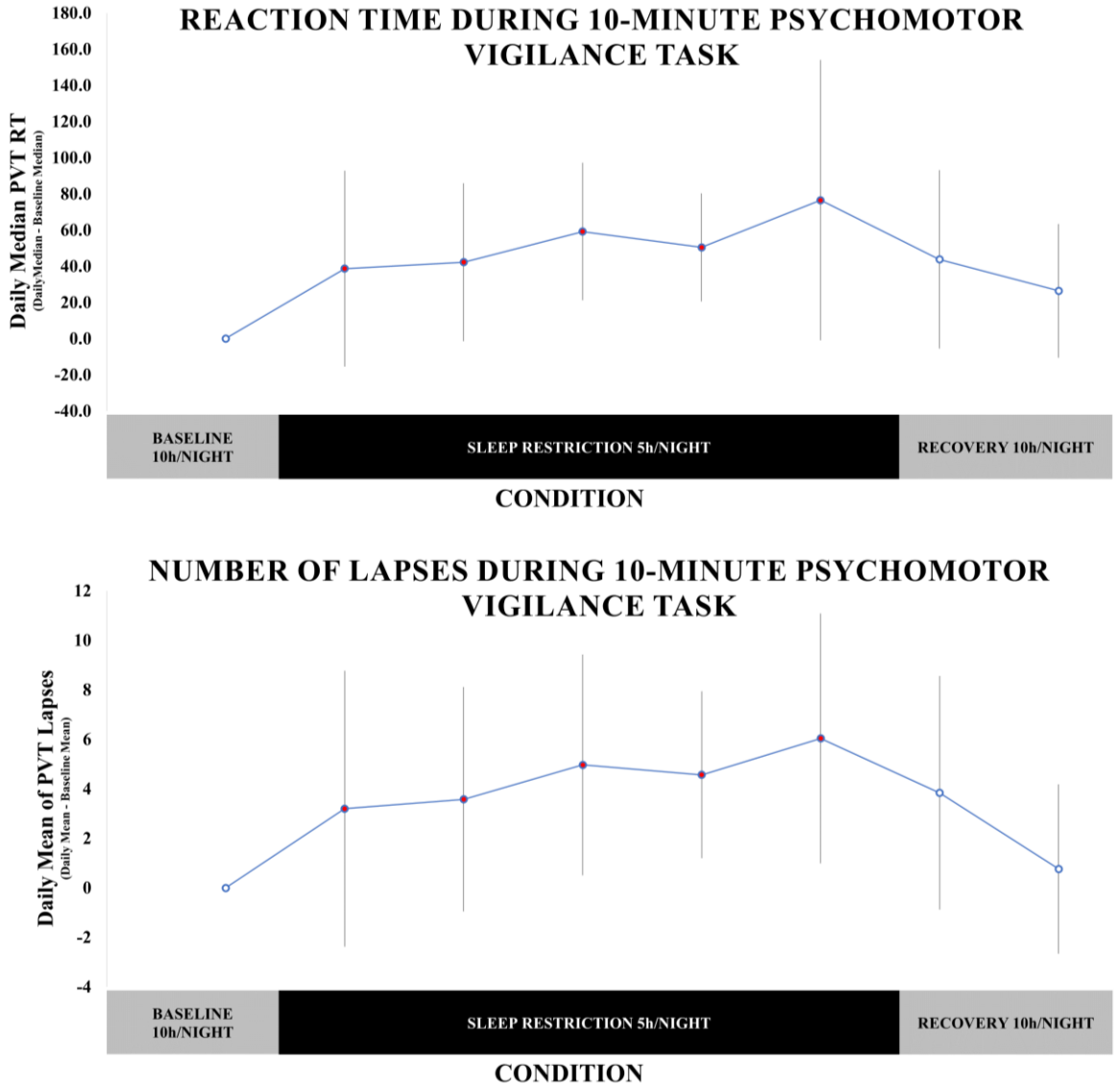


Figure. 3 Measures of PVT performance as measured by Joggle cognitive battery. PVT data were collected during baseline period (10h/night TIB, 4 days), restriction period (5h/night TIB, 5 days) and recovery period (10h/night TIB, 2 days). Data were normalized for PVT Reaction time by subtracting the mean of the baseline medians from the daily median for each day of restriction and recovery. PVT lapses were normalized by subtracting the baseline mean from the daily mean for each day of restriction and recovery. Reaction time was measured in milliseconds. Lapses were determined as any reaction to stimulus totaling longer than 500 ms.

Neurocognitive performance. Objective measures of performance on the psychomotor vigilance task decreased during sleep restriction (Fig 3). During sleep restriction, the number of lapses in attention increased relative to baseline. Following one night of recovery, the daily mean of number of lapses decreased and after two full nights the daily mean returned to baseline levels (Fig. 3). Daily mean reaction times followed a similar trend. During restriction mean RT increased relative to baseline. Following recovery sleeps the mean RT again decreased towards baseline levels (Fig. 3).

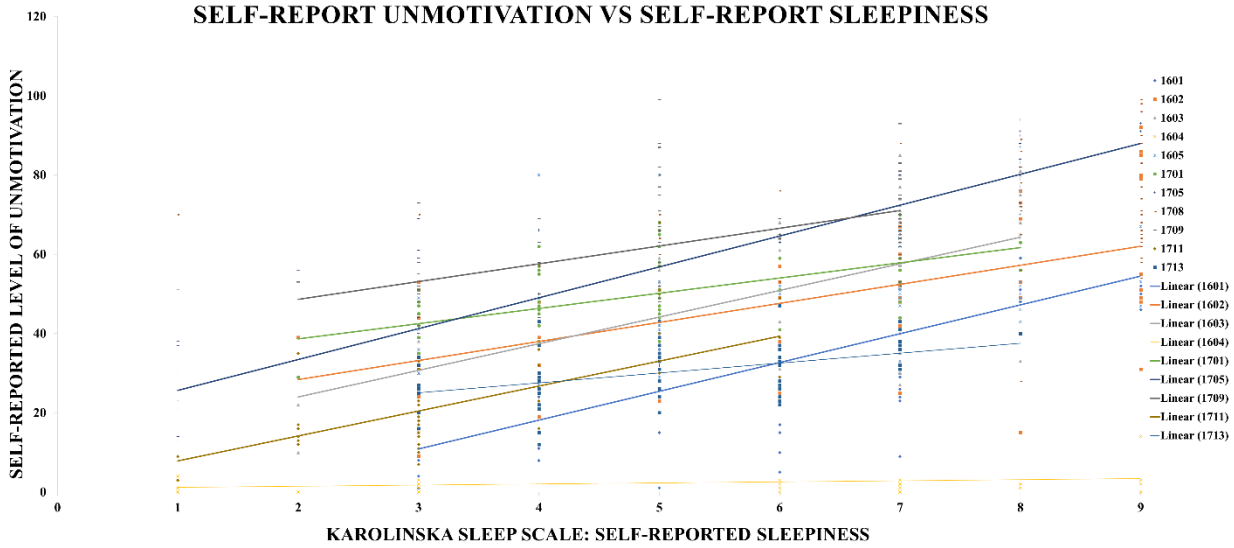


Figure 4 Correlation between the self-reported level of unmotivation as determined by VAS survey versus level of sleepiness as determined by Karolinska sleep scale. A positive correlation was seen in 9 of 11 participants: 1601 (r=.678, p<0.001, n=53), 1602 (r=.570, p<0.001, n=55), 1603 (r=.586, p<0.001, n=60), 1605 (r=.310, p=.019, n=57), 1701 (r=.591, p<0.001, n=59), 1705 (r=.855, p<0.001, n=62), 1709 (r=.485, p<0.001, n=59), 1711 (r=.695, p<0.001, n=62), and 1713 (r=.454, p<0.001, n=62).

Correlation of unmotivation and sleepiness. The level of unmotivation measured by VAS survey was positively correlated with self-report sleepiness as measured by the KSS in 9 of 11 subjects. As sleepiness increased participant motivation decreased (unmotivation increased) (Fig. 4).

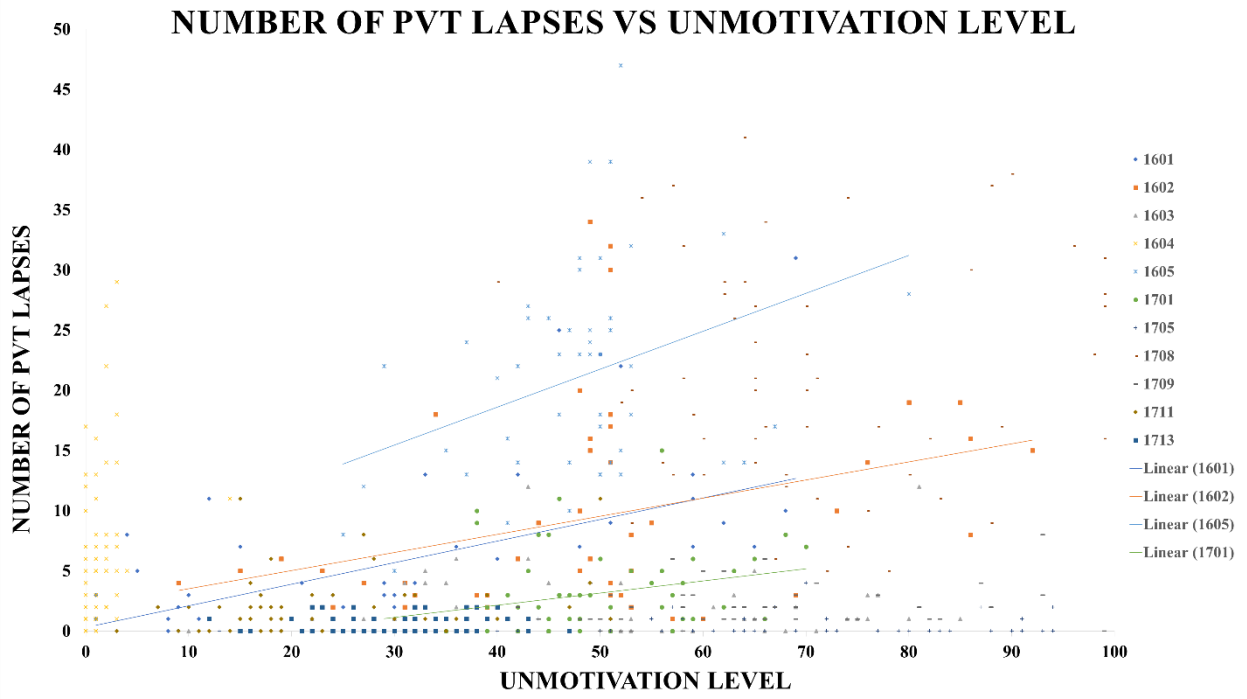


Figure 5 Correlation between the number of PVT lapses per test and self-reported level of unmotivation as determined by VAS survey following each test. A positive correlation was seen in 4 of 11 participants: 1601 (r=.5283,p<0.001, n=52), 1602 (r=.3390, p=.02, n =47), 1605 (r=.3575, p=.011, n=50), and 1701 (r=.2814, p=.039, n=54).

Correlation of PVT lapses and unmotivation. Objective neurobehavioral (PVT) performance, as measured by number of lapses per 10-minute test, was positively correlated with self-reported unmotivation in 4 of 11 subjects (Fig 5). As unmotivation increased, or motivation decreased, the number of PVT lapses observed increased.

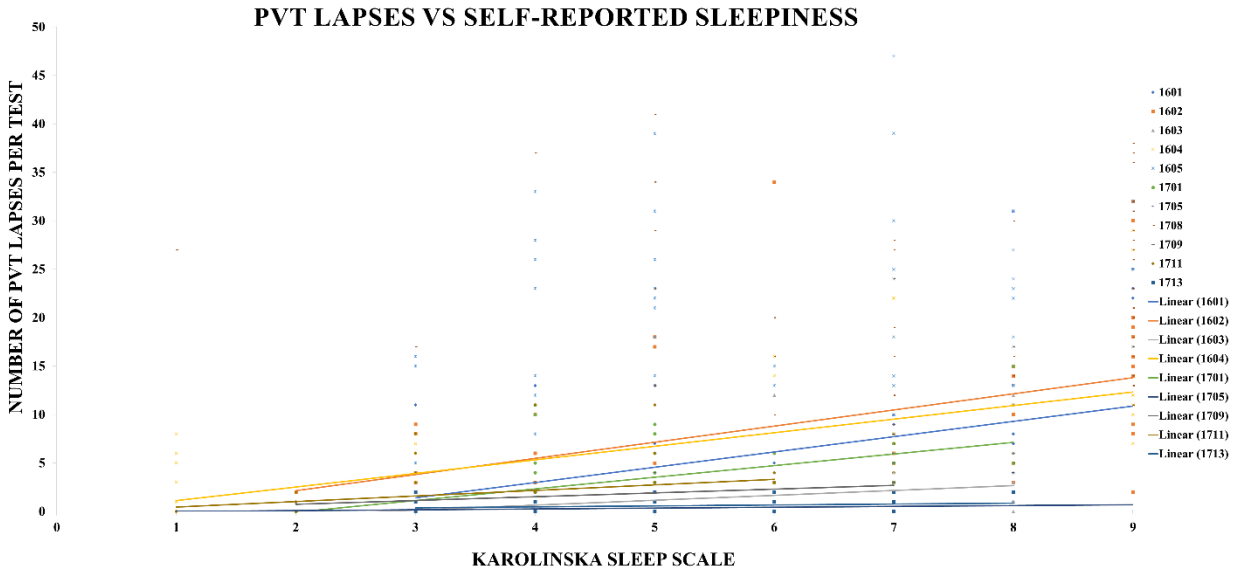


Figure 6 Correlation between the number of PVT lapses per test and self-reported level of sleepiness as determined by the Karolinska Sleep scale. A positive correlation was found in 9 of 11 subjects 1601 (r=.431, p=.001, n=52), 1602 (r=.472, p=.001, n=47), 1603 (r=.298, p=.024, n=57), 1604 (r=.594, p=0, n=58), 1701 (r=.524, p<0.001, n=54), 1705 (r=.323, p=.011, n=62), 1709 (r=.344, p=.01, n=55), 1711 (r=.299, p=.02, n=60), 1713 (r=.169, p=.194, n=61).

Correlation of PVT lapses and self-reported sleepiness. PVT performance measured with PVT lapses was positively correlated with self-reported sleepiness in 9 of 11 subjects (Fig. 6). As sleepiness increased so did the number of lapses of attention during the PVT task.

Mixed Model. Statistical analysis run within SAS software found a significant, within subject relationship (p=0.001) between the self-reported level of participant sleepiness and number of PVT lapses. For every 1-point increase in sleepiness, the number of PVT lapses was found to increase 0.8420 per test. There was no significant relationship between participant motivation level and PVT lapses. Both motivation and sleepiness were run simultaneously.

Chapter 4

Discussion

This study evaluated the association of objective measures of neurocognitive performance using the psychomotor vigilance task with subjective measures of sleepiness and motivation at regular intervals throughout each of the 11 days including five days of sleep restriction (5h/night TIB). It was observed that neurocognitive performance declined during a period of sleep restriction relative to baseline. Neurocognitive performance was strongly and negatively associated with participant self-reported sleepiness, consistent with previous research collected. The relationship between motivation and performance was not significant. Thus, the hypothesis that participant motivation would serve as a covariate in the association between neurocognitive performance and sleepiness was not supported.

4.1 Sleepiness / Alertness

Relative to baseline, the level of participant self-reported sleepiness measured by KSS indicated a dose-response relationship with the day of restriction when measuring the daily mean across all participants (n=11). Sleepiness levels peaked on restriction day 4, a full 2 points higher than that observed during the baseline condition. The trend of an increased level of self-reported sleepiness during restriction was also reflected in the daily mean across all participants (n=11) for the VAS measure of alertness. Subjects reported becoming less alert as they progressed into sleep restriction relative to their baseline levels. Self-reported alertness levels reached their lowest point on day of 4 of restriction, 20 points lower than reported at baseline (Fig. 1).

Previous research has indicated that levels of sleepiness and alertness increase after one night of restriction before leveling off and remaining consistent for each subsequent day of continued sleep restriction. This was not observed as sleepiness continued to increase for both days

1 and 2. Alertness also declined across restriction days 1 and 2. Days 3-5 of restriction showed sustained levels of both elevated sleepiness and reduced alertness (Fig. 1). These results suggest that the expected 'leveling off' of sleepiness levels occurred, though after two nights of restriction as opposed to just one. Other research has shown that in some instances sleepiness can continue to increase for each subsequent day of restriction, though this trend was not observed within this study. Both measures showed a return to baseline levels of sleepiness and alertness after one day of recovery sleep (10h/night TIB).

4.2 Motivation

Throughout sleep restriction the participants daily mean motivation decreased relative to baseline. The further into sleep restriction (5h/night TIB) the participants progressed corresponded to a decrease in motivation as self-reported through the VAS survey. Level of unmotivation peaked on the fourth day of restriction, 10 points higher than baseline with day 5 of restriction being slightly less. Following one night of recovery sleep (10h/night TIB) participants returned to their baseline levels of motivation (Fig. 2). These results suggest that participant motivation level is related to the sleep restriction condition. The return to baseline after one night of recovery mirrors that of sleepiness level. This observation suggests that the level of participant motivation is related to sleepiness levels.

The PEERS measure of test improvement was used to indicate whether or not participants felt they could have performed better on tests of neurocognitive performance had they tried harder. Throughout restriction and recovery conditions the response scores remained level with the baseline condition. Participants felt that increasing their effort would not lead to improved

performance (Fig. 2). Compared to the VAS test of motivation, this finding suggests that while participants do not believe more effort could improve performance, they were increasingly unmotivated to attempt.

4.3 Neurocognitive Performance

Neurocognitive performance as objectively measured through a PVT test was negatively affected by sleep restriction. After only one night of restriction the daily mean number of PVT lapses increased by 4 points. The mean reaction time also increased by ~40ms. Across the subsequent four days of restriction these performance levels remained fairly consistent. This finding supports previous research that has shown the decline in performance during sleep restriction is neuromodulatory in nature, decreasing to a certain level before remaining constant. Day 5 of restriction yielded the worst performance on PVT, with daily mean number of PVT lapses per test an average of 6 more than baseline and the daily median of the mean RT reaction time ~80ms slower (Fig. 3).

Following one night of recovery sleep (10h/night TIB) both lapses and reaction time decreased towards baseline. After two full nights of recovery sleep the number of PVT lapses was equivalent to the baseline mean, while reaction time was still slightly elevated over baseline but nonetheless lower than that observed during restriction (Fig. 3). This return towards baseline after one night of recovery sleep mirrors the trend seen in participant motivation as well as sleepiness and alertness.

4.4 Correlation of sleepiness / motivation / PVT lapses

Correlations between measures of motivation, sleepiness, and neurocognitive performance were run at the test level to determine the relationships between variables. In 9 of 11 subjects it was found that self-report levels of unmotivation were positively correlated with sleepiness at the

.05 level. As self-reported sleepiness increased so too did unmotivation (Fig. 4). This correlation suggests that the variables of sleepiness and motivation levels are related as hypothesized.

Sleepiness was related to PVT lapses in 9 of 11 participants. An increase in reported sleepiness correlated with an increase in the number of PVT lapses. This relationship supports the hypothesis that an increase in sleepiness is related to a decline in neurocognitive performance, as has been demonstrated in previous research (Fig. 6).

A self-reported decrease in motivation was also related to the number of PVT lapses per test in 4 of 11 subjects. Participant unmotivation was positively correlated with the number of PVT lapses per test. An increase in PVT lapses is indicative of a decline in neurocognitive performance. This relationship supports the hypothesis that participant motivation is related to neurocognitive performance levels (Fig. 5).

4.5 Mixed Model

A mixed model controlling for random effects found a significant relationship between self-reported sleepiness and number of PVT lapses for within-subject tests. An increased level of self-reported sleepiness is predictive of worse performance on the PVT as evidenced by an increased number of lapses in attention per test. This decline in PVT performance is indicative of a decrease in neurocognitive ability.

The same model was used to compare the effect participant motivation had on PVT lapses. There was no significant relationship between motivation and number of PVT lapses. This finding disputes the hypothesis that motivation has an effect on neurocognitive ability independent of sleepiness. Despite these variables being correlated in 4 of 11 subjects, motivation was not found to be a significant predictor of neurocognitive performance.

Chapter 5

Limitations and Future Directions

Limitations of this study include that the measures of motivation and sleepiness were collected using self-report survey methods. Using self-report measures could have led to bias in their answers. Motivation in particular was subject to this bias as participants may have felt pressure to respond that they were more motivated than was accurate to appear compliant with the study protocol. Also, participants answered survey questions immediately following cognitive battery. The last task in this battery was the 10-min psychomotor vigilance task. This task is the longest and most monotonous of tests in the battery. It is possible that this may have resulted in a recency effect where participants reported feeling less motivated due to the proximity of the psychomotor vigilance task. This recency effect and subject bias are limitations of using a self-report measure of motivation and sleepiness.

Future research could examine the effect motivation might have on other domains of neurocognitive performance. The PVT is an objective measure of performance, but by using tests that target specific domains of cognition, such as risk taking or abstract thought, it would be possible to develop a further understanding of motivation as a possible covariate in the association between neurocognitive performance and sleepiness. Also, this study used test level measures of variables to determine relationships across the full 11-day study. Additional research could further examine the influence of time of day on the potential association between neurocognitive performance and motivation. This would allow examination of whether a test taken later in the

daily series would be performed with less motivation than tests taken earlier in the daily series and if this potential change in motivation affects neurocognitive performance.

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Academic Vita of David Scott Bailey

Dvb5249@gmail.com

Education

The Pennsylvania State University, Schreyer Honors College
Bachelor of Science in Biobehavioral Health
Spring 2018

Research

Research Assistant **August 2015-May 2018**
Undergraduate Assistant *State College, PA*
Assisted in the administration of tasks to evaluate the effect sleep restriction has on the body in metabolic and cognitive domains. This research was conducted under the supervision of Dr. Orfeu Buxton and Dr. Anne-Marie Chang.

Awards and Honors

Health and Human Development Dean's List
Fall 2015, Spring 2016, Fall 2016, Spring 2017, Fall 2017

Extracurricular Activities

Penn State IFC/Pan-Hellenic Dance Marathon **September 2014-February 2018**
Volunteer *State College. PA*
Participation in the student run philanthropy group benefiting pediatric cancer research and care, culminating in a 46 hour no sitting, no sleeping dance marathon. Served in a variety of leadership roles responsible for managing logistical projects to ensure event success.

HealthWorks Advisor **August 2016-May 2018**
Student Advocate *State College, PA*
Served as a student peer advisor responsible for leading outreach programs that were aimed at improving physical, social and mental wellness among Penn State students. Had particular focus on the domains of healthy eating and sleep.

Penn State Lionscout **October 2015-December 2017**
Tour Guide *State College, PA*
Assisted Penn State admissions by giving tours and leading information sessions to prospective students.

Physics 251 Lecture Assistant **August 2016-May 2017**
Lecture Assistant *State College, PA*
Led study groups of students and served as a resource for students within the context of the physics department.

Teaching Assistant **August 2015-December 2015**
Sociology 001 *State College, PA*
Helped facilitate a sociology lecture while also acting as a resource for students to ask questions and help with their success in class.