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The Influence of Sleep on Negative Social Judgment

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The Influence of Sleep on Negative Social Judgment

DISSERTATION

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for the degree of

DOCTOR OF PHILOSOPHY

in Cognitive Sciences

by

Frida Corona

Dissertation Committee:
Professor Sara C. Mednick, Chair
Professor Belinda Campos
Associate Professor Alyssa Brewer

2022

DEDICATION

To

My dog Butter, Ian, Mom, family, and friends for your support here and beyond

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Sleep, stress, and underlying factors

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ABSTRACT OF THE DISSERTATION

The Influence of Sleep on Negative Social Judgment

by

Frida Corona

Doctor of Philosophy in Cognitive Sciences

University of California, Irvine, 2022

Professor Sara C. Mednick, Chair

Sleep is crucial for emotional and physiological health by allowing for restorative processes to occur. Disruption of sleep, such as that caused by stress, can result in adverse health outcomes. Given the importance of stress levels and sleep for health, disparities present are troubling and have not been the focus of studies until recently. In mainly middle-age and older adult samples, ethnic minorities and those with lower socioeconomic status experience poorer sleep and higher stress. However, fewer studies with young adult samples exist. One form of stress these groups report higher incidences of is that caused by perceived judgment. Given sleep's benefit on other forms of stress, the stress stemming from the feeling of being judged by others may also be reduced. My first two studies explore possible factors influencing sleep and stress. First, I examine whether the impact of stress on sleep is influenced by factors such as Ethnicity. Next, I explore whether environment, in the form of feelings of neighborhood safety, influences sleep and stress levels. My final study now looks at the beneficial effects of sleep with the hypothesis that sleep, through emotional regulation, can buffer the negative effects of being judged by a peer in a lab-setting.

INTRODUCTION

Sleep background

Sleep is generally classified into the states of non-rapid eye movement (non-REM) and rapid eye movement (REM). Non-REM consists of stages 1, 2, and slow-wave sleep (SWS). Electroencephalography (EEG) is commonly used to record electrical brain activity, electro-oculography (EOG) tracks eye muscle movements, and electromyography (EMG) measures muscle movement. During REM sleep, electromyography (EMG) and electro-oculography (EOG) recordings are important measurements. REM sleep is characterized by the presence of eye movement bursts. Eye movement increases compared to prior sleep stages. Meanwhile, during REM, muscular activity becomes suppressed. REM is involved in cognitive and emotional processes, including procedural memory consolidation, and emotional memory processing (Baran et al., 2012; Helm & Walker, 2011; C. Smith, 2001; Tucker et al., 2006).

Sleep's role in health outcomes

Sleep is beneficial for both physical and emotional health by allowing for restorative processes to occur in the brain and body (Acosta-Peña et al., 2012; Colten et al., 2006). However, sleep can be disturbed. Disturbances to sleep can lead to a variety of detrimental health outcomes including increased risk for cardiovascular disease, hypertension and high blood pressure (Akerstedt, 2006; Hoevenaar-Blom et al., 2011).

Poor sleep has notable effects on daily emotional health. One major component of emotional health, mood, suffers when poor sleep occurs (Riemann, 2007). Clinically, there are further negative outcomes: individuals with sleep disturbances exhibit major incidences of anxiety, depression, and substance abuse (Breslau et al., 1996).

An important process that occurs during sleep is emotional memory consolidation and regulation. During emotional memory consolidation, emotional memories are selected for and strengthened during sleep (Payne & Kensinger, 2018; Stickgold, 2005). When sleep-deprivation is imposed, positive memories are harder to recall compared to negative memories (van der Helm & Walker, 2009). This bias demonstrated in highlights how positive and negative memories are impacted by sleep. The prevalence of these positive and negative memories may be a component of emotional health, making decreasing detriments to sleep crucial. During emotional regulation, REM is thought to play an important role. When REM is decreased through insomnia, the amount of REM experienced is associated with emotional regulation outcomes. Having lower amounts of REM results in emotional dysregulation (Galbiati et al., 2020). Emotional reactivity is also increased when REM is deprived, showing the importance of REM for healthy regulation of emotions (Rosales-Lagarde et al., 2012).

Sleep and health disparities

Due to the severity of these health outcomes, the health disparities present in the United States are a great cause for concern (Rosales-Lagarde et al., 2012). Ethnic minorities are at higher risk for disturbed sleep (Frist, 2005). It is well-established that Black Americans are particularly affected by the negative health outcomes resulting from poor sleep. They have a higher likelihood of sleep disturbances, longer sleep latency, more fragmented sleep, and shorter sleep duration, compared to White Americans (Frist, 2005;

Krieger et al., 1998; Lauderdale et al., 2006; Mezick et al., 2008; Ruiter et al., 2011; Sheehan et al., 2018).

As a result of these disparities leading to inequities, areas where these disparities are present, such as ethnicity and socioeconomic status, need to be a focus of sleep research (Loredo et al., 2010; Van Cauter & Spiegel, 1999). Short sleep (under 5 hours a night) is significantly more likely to occur to Black participants and other ethnic minorities compared to participants who identified as White. These results suggest that there is a relation between ethnicity and sleep, although mediating factors, such as socioeconomic status may play a role (Whinnery et al., 2014). In a study by Stamatakis and colleagues, socioeconomic status and being of an ethnic minority were associated with poor sleep (Stamatakis et al., 2007). This was consistent with another study by Grandner and colleagues on ethnicity, socioeconomic status, and sleep. They found that ethnic minorities had higher incidences of sleep complaints and this result was shared with those who reported lower income and fewer years of education (Grandner et al., 2010). The combination of these findings gives weight to both ethnicity and socioeconomic status being factors behind health disparities in sleep.

Disparities in sleep and overall health also exist as a result of the environment in which we live (Diez Roux, 2002). Ethnic minorities are more likely to live in neighborhoods that are socioeconomically disadvantaged (Jargowsky, 1997). Living in these neighborhoods is associated with higher depression, anxiety, psychological distress, and coronary heart disease (Burdette & Hill, 2008). These detriments to overall health are also true for sleep: negative neighborhood characteristics, such as increased noise, traffic, and safety can disturb sleep (Johnson et al., 2018). This makes living environments a possible area for intervention for improving sleep outcomes.

The detrimental effect of stress on sleep

Stress has a detrimental impact on sleep. Elevation of stress levels leads to fragmented sleep, as well as decreased sleep quality and duration (Eliasson et al., 2010). In addition, experiencing high levels of stress is a contributing factor for poor sleep, by resulting in more frequent awakenings, shorter sleep duration, reduced REM, and reduced sleep efficiency (Kim & Dimsdale, 2007; Morin et al., 2003). One form of stress is that stemming from perceived discrimination. In this form of stress, life stress that is experienced by an individual includes an added layer of the particular interactions that are influenced by race. The effect of these experiences on health and well-being are based upon an individual's subjective response to them, but these responses are not always accepted by others. This possibility of distrust of personal experience can also be a component of the stress response experienced by the individual, as well as the time spent ruminating about the perceived discrimination incident (Harrell, 2000). One component of feeling discriminated against is the feeling of being judged by others. Given that the psychosocial stress imparted by this feeling can lead to adverse health outcomes such as cardiovascular disease (Cohen et al., 2007) it is crucial to investigate forms of intervention, including sleep.

In the following 3 studies, I will explore 1: Whether differences in ethnicity affect sleep in young adults, 2: The influence of socioeconomic factors, like appraisal of feelings of neighborhood safety on sleep, and 3: How sleep may benefit a form of stress linked to negative outcomes: perceived social judgment.

Chapter 1: Does ethnicity impact the association between sleep and stress in Asian, Latino, and White young adults?

Introduction

Sleep is a crucial component of both physical and psychological health where the body undergoes a variety of restorative processes (Acosta-Peña et al., 2012). Crucially, an approximated 50 to 70 million Americans suffer from chronic sleep disorders, making disturbed sleep a health concern at a national scale (Colten et al., 2006; Loredo et al., 2010; Luyster et al., 2012). Detriments to sleep have repeatedly been shown to contribute to negative health outcomes, such as hypertension, diabetes, and earlier mortality rates (Akerstedt, 2006; Buxton & Marcelli, 2010; Luyster et al., 2012). Specifically, sleep duration that is shorter or longer than the ideal 7-8 hours and poor self-reported sleep quality is associated with higher rates of coronary artery and coronary heart disease (Cappuccio et al., 2010, 2011; Yang et al., 2015), highlighting the importance of both subjective (ie. self-reported questionnaires) and objective measures of studying sleep for health outcomes.

Within these measures, disparities in health outcomes have been shown to exist among ethnic groups- Latino, Asian, and Black Americans, are at higher risk for poor and disrupted sleep (Frist, 2005; Whinnery et al., 2014). Expanding on this, we will focus on a lesser studied population for these health disparities studies: young adults. Specifically, we will study Latino and Asian American young adults, due to the gap in focus on these groups. Exploring the contributing factors for these differences in sleep is an important step towards decreasing existing health disparities.

Stress

Stress is a determinant and contributing factor to sleep outcomes, with many of the factors that disturb sleep likewise disturbing stress. Like sleep, higher levels of stress are associated with numerous diseases, including cardiovascular disease (Cohen et al., 2007; Dimsdale, 2008), hypertension, and higher rates of psychological conditions, including depression (Cohen et al., 2007).

In a college student sample, a population experiencing a major life change, stress levels were associated with higher rates of anxiety and depression (Rawson et al., 1994). In addition, this population also suffers from poor sleep (Orzech et al., 2011). Despite the strong relation between stress and sleep (Bassett et al., 2015; Hall et al., 2004; Yap et al., 2020), it has not been specifically explored whether ethnicity might influence the association between sleep and stress in a young adult population. However, differences in stress levels among ethnic groups have been established: higher stress levels were reported by young adult Latino Americans compared to young adult White Americans (Gallo et al., 2015).

In another study, college-aged Asian Americans reported more sources of stress stemming from academic expectations compared to White Americans (Tan & Yates, 2011). These differences in sources of stress, along with the previously mentioned overall higher incidences of disturbed sleep and higher stress levels in minority ethnic populations, make it imperative to further explore factors linked to increased stress, allowing for possible intervention measures to decrease stress and improve sleep in young adults.

Health Disparities

Sleep is understood to play a role in the health disparities present in the United States (Luyster et al., 2012). Ethnic minorities, including Latino, Asian, and Black Americans, are at higher risk for sleep disturbances (Frist, 2005; Krieger et al., 1998; Mezick et al., 2008; Ruiter et al., 2011). In a middle-aged sample, Black Americans between the ages of 40-59 showed increased sleep disturbances-ie., longer sleep latency, more fragmented sleep (Mezick et al., 2008), and shorter sleep duration (Lauderdale et al., 2006; Mezick et al., 2008; Sheehan et al., 2018), compared to White Americans of the same age group. Though fewer studies have included Asian or Latino participants, those that have show that both Latino and non-Latino Black Americans report the shortest and the longest sleep hours, compared to non-Latino White Americans (Krueger & Friedman, 2009). In general, both Latinos (Stamatakis et al., 2007), and Asian Americans (Jackson et al., 2014) have reported shorter sleep duration at higher rates. Despite the disparities present in health outcomes for ethnic minorities, the number of studies published on sleep differences across ethnicities was slow to keep up and did not rise to double digits until the early 2000s (Lichtenstein et al., 2006).

Sleep differences in young adults

Furthermore, additional research is needed to determine if these findings of present disparities would generalize or extend to younger age groups. Sleep is of particular importance during adolescence and young adulthood due to the significant changes, both biological and behavioral, in sleep experiences that occur during this time of life. In adolescents, these changes include later bedtimes and fewer hours of sleep (Colrain &

Baker, 2011). African-American adolescents experience lower sleep efficiency (Rao et al., 2009) and Mexican American adolescents report the most sleep complaints, followed by White Americans and Asian Americans (Roberts et al., 2000).

As a result of academic pressure-induced stress levels, increased responsibilities, and changes in lifestyle, there are major sleep changes for young adults entering college. In studies examining ethnic differences in college students—a population at risk for sleep deprivation—the metrics used to assess sleep differ and are not normalized, making comparisons between studies difficult. Latino American students report shorter sleep duration (Gaultney, 2010; Towne et al., 2017), while both Latino and White American students report higher insomnia rates compared to Asian and Black American students. Criticism of these studies on college-age populations, include stress responses not always being collected, making associations and determining possible causes difficult (Gaultney, 2010). Sleep disturbances have been shown to have detrimental impacts on the academic performance and mental health of college students (Orzech et al., 2011), so further studies are required to examine the extent to which ethnic differences play a role in sleep and stress among young adult populations.

Our aims in this study were to 1) test the association of stress with subjective sleep quality in a diverse sample of college-aged individuals and (2) examine whether ethnicity moderates the predicted association of stress with subjective sleep quality. We hypothesized that the ethnic minorities (in this case Latino and Asian participants) would have higher stress levels and worse sleep compared to White participants. We also hypothesized that ethnicity would moderate the association of stress with sleep.

Methods

Self-reported survey responses were collected from 581 college-aged participants (Male= 256, Female=325, mean age of 20.04, SD= 2.73) In order to collect data from a wide variety of college-aged students, participants completed the questionnaires either online or in person at our laboratory. Inclusion criteria involved no self-reports of mental illness, head injuries, serious health conditions, or high alcoholic beverage intake. Each participant gave written informed consent, confirmed by research staff, prior to administration of the questionnaires and was provided instructions on how to complete the survey. No minors participated in our study. All procedures and questionnaire measures were approved by the Human Review Research Boards of the University of California San Diego and the University of California, Riverside. The distribution of ethnic groups participating in the survey reflected the distribution in the local area (Asian n= 273, Latino n= 219, White n= 89, mean age= 22.18). Of the questionnaires included in the survey, Perceived Stress Scale (PSS), Pittsburgh Sleep Quality Index (PSQI), and the Epworth Sleepiness Scale (ESS) were selected for analysis due to their prevalence as measures of subjective sleep quality and stress levels.

Measures

Perceived Stress Scale (PSS)

Perceived stress was measured using the Perceived Stress Scale (PSS) (Dimsdale, 2008). The PSS consists of 10 items and measures when demands of a stressor exceed one's coping resources and one's ability to effectively respond and has internal reliability of $\alpha = >.70$ (Lee, 2012). Sample items include "In the last month, how often have you been upset because of something that happened unexpectedly?" and "In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?" These items are rated on a scale of 0 = Never, 1 = Almost Never, 2 = Sometimes, 3 = Fairly Often, and 4 = Very Often. A higher score indicates a higher appraisal of stress.

Pittsburgh Sleep Quality Index (PSQI)

PSQI measured using the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989), is a measure of sleep quality and sleep disturbances with high internal reliability (α= .83). It is validated for use in non-clinical populations of both younger and older adults (Grandner et al., 2006). The PSQI measures 7 components: 1) subjective sleep quality, 2) sleep latency, 3) sleep duration, 4) sleep efficiency, 5) sleep disturbance, 6) use of sleep medication, and 7) daytime dysfunction. Global PSQI is calculated as a sum of all 7 PSQI components, with higher scores indicating worse sleep quality. Sample items include "During the past month, what time have you usually gone to bed at night?" and "During the past month, how would you rate your sleep quality overall?" A higher PSQI value indicates worse overall sleep.

Epworth Sleepiness Scale (ESS)

Daytime sleepiness was assessed using the Epworth Sleepiness Scale (ESS) (Johns, 1991), a self-report measure of a participant's daytime sleepiness level. The ESS has an internal reliability α= .81 and is reliable across various populations (Chan & La Greca, 2013; Chen et al., 2002). The 8-item scale consists of questions such as: "How likely are you to doze off or fall asleep in the following situations, in contrast to just feeling tired?" These items are rated on a scale of 0= would never doze, 1 = slight chance of dozing, 2 = moderate chance of dozing, and 3 = high chance of dozing. A higher score indicates a higher likelihood of experiencing daytime sleepiness.

Analysis

The variables analyzed in the present study were Perceived Stress (PSS), Global Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS), and ethnicity. Prior to performing linear regressions, preprocessing in the form of mean-centering was performed on the data for these scored variables, to reduce multicollinearity and make interpretation of the intercepts simpler. Ethnicity responses were coded as three categorical variables: Asian, Latino, and White, with White chosen as the comparison group (due to it being the most studied ethnic group), to allow its use in our multiple regression models. Pearson correlations were calculated to examine the associations among sleep, stress, daytime sleepiness, and ethnicity. Interaction terms were computed for ethnicity variables by sleep, daytime sleepiness, and stress. Multiple linear regression models were tested for assumptions and run to test our hypotheses and examine the relation among sleep, stress, and ethnicity. Analysis of the data was completed with R Statistics Software (Version 1.1.463 – © 2009-2018. RStudio, Inc.)

Participant Characteristics

Table 1: Participant demographics.

	White (n=89)	Asian (n=273)	Latino (n=219)	Total (N=581)	P-value
Gender					0.028
Female	46 (51.7%)	141 (51.6%)	138 (63.0%)	325 (55.9%)	
Male	43 (48.3%)	132 (48.4%)	81 (37.0%)	256 (44.1%)	
Age					< 0.001
Mean (SD)	22.180 (4.078)	19.535 (1.636)	19.790 (2.748)	20.036 (2.732)	

The average age in our sample was 20 years (SD=2.73) (Female: 55.9%, Male: 44.1%). Compared to the White and Asian groups, females (63%) made up a larger percentage of the Latinos participants compared to male participants (37%). Mean age was significantly higher for Whites (M= 22.18, SD= 4.08) than Latinos (M=19.79 (SD=2.75) or Asians (M=19.54, SD= 1.63). (See Table 1).

Results

Perceived Stress Scale (PSS)

PSS scores were highest for Asian participants ($p < 0.001$), followed by Latino participants ($p<0.001$). White participants had the lowest PSS scores when compared to Asian and Latino participants ($p<0.001$). (Table 2). There were no significant gender differences observed.

Table 2: Descriptive Statistics for stress by ethnic group.

	White (n=89)	**Asian (n=273)**	**Latino (n=219)**	**Total (N=581)**	P-value
Stress					< 0.001
Mean (SD)	-3.168 (7.637)	1.651 (6.790)	-0.771 (8.075)	-0.000 (7.618)	
Range	-18.876 - 16.124	-15.876 - 22.124	-20.876 - 18.124	-20.876 - 22.124	

Higher values indicate worse scores (higher stress level).

Pittsburgh Sleep Quality Index (PSQI)

In the PSQI, scores were highest for Asian participants ($p<0.001$), followed by Latino participants. Asians reported the highest scores ($p<0.001$), where a higher score indicates a higher sleep quality perception by the participant (Table 2).

Epworth Sleepiness Scale (ESS)

ESS scores were highest for Asian participants ($p<0.001$), followed by Latino participants ($p<0.001$), compared to White participants.

Table 3: Descriptive Statistics for Overall Sleep, Sleep Quality, and Daytime Sleepiness by ethnic group.

	White (n=89)	**Asian (n=273)**	**Latino (n=219)**	**Total (N=581)**	P-value
Sleep					< 0.001
Mean (SD)	-0.828 (2.440)	0.591 (3.196)	-0.400 (2.696)	0.000 (2.959)	
Range	-4.592 - 6.408	-5.592 - 10.408	-5.592 - 7.408	-5.592 - 10.408	
Sleep Quality					< 0.001
Mean (SD)	-0.190 (0.487)	0.087 (0.635)	0.032 (0.702)	-0.000 (0.648)	
Range	-1.077 - 0.923	1.077 - 1.923	-1.077 - 1.923	-1.077 - 1.923	
Sleepiness					< 0.001
Mean (SD)	-0.896 (3.885)	0.908 (3.434)	-0.768 (3.608)	-0.000 (3.667)	
Range	-7.795 - 12.05	-6.795 - 11.205	-7.795 - 12.205	-7.95 - 12.205	

For Overall Sleep and Daytime Sleepiness, higher values indicate worse scores. For Sleep Quality, higher values indicate better scores.

Models

To investigate the possible ethnic differences in overall sleep and stress, sleep and stress variables were chosen as the parameters with which our regression models were constructed. Variability, through adjusted R^2 values, was compared in order to determine the percentage of variability explained by each model.

Sleep as an outcome:

Table 4: Linear model comparison with sleep as the outcome variable.

Parameters				
Sleep	Model 1	Model 2	Model 3	Model 4
	Stress	Ethnicity	Stress+Ethnicity	Stress+Ethnicity+StressxEthnicity
Adjusted R^2	0.223	0.03438	0.229	0.2267
p	<0.001	<0.001	<0.001	<0.001

* ~ signifies "is predicted by."

Model 1: Sleep ~ Stress: Adjusted R^2: 0.223, $p < 0.001$

The goal of Model 1 was to examine the relation observed between stress and sleep. Stress significantly is associated with sleep, and in turn, higher stress levels resulted in worse sleep quality (Fig 1).

Model 2: Sleep ~ Ethnicity: Adjusted R^2: 0.03438 $p < 0.001$

The goal of Model 2 was to examine the influence of ethnicity on sleep. It supports our finding of group differences in sleep seen in Tables 2 and 3, where Asian participants showed the worst sleep quality compared to Latinos, followed by White participants. Model 2 shows that sleep measures were significantly predicted by the ethnicity of the participant.

Model 3: Sleep ~ Stress + Ethnicity: Adjusted R^2: 0.229, p = < 0.001*

With the addition of ethnicity as a variable, a minimal increase in variability explained was observed (adjusted R^2 change= 0.008733, p = 0.0381). This minimal increase lacks the ability to explain more variability than that explained by the R^2 change after adding stress as a predictor (0.1953176, $p < 0.001$).

When compared with Models 1 and 2, Model 3 indicates that adding stress level explains significantly more variability in sleep measures to the model than when only considering the ethnicity of the participant.

Model 4: Sleep ~ Stress + Ethnicity* + (Stress x Ethnicity): Adjusted R^2: 0.2267, $p < 0.001$*

We found that the interaction of stress and ethnicity was not associated with sleep. When compared to Model 3, the R^2 change (0.00038, p = 0.86712) after the addition to the model of the stress and ethnicity interaction was not significant for Model 4. This suggests that ethnicity and stress each influence sleep independently.

Our results indicate that stress is the strongest predictor of sleep, explaining the highest amount of variability in the model ($p < 0.001$). Ethnicity on its own explains a minimal amount of variability (R^2 change (0.00038, $p = 0.86712$).

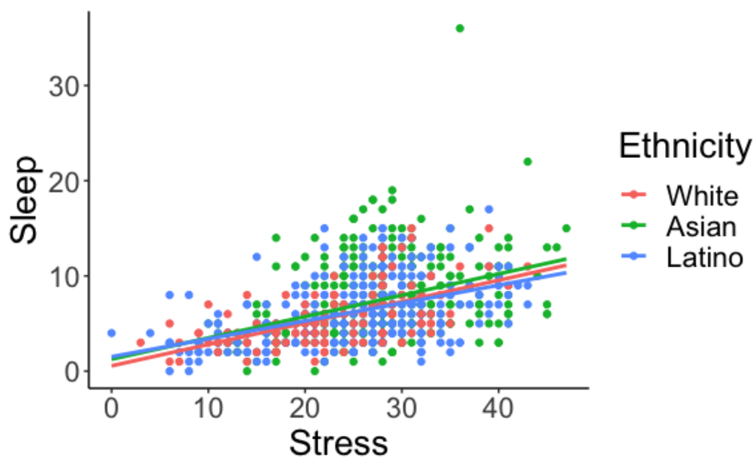

Figure 1: Worse sleep is indicated by a higher score, higher stress is indicated by a higher score. p <0.001 for Asians and p=0.069 for Latinos. White is the reference group.

Stress as an outcome

Table 5: Linear models with stress as the outcome variable.

Parameters	Stress		
	Model 5	Model 6	Model 7
	Ethnicity	Ethnicity+Sleep	Ethnicity+Sleep+EthnicityxSleep
Adjusted R^2	0.04925	0.2409	0.2583
p	<0.001	<0.001	<0.001

Following the results of Model 3 showing the strength of stress as a predictor, we visualized the group differences in stress levels.

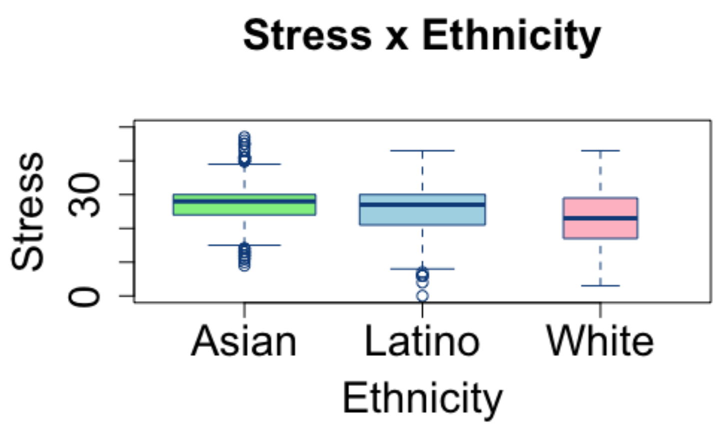

Figure 2: Higher stress is indicated by a higher score. Asian and Latino groups have higher stress levels when compared to White as a reference group.

Model 5: Stress ~ Ethnicity: Adjusted R^2*: 0.04925, p < 0.001*

Model 5 showed that higher stress is significantly predicted by ethnicity. This is supported by the significant differences across ethnicities when reporting stress levels (Fig 2), with Asians showing the highest stress levels, followed by Latinos and Whites.

Model 6: Stress ~ Ethnicity + Sleep: Adjusted R^2*: 0.2409,* $p < 0.001$

As evidenced by the change in variability compared to model 5 (adjusted R^2 change=0.1923088, $p < 0.001$), adding sleep as a predictor can explain significantly more variability in stress, compared to solely using ethnicity as a predictor.

Model 7: Stress ~ Ethnicity + Sleep + (Ethnicity x Sleep)* : Adjusted* $R^2 = 0.2583$ $p < 0.001$

The interaction of sleep and ethnicity predicts stress and is our most robust model, increasing the variability explained by model 6 (0.01985342, $p < 0.001$), indicating that ethnicity and sleep are the best predictors of stress levels.

Discussion

This study examined self-reported survey data collected from a college-aged population in an effort to determine ethnic differences in stress and sleep, as well as the extent of their associations. My findings confirm the presence of ethnic differences in two areas crucial to health outcomes: stress and sleep. Ethnic differences in sleep are most frequently investigated by comparing White and Black populations (Krieger et al., 1998; Lauderdale et al., 2006; Mezick et al., 2008; Ruiter et al., 2011). In this sample, however, I chose to focus on two groups less commonly represented: Asian and Latino Americans. This study consisted of a young adult sample, contrasting with similar studies examining ethnic differences in sleep and stress in middle-aged adults. When measuring stress, I found that Asians experienced significantly higher stress levels compared to Latinos and

Whites. This is in contrast to another study's findings that Latinos are more likely than Asians and Whites to experience higher levels of stress (Gallo et al., 2015). A possible explanation for this is this study's use of a stress survey that specifically measures perceived stress (Chan & La Greca, 2013). Stressors experienced by the Latino participants could be of a nature not measured by our study, such as stress stemming from discrimination, a measure for which experience differs significantly among ethnicities (Krieger et al., 1998; Ruiter et al., 2011).

The findings of ethnic differences in sleep, with Asians having the worst sleep quality and highest daytime sleepiness, compared to Latinos and Whites, are also novel in a young adult sample. However, supporting evidence from other studies (Cohen & Janicki-Deverts, 2012; Sheehan et al., 2018) shows that Whites typically have the best sleep and lowest daytime sleepiness of the three groups. Differences in sleep hygiene could account for the poor sleep quality in Latinos, a population with high self-reported poor sleep hygiene (Loredo et al., 2010). However, this could not account for the poor quality of sleep and high level of daytime sleepiness reported by Asian participants in this study. These differences could be related to other sociocultural stressors, including family and adherence to cultural values (Iwamoto & Liu, 2010).

With my first model, I confirmed previous findings that stress predicts sleep. The addition of ethnicity into the model did not result in a large increase in variability, as evidenced by our 3rd model. However, its significance supported findings of a significant correlation of sleep and stress by ethnic group, demonstrating ethnic differences in sleep and stress. Ethnicity was also confirmed as a significant predictor of stress. Most importantly, my final model was able to determine the relative importance of ethnicity in the relation among stress, sleep, and ethnicity.

One of the main limitations was the lack of a substantial African-American sample in our analysis. Given prior results indicating that this population has high levels of disturbed sleep and high levels of stress (Gaultney, 2010; Rao et al., 2009), follow-up studies should seek to collect a larger, more representative sample of ethnicities.

To our knowledge, this study is the first study in a young adult population to show that under the influence of ethnicity, sleep levels can predict stress outcomes. Future research should pursue our findings of poor sleep and heightened stress in Asians and examine the contribution of socio-cultural differences across ethnicities. The influence of ethnicity on the association between sleep and stress might indicate causal differences in stress experiences across ethnicities, making studies comparing the effects of different types of stressors an area in need of further examination. Further work should be done comparing the effects of various types of contributors to stressors, including the role of stress stemming from discrimination. As these disparities in health across ethnicities become more pronounced, the elucidation of possible factors is critical.

Chapter 2: The influence of feelings of neighborhood safety on stress and sleep.

Introduction

It is well-established that the environment in which we live influences our health (Diez Roux, 2002; Hale et al., 2013; Johnson et al., 2017; Matthews & Yang, 2010). Due to socioeconomic differences, disparities exist across neighborhoods, with certain groups, such as those indicated by social class, experiencing higher detriments to their health compared to others (Henderson et al., 2016; G. D. Smith et al., 1998). Living in neighborhoods with lower socioeconomic conditions is associated with increased incidences of coronary heart disease, obesity, and associated mortality rates (Burdette & Hill, 2008; Diez Roux, 2002; G. D. Smith et al., 1998). There is also an impact on emotional health: neighborhoods with lower quality housing, increased crime, and a lack of resources such as hospitals, public transportation, and supermarkets increase the likelihood of experiencing anxiety and depression (Aneshensel & Sucoff, 1996; Echeverría et al., 2008; Galea et al., 2007; Ross & Mirowsky, 2001). In addition, living in environments with other neighborhood characteristics, such as low social involvement, is associated with higher mortality rates (Yen & Kaplan, 1999).

One important contributor to health outcomes, stress, is also influenced by our living environment. When emotional distressing experiences occur due the neighborhood in which we live, stress levels rise, resulting in negative health outcomes (Kwarteng et al., 2017). Numerous diseases, including increased likelihood of cardiovascular disease hypertension, and higher rates of psychological conditions, such as depression are associated with higher stress levels (Cohen & Janicki-Deverts, 2012; Dimsdale, 2008). These negative health outcomes are thought to be the result of negative affective states altering the biological or disease patterns which may lead to disease (Cohen et al., 2007).

Further, low feelings of being safe in ones neighborhood, commonly referred to as neighborhood safety, are associated with higher stress levels (Matthews & Yang, 2010).

Along with increased stress, a related factor disturbed by our environment is sleep (Hale et al., 2010, 2013; Johnson et al., 2016, 2017). Sleep allows for restorative processes to occur in brain and body, resulting in benefits to our physical, emotional, and cognitive health (Acosta-Peña et al., 2012; Colten et al., 2006). When disturbed however, a variety of detrimental health outcomes can occur. These include cardiovascular disease, hypertension, diabetes, and high blood pressure, which are higher in individuals with sleep disorders (Akerstedt, 2006; Buxton & Marcelli, 2010; Hoevenaar-Blom et al., 2011), as well as earlier mortality rates (Luyster et al., 2012). In contrast, individuals who sleep between 7 to 8 hours a night, have in lower cardiovascular disease risk compared individuals who report short sleep (under 7 hours of sleep), and long sleep (over 8 hours of sleep) (Buxton & Marcelli, 2010; S. R. Patel et al., 2004).

Stress disturbs sleep: increased levels leads to a decrease in sleep quality, hours slept, as well as fragmentation of sleep (Eliasson et al., 2010). Given the psychological and physiological impact of stress, experiencing high levels of stress is a contributing factor for poor sleep, by resulting in more frequent awakenings, shorter sleep duration, reduced SWS, reduced REM, and reduced sleep efficiency (Kim & Dimsdale, 2007; Morin et al., 2003). Importantly, stress is a primary factor associated with insomnia, a sleep disorder with notably detrimental health outcomes (Akerstedt, 2006; Morin et al., 2003; Ohayan, 2002). Various components of our environment, such as noise and safety, can disturb sleep, leading to detriments to health (Johnson et al., 2018). As a result of sleep's role in overall health, there is a pressing need to investigate specific factors contributing to the relationship among sleep disturbance, stress, and neighborhood safety.

There is a prevalence of sleep-related health disparities in the United States with negative health outcomes, including social factors, such as ethnicity and socioeconomic status (Loredo et al., 2010; Van Cauter & Spiegel, 1999). Gellis and colleagues investigated the influence of socioeconomic status on sleep and found that participants with lower SES were more likely to report insomnia and sleep problems compared to higher SES participants (Gellis et al., 2005). In a study by Whinnery and colleagues, very short sleep was more likely to occur to ethnic minorities compared to White participants (Whinnery et al., 2014). Similarly, Stamatakis and colleagues found that participants identifying as African-American and Hispanic reported shorter sleep duration compared to participants identifying as White. They also found that better household living conditions reduced odds of very short sleep in these groups (Stamatakis et al., 2007). Given this association of household living conditions, ethnicity, and sleep, determining whether a missing link is stress, is of particular interest.

Our aims in this study were to 1) confirm the association of neighborhood safety and stress 2) determine whether ethnic differences in neighborhood safety, stress, and sleep exist in this sample, and 3) determine whether neighborhood safety mediates the influence of stress on sleep. We predict that 1) lower levels of neighborhood safety will be associated with higher levels of stress, 2) ethnic minorities will report lower feelings of neighborhood safety, higher stress levels, and worse sleep compared to White participants.

Methods

Self-reported data was collected from 1,606 participants (mean age of 36.07, SD= 11.19). Data was collected through Amazon Mechanical Turk, with a participation requirement of a 70% or greater assignment acceptance rate on past assignments. No minors participated in our study. The distribution of ethnic groups participating in the survey reflected an effort to obtain sufficient sample sizes of each of the ethnic groups, despite the distribution of the participant pool that would otherwise be heavily skewed towards White participants (Asian n= 290, Black n= 446, Latino n= 219, White n= 477). Of the questionnaires included in the survey, Perceived Stress Scale (PSS), Pittsburgh Sleep Quality Index (PSQI), and the Neighborhood Questionnaire were selected for analysis due to their prevalence as measures of stress levels, subjective sleep, and neighborhood safety levels.

Measures

Perceived Stress Scale (PSS)

Perceived chronic stress was measured using the Perceived Stress Scale (PSS) (Dimsdale, 2008). The PSS consists of 10 items and measures when demands of a stressor exceed one's coping resources and one's ability to effectively respond and has internal reliability of α= >.70 (Lee, 2012). Sample items include "In the last month, how often have you been upset because of something that happened unexpectedly?" and "In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?" These items are rated on a scale of 0 = Never, 1 = Almost Never, 2 = Sometimes, 3 = Fairly Often, and 4 = Very Often. A higher score indicates a higher appraisal of stress.

Pittsburgh Sleep Quality Index (PSQI)

PSQI measured using the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989). The PSQI measures sleep quality and sleep disturbances. It has a high internal reliability (α= .83) and is validated for use in adult non-clinical populations (Grandner et al., 2006). The following components are measured: 1) subjective sleep quality, 2) sleep latency, 3) sleep duration, 4) sleep efficiency, 5) sleep disturbance, 6) use of sleep medication, and 7) daytime dysfunction. Global PSQI is calculated through a sum of the 7 PSQI components, with higher scores indicating worse sleep quality. Sample items include "During the past month, what time have you usually gone to bed at night?" and "During the past month, how would you rate your sleep quality overall?" A higher PSQI value indicates worse overall sleep.

Neighborhood Questionnaire

Neighborhood safety was measured through the neighborhood questionnaire. The neighborhood consists of 16 questions exploring general feelings of safety, availability and quality of public services, social environment, crime, and overall feelings of satisfaction with the neighborhood (Greenberg et al., 1999). The questionnaire consists of 3 subscales: 1) Neighborhood Safety, 2) Social Involvement, and 3) Public Services. For this study, our focus was on the Neighborhood Safety subscale.

Sample items include:

In general how do you feel about this neighborhood?
How many of your neighbors do you know well enough to visit or call on?
How satisfied are you with police protection around here?
How satisfied are you with garbage collection around here?
How satisfied are you with schools around here?
How do the police and the people in this neighborhood get along?

How involved are you in your neighborhood.

Analysis

Data was preprocessed by mean-centering the sleep, stress, and neighborhood safety variables. Ethnicity responses were dummy coded as three categorical variables: Asian, Black, Latino, and White. White was the comparison group (due to it being the most studied), allowing use of ethnicity in our multiple regression models. Our hypotheses were tested through multiple linear regression models, allowing us to examine the relationship among sleep, stress, and neighborhood safety. Mediation models were computed using the mediate library package on RStudio. Data was analyzed using R Statistics Software (Version 1.1.463 – © 2009-2021. RStudio, Inc.)

Participant characteristics

Table 1: Participant demographics

	White (n=477)	**Asian (n=290)**	**Latino (n=275)**	**Black (n=446)**	Total (N=1,606)	P-value
Age						<0.01
Mean (SD)	38.60(12.57)	33.55(9.78)	38.02(10.85)	32.12(32.12)	36.07	
Education						0.41
Less than high school Percentage	0.43%	0.00%	0.00%	0.00%	0.17%	
High school or equivalent Percentage	3.48%	2.86%	2.68%	5.32%	3.53%	
Some college Percentage	4.78%	1.43%	1.79%	5.31%	3.53%	
Associate's degree	3.04%	4.29%	3.57%		3.36%	

Percentage				2.65%		
Bachelor's degree Percentage	73.48%	65.71%	73.21%	64.60%	69.92%	
Post-graduate degree Percentage	14.78%	25.71%	18.75%	22.12%	19.50%	

The average age in our sample was 36.07. White and Latino participants were the oldest participants at average ages 38.60 and 32.02 years of age respectively. Black participants were the youngest at an average of 32.12 years of age. 89.42% of participants had either a bachelor's degree or higher, making this a highly educated sample.

Results

Neighborhood Safety

Neighborhood safety scores, where a higher score indicates a higher feeling of neighborhood safety, were highest for White participants (p =0.0016), followed by Asian participants (p= 0.0092), and Black participants (p> 0.001). Latino participants had the lowest PSS scores when compared to Asian, White, and Black participants (p=0.0025). (Table 2).

Table 2: Descriptive statistics for neighborhood safety by ethnic group.

	White	**Asian**	**Latino**	**Black**	Overall	P-value
Neighborhood safety score						< 0.001
Mean (SD)	9.68(2.53)	9.29(2.01)	9.14(1.98)	9.17(2.10)	9.32(2.21)	
Range	4-16	5-15	7-16	6-16	4-16	

Perceived Stress Scale (PSS)

PSS scores, where a higher score indicates higher stress levels, were highest for Latino participants (p <0.001), followed by Asian participants (p= 0.002), and Black participants (p= 0.017). White participants had the lowest PSS scores when compared to Asian, Latino, and Black participants. (Table 3).

Table 3: Descriptive statistics for stress by ethnic group.

	White	**Asian**	**Latino**	**Black**	Overall	P-value
Stress						< 0.001
Mean (SD)	28.47 (5.45)	29.79 (5.37)	30.02 (5.32)	29.37 (5.38)	29.34 (5.32)	
Range	14-40	16-41	15-41	16-40	14-41	

Pittsburgh Sleep Quality Index (PSQI)

PSQI scores, where a higher score indicates worse sleep, was highest for Latino participants (p <0.001), followed by Asian participants (p), and Black participants (p= 0.017). White participants had the lowest PSS scores when compared to Asian, Latino, and Black participants. (Table 4).

Table 4: Descriptive statistics for sleep by ethnic group.

	White	**Asian**	**Latino**	**Black**	Overall	P-value
Sleep						< 0.01
Mean (SD)	32.02(8.80)	34.54(8.74)	34.94(8.14)	33.81(8.92)	33.66(8.67)	
Range	14-52	14-55	15-53	14-50	14-55	

Models

In order to test our hypotheses, regression models including the variables neighborhood safety, stress, and sleep were constructed. Adjusted R^2 values were compared to examine the variability explained by each model.

Table 5: Linear models tested.

Parameter	**Model 1**	**Model 2**	**Model 3**
	Sleep ~ Neighborhood Safety	Stress ~ Neighborhood Safety	Sleep ~ Stress + Neighborhood Safety
Estimates (b)	-1.6	-0.78	1.04, 0.77
P-value	<0.001	<0.001	<0.001, < 0.001
Adjusted R^2	0.15	0.10	0.53

*** ~** signifies "is predicted by."

Model 1: Sleep ~ Neighborhood Safety: Adjusted R^2: 0.15, p< 0.001

Model 1 examined the association between sleep and neighborhood safety. Neighborhood safety significantly predicted sleep: higher neighborhood safety levels resulted in better sleep quality. (Fig. 1).

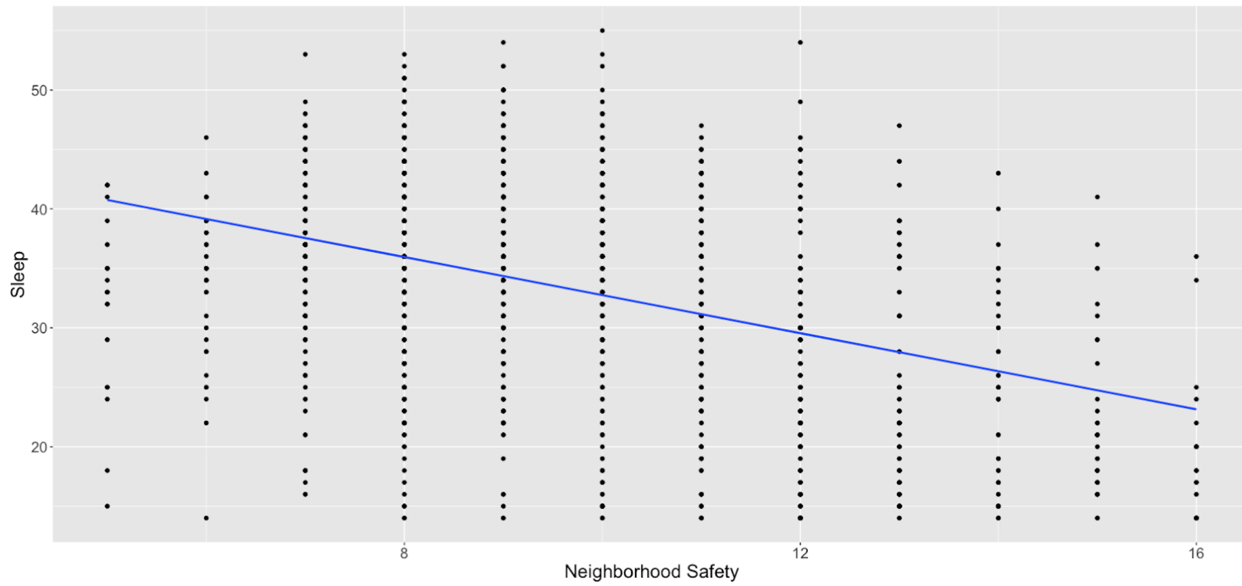

Figure 1: Regression plot of sleep and neighborhood safety regression model. Regression plot of model 1 (adjusted R^2 = 0.15, β = -1.60, p< 0.001).

Model 2: Stress ~ Neighborhood Safety: Adjusted R^2: 0.10, p< 0.001

Model 2 examined the association between stress and neighborhood safety. Neighborhood safety significantly predicted stress levels: higher stress levels resulted in lower feelings of neighborhood safety. (Table 2; Fig.1).

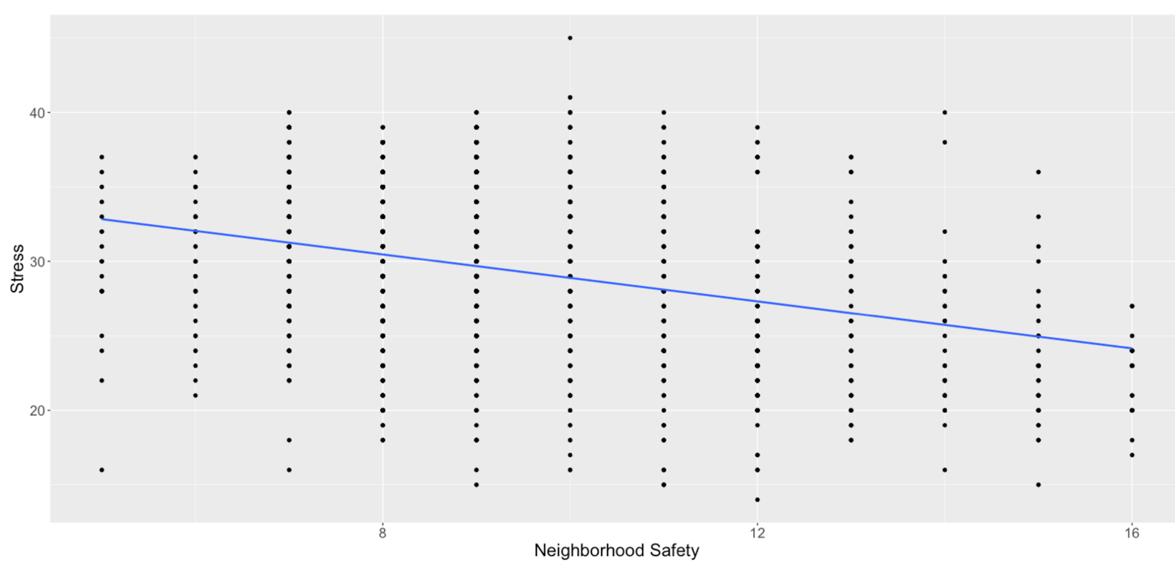

Figure 2: Regression plot of stress and neighborhood safety regression model**.** Regression plot of model 2 (adjusted R^2 = 0.10, β = -0.79, p< 0.001).

Model 3: Sleep ~ Stress + Neighborhood Safety: Adjusted R^2*: 0.53, p< 0.001*

In model 3, Stress was added to Model 1, which had a substantial increase in variability explained from 0.16 to 0.53 adjusted R^2 value. In comparison to models 1 and 2, model 3 is the our most robust model. (Table 2; Fig. 2)

Mediation analysis

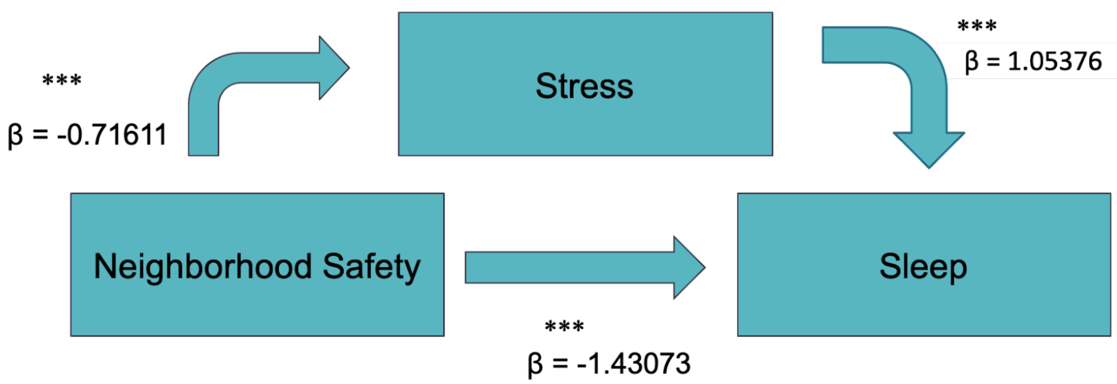

Figure 3: Bootstrapped mediation analysis. Significant mediating effect of stress on the association between neighborhood safety and sleep.

Per our hypothesis, we predicted that stress could mediate the effect of neighborhood safety on sleep. We ran a bootstrapped mediation analysis consisting of 1000 simulations. Neighborhood safety was the predictor variable, sleep as the criterion, and stress as the potential mediator. Our results showed a significant negative direct effect of neighborhood safety on sleep (effect = -1.43, p> 0.001). The indirect effect of neighborhood safety via stress on sleep showed a significant negative effect (effect = -0.72, p> 0.001). These results demonstrate that stress mediates the association between neighborhood safety and sleep. ($p < 0.001$).

Discussion

In this study, we analyzed online survey data in order to explore determinants of poor sleep. We had the following aims: 1) Confirm the association of neighborhood safety and stress 2) Determine whether ethnic differences in neighborhood safety, stress, and sleep exist in this sample, and 3) Determine whether neighborhood safety mediates the influence of stress on sleep. Our results show that 1) the association between neighborhood safety and stress is significant: as neighborhood safety levels rise, stress levels lower. 2) Ethnic differences exist for each of our variables of interest. Latino participants had the lowest feelings of neighborhood safety, highest stress levels, and worst sleep. Meanwhile, White participants reported the highest feelings of neighborhood safety, lowest stress levels, and best sleep. 3) Stress mediates the association of neighborhood safety and sleep. These findings are important given the established influence of neighborhood safety and stress on sleep.

Our finding of the association between neighborhood safety and stress is consistent with prior research on the role of detrimental neighborhood environment and negative neighborhood characteristics on stress and health outcomes (Matthews & Yang, 2010). Specifically, we confirmed the influence of neighborhood safety on stress in a younger sample than studies where participants averaged 55 years of age, compared to our sample’s 36 year mean age, creating a more robust overview of their association (Henderson et al., 2016). The strong association between sleep and stress was also consistent with the well-established literature on the subject (Akerstedt, 2006; Benham, 2010; Garde et al., 2012; Kim & Dimsdale, 2007; Payne & Kensinger, 2018; Prather et al., 2013; Yap et al., 2020).

Along with stress, disparities in sleep among ethnic groups continue to be a national health area of concern (Goodin et al., 2010; Jehan et al., 2018; N. P. Patel et al., 2010; Stamatakis et al., 2007; Van Dyke et al., 2016). As a result, determining mediators on the association of negative experiences, such as experiencing low feelings of neighborhood safety and sleep is necessary. Our finding on the mediating effect of stress on neighborhood safety further explains the influence of neighborhood safety on sleep. Higher feelings neighborhood safety are associated with objective measures of longer sleep duration (Hale et al., 2010; Johnson et al., 2017). Likewise, self-reported sleep quality data shows that lower feelings of neighborhood safety are associated with worse sleep. Establishing that stress may also mediate the effects found in studies such as these may benefit the pinpointing of specific characteristics necessary to improve sleep in different living environments. Altogether, our results demonstrate the importance of the impact of feelings of neighborhood safety on sleep outcomes. Future work should investigate neighborhood characteristics influencing neighborhood safety as possible areas of intervention benefitting sleep.

Chapter 3: The Influence of Sleep on Negative Social Judgment

Introduction

Sleep stages background

Sleep can be physiologically separated into the states of non-rapid eye movement (non-REM) and rapid eye movement (REM). Sleep stages are typically measured using electroencephalography (EEG) to record electrical brain activity, electro-oculography (EOG) to measure eye movements, and electromyography (EMG) to measure muscle movement. Within each of the stages of sleep, there are distinct features that allow for their classification. Just prior to falling asleep, during relaxed wakefulness, rhythmic alpha waves are observed, with approximate amplitudes between 8-13 Hz (Carskadon & Dement, 2011). In stage 1 (2-5% of sleep in young adults), amplitudes increase, and theta waves with frequencies of 3-7 Hz occur (Carskadon & Dement, 2011). During stage 2, which comprises 45-55% of sleep in young adults, several crucial features begin to occur, including sleep spindles and k-complexes. Sleep spindles, and the density of sleep spindles, have an important role in various cognitive functions, among these, learning and memory. Sleep spindles occur at amplitudes between 12 and 14 Hz and are most frequent during stage 2 of sleep. When visualizing EEG, spindles present as rhythmic waves which first rise, and then fall in amplitude, lasting about 1 second in duration (De Gennaro & Ferrara, 2003). As we age, sleep spindle density decreases, aligned with a general decrease in sleep continuity in older adults (Clawson et al., 2016).

Next, stages 3 and 4 comprise the deepest stage of sleep, slow-wave sleep or SWS, which is dominated by waveforms typically under 2 Hz, referred to as slow-wave activity (SWA) (Berry et al., 1987; Dijk & Landolt, 2019). Slow-wave sleep decreases as we age, with children having the most amounts of it and the least amounts occurring after the age of 60 (Carskadon & Dement, 2011). One of the cognitive areas where slow-wave sleep is important is declarative memory, including its consolidation during both naps and overnight sleep (Rasch & Born, 2013; Zhang & Gruber, 2019).

REM sleep comprises 20-25% of sleep in young adults. In addition to EEG waves, there is now a greater focus placed on electromyography (EMG) and electro-oculography (EOG) recordings. A defining characteristic of REM sleep is the presence of eye movement bursts. The eye movements present, measured by EOG, are now rapid, compared to prior sleep stages. Muscular activity, as measured by EMG, is more suppressed during REM. In addition, features such as theta waves and alpha waves are observed in EEG. The more frequent of the two, theta waves, most commonly show up in REM in a pattern referred to as a “sawtooth wave,” due to their sharp up and down amplitude (Carskadon & Dement, 2011). REM is involved in various crucial processes, including procedural memory consolidation, and emotional memory processing (Baran et al., 2012; Helm & Walker, 2011; C. Smith, 2001; Tucker et al., 2006).

Sleep, emotional regulation, and REM

Sleep plays an important role in emotional regulation and the strengthening of memory, while reducing emotional affectivity (van der Helm & Walker, 2009). Emotionally, there are notable detrimental effects resulting from poor sleep: mood and affect are heavily affected by sleep disturbance (Riemann, 2007). Individuals with sleep disturbances (including insomnia and hypersomnia) exhibit major incidences of anxiety, depression, and substance abuse (Breslau et al., 1996). Further, insomnia may be a predictor of psychiatric disorders, including depression, represented by reduced total sleep time and sleep efficiency, more night-time awakenings, longer time spent sleeping, as well as less time in stage 2 and more time in REM (Perlis et al., 1997; Riemann et al., 1994). Highlighting the specific aspects of sleep architecture that influence emotional health, a reduction in slow-wave sleep and REM latency has been associated with depression (Riemann et al., 2001). Additionally, fMRI studies have shown that amygdala activity following exposure to emotional stimuli decreases following a night of sleep with REM (Helm & Walker, 2011). However, when deprived of REM, emotional reactivity is enhanced, signaling its importance in regulation of emotional responses (Rosales-Lagarde et al., 2012).

Although social stressors, such as discrimination, have been shown to elevate stress levels and disturb sleep, whether sleep can regulate emotions arising from social judgment is not well established.

Present Study

The aim of this study is to determine whether sleep can reduce the effects of negative social judgment. We will use a social judgment task followed by a laboratory-administered nap opportunity. We hypothesize that sleep will reduce emotional reactivity to negative social judgment in 2 forms: physical (skin conductance, heart rate) and subjective (mood) and arousal, by allowing for emotional regulation to occur.

Methods and Materials

Participants

Participants were 25 young adults between 18-35 years old (mean age= 19.8, SD=1.82, 45% Asian, 17% Latino, 14% White, 14% Multiracial, 7% Middle Eastern, 3% Black) who reported no known history of traumatic head injuries or neurological disorders. Written consent was obtained from each participant prior to the study and procedures were approved by the Institutional Review Board at the University of California, Irvine. Participants were compensated $70 for their time in the study.

Procedure

The study was conducted at the Mednick Sleep and Cognition Lab at the University of California, Irvine campus. It consists of a cross-sectional between-subjects design and involves 1) a group that underwent a social stress task followed by a nap and 2) a group that underwent a social stress task followed by no nap. All participants had a second experimental visit two days after the main experimental day. Participants were in the lab for 5.5 hours on visit 1, and 0.5 hours on visit 2, for a total of 6 hours of participation. Pre and post mood surveys were administered 4 times during visit 1 and 2 times during visit 2. Participants arrived to the Sleep and Cognition Lab at 10:00am, where they met with a gender-paired confederate (lab member they believe is another participant in the study) and underwent a modified Trier Social Stress Task developed by Keeley Muscatell (Muscatell et al., 2016). They were told that during this task, they would be video-recorded and judged on their performance remotely by the confederate. After the interview, the participant viewed a recording of the "real-time" on-screen ratings of their interview by the confederate while their heart rate and skin conductance were recorded. These ratings were chosen from a grid of 24 descriptive words equally divided into negative, neutral, and positive, with ratings biased towards negative.

This was followed by a 2-hour electroencephalography recorded nap or quiet wake condition.

Participant responses to the Social Judgement task were measured immediately after the test, after the sleep/wake condition, and after a 2 day delay (Figure 1). Upon the conclusion of the experiment, subjects will be thoroughly debriefed by providing a rationale for the study and giving them information about resources on campus to seek counseling, if needed.

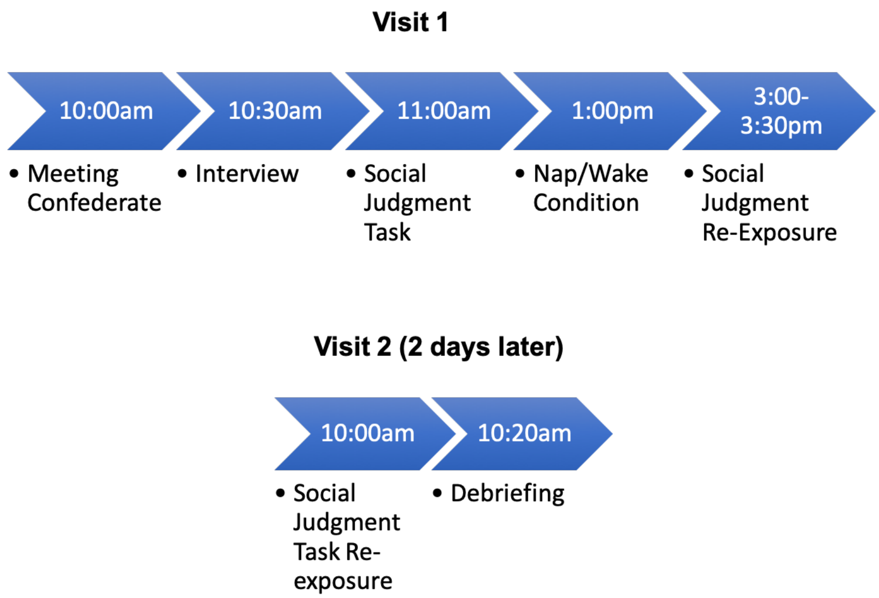

Figure 1: Study Visit 1 and Visit 2 timelines.

Participants also answered a series of psychological questionnaires, measuring their mood throughout the experiment to measure these changes across conditions. At the end of the experiment, subjects were thoroughly debriefed and given information about resources on campus to seek counseling, if needed.

Tasks

Modified Trier Social Stress task

Participants were asked the following questions about their life:

1. Tell me about your favorite hobbies.

2. Tell me about what makes you happy. What would a perfect day be like for you if you had no obligations? Walk me through what you would do.
3. Tell me about what you're most proud of that you've done in your life so far.
4. If you didn't have to have a job or worry about money, what would you do with your life?
5. Tell me a little about your family background—what do your parents do for work? Where did you grow up? Do you have siblings? How would you describe your family life, like, what was the family dynamic when you were growing up?
6. Tell me about the person you most admire. What qualities do you admire them for?
7. What do you feel like is your greatest shortcoming?
8. Tell me about what you think people like about you.
9. What about the opposite—what do you think people dislike about you?
10. Tell me about a time when you were a bad friend or a bad family member, like when you really disappointed someone.
11. Tell me about your goals and aspirations in life—what do you want to accomplish? How do you define success or failure for yourself?
12. Tell me about what you're most afraid of, or worried about, in life.

Subjects were told were being video-recorded during this task, however, no actual recordings were made. In addition, participant heart rate and skin conductance response was recorded through electrodes. The video recording is meant to induce moderate psychological stress responses.

Social Judgment task

Participants viewed a recording of the "real-time" on-screen ratings of their interview by the confederate while their heart rate and skin conductance were recorded. (Fig. 2) These ratings were chosen from a recording of a grid of 24 descriptive words equally divided into negative, neutral, and positive, with ratings biased towards negative (Muscatell et al., 2016).

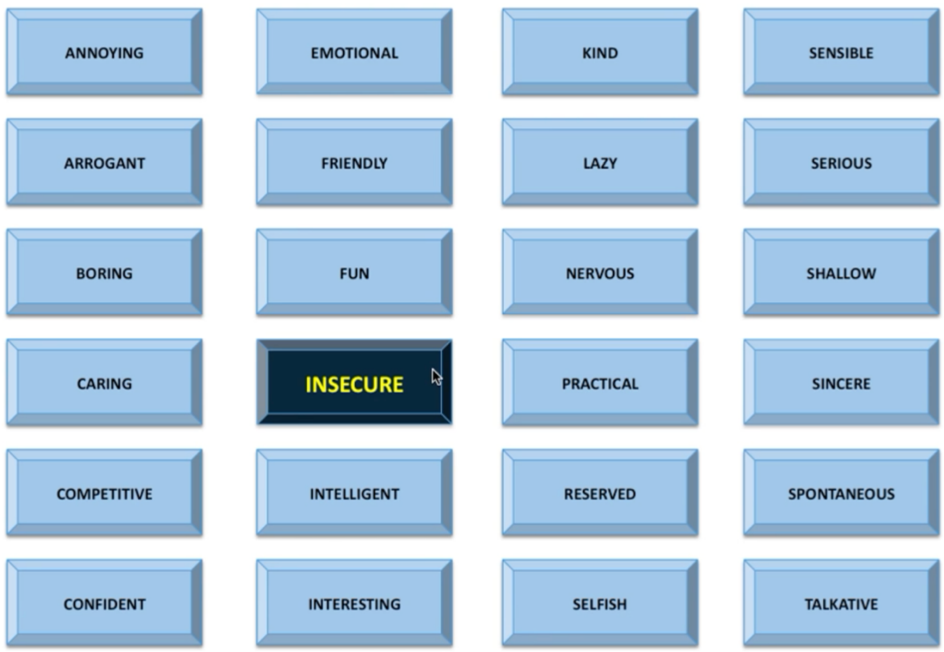

Figure 2: Social Judgment Task

Physiological data

This study collected data from participants through electroencephalography (EEG) during the nap, as well as electrocardiography (ECG) and skin conductance response (SCR) during tasks. For sessions involving EEG recording, electrode caps were placed on the subjects by trained research staff, before a two-hour nap opportunity.

The electrodes in the EEG cap to detect voltage changes, measured at the subjects' scalp. These small changes in voltage are caused by the electrical activity of the brain or brainwaves. The EEG systems we will use in this study are research-grade and consist of a multi-mode biosignal amplifier, power supply, EEG cap, and detachable electrodes (e.g. EASYCAP 32 channel cap by Brain Products GmbH). The 32 electrodes in the cap were placed over the scalp using a conductive paste, after preparing the scalp area by light abrasion with skin prepping gel (Brand: EASYCAP) to reduce the scalp impedance. These electrodes connect to a small data acquisition system that digitizes the signals and transfers them to a computer.

Heart rate and skin conductance were acquired and recorded through electrodes connected to the MP150 BIOPAC data acquisition system using Acknowledge analyzer software to analyze the physiological measurement outputs (Figure 3).

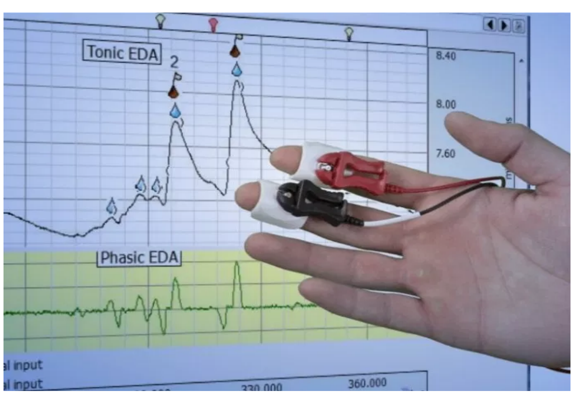

Figure 3: Schematic diagram of physiological response measurement system.

Electrodes were placed on the following body parts:

1. For skin conductance response (SCR) measurement, BIOPAC model EL507 electrodes (pre-gelled with isotonic gel) were used on the palm of the subject's non-dominant hand.
2. For electrocardiogram response (ECG) measurement, BIOPAC model EL503 disposable electrodes were placed on the subject's right first intercostal space (just below the collar bone) and below the lowest rib the participant can feel on their left side. Conductive electrode gel (Brand: Parker) were applied to each electrode before being placed on the skin.

Questionnaires

Self-Assessment Manikin for Valence and Arousal

The Self-Assessment Manikin for Valence and Arousal (Figure 4), a non-verbal measure where participants rate how they feel on scales of Valence and Arousal from 1-9, in response to stimuli (Bradley & Lang, 1994).

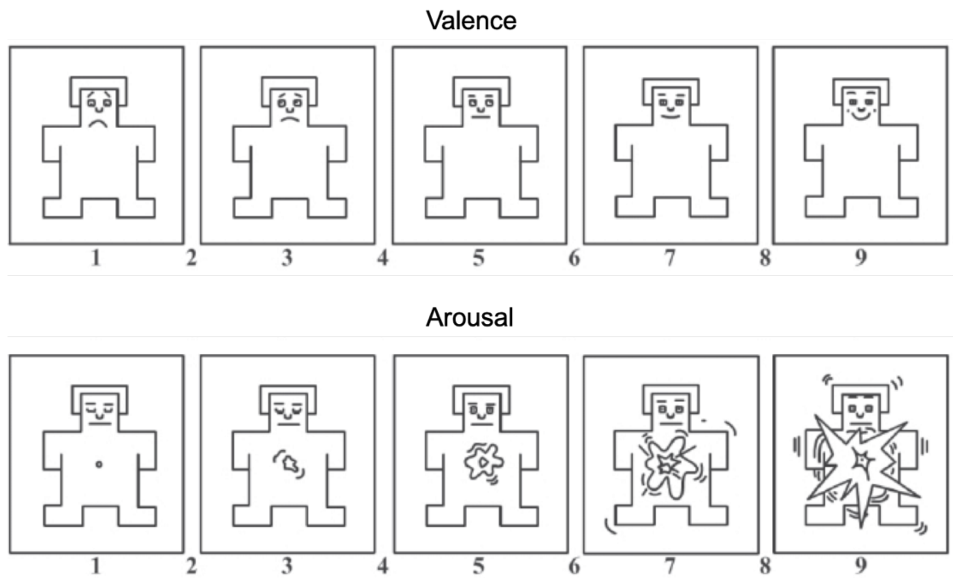

Figure 4: SAM Self-Assessment Manikin used to measure valence and arousal to stimuli.

The MacArthur Scale of Subjective Social Status

The MacArthur Scale of Subjective Social Status measures a participant's sense of their social standing in United States society. This scale asks the participant to identify where they see themselves in US society on a scale of 1 to 10, with 10 being the highest social standing (Adler et al., 2000).

Daily and Lifetime Discrimination Scale

The perceived discrimination scale has two subscales. In the lifetime discrimination scale participants indicate how many times they have been treated unfairly over the course of their lives. An example question is how many times "You were discouraged by a teacher or advisor from seeking higher education"). The Daily Discrimination scale asks about participants' experience with unfair treatment in their daily lives. For example: (e.g., "You are treated with less courtesy than other people") (Williams et al., 1997).

Sample items:

You were discouraged by a teacher or advisor from seeking higher education. ____

You were denied a scholarship. ____

You were not hired for a job. ____

You were hassled by the police. ____

You are treated with less respect than other people. _____

The aim of this study is to determine whether sleep can reduce the effects of negative social judgment. We will use a social judgment task followed by a laboratory-administered nap opportunity. We hypothesize that sleep will reduce emotional reactivity (heart rate, skin conductance, mood) to negative social judgment by allowing for emotional regulation to occur.

Analysis

Heart rate and skin conductance data was recorded at a sample rate of 2000 Hz and pre-processed using Acqknowledge Software by Biopac (©2022.) Skin conductance scores were calculated by subtracting the average from a 3-minute baseline period from the average response during the task. Heart rate was calculated as the peak-to-peak beats per minute. Baseline average was subtracted from Task response for an overall average. Sleep EEG data was recorded at a 1000 Hz sampling rate and re-referenced to mastoids. It was pre-processed in Brain Vision Analyzer (©2022) through low-pass filter set at 35 Hz and a high-pass filter set at 0.3 Hz prior to being scored in the Hume (Saletin, 2022) program through Matlab. Statistical testing, including repeated measures ANOVA, was performed using R Statistics Software (Version 1.1.463 – © 2009-2021. RStudio, Inc.) Outliers greater than 2.5 standard deviations from the mean were removed from the sample. Normality was checked using the Shapiro-Wilk normality test and the variance of the difference between groups was confirmed to be equal.

Results

Physiology: Heart Rate and Skin Conductance

There were no significant baseline heart rate or skin conductance differences for Nap or Wake. A two-way repeated measures ANOVA was performed to test the effects of session and condition (Nap/Wake) on average heart rate. There was a main effect of session, with participants' average heart rate decreasing across the 3 sessions ($p=0.0365$), however no main effect of condition, and no interaction between session and condition (Figure 5). In skin conductance response, no baseline differences or main effects were present, however there was a trend of the Nap group having a higher heart rate compared to the Wake group (Fig 6).

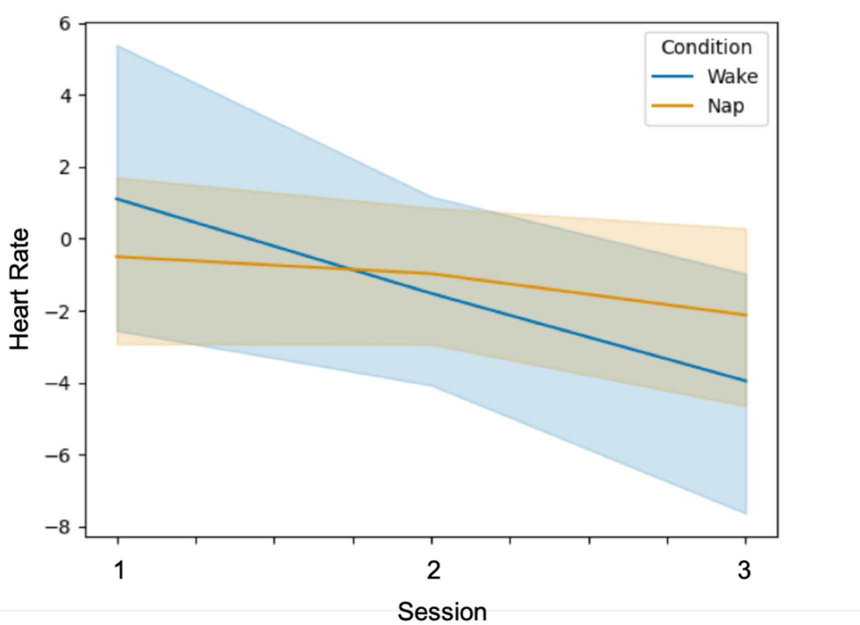

Figure 5: Line plot of heart rate mean across 3 sessions, 1) 1st exposure to task during 1st visit 2)2nd exposure to task after Nap/Wake condition during 1st visit 3)3rd exposure to task

after 2 day delay, on 2nd Visit. Participants showed an overall decrease across sessions (p=0.0365), but no effect of condition.

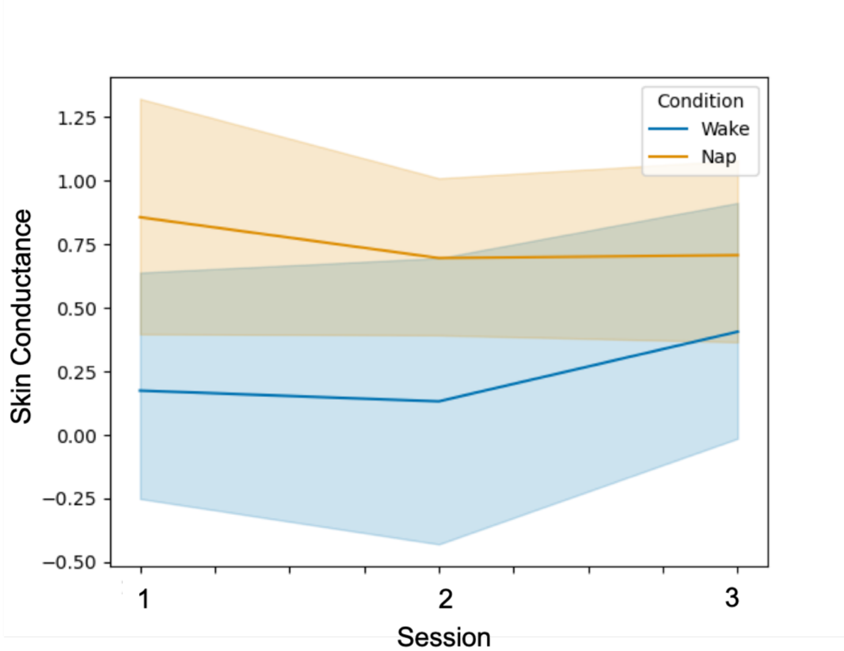

Figure 6: Line plot of skin conductance mean across 3 sessions, 1) 1st exposure to task during 1st visit 2)2nd exposure to task after Nap/Wake condition during 1st visit 3)3rd exposure to task after 2 day delay, on 2nd Visit. While both groups show a decrease over sessions, the main effects of session and condition are not significant.

Arousal

There was a significant main effect of condition for arousal ratings (p=0.03), with the Nap group showing overall lower arousal levels when combined across conditions (Figure 6).

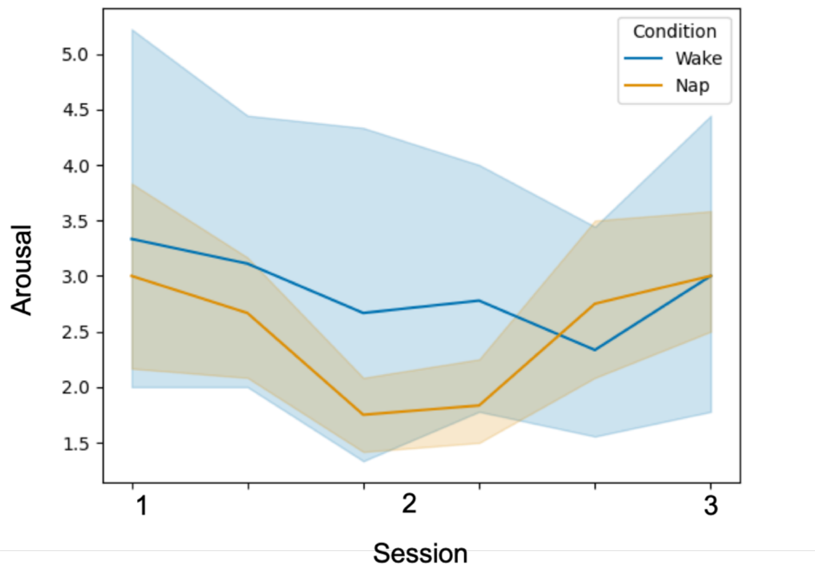

Figure 7: Line plot of arousal rating mean across 3 sessions, 1) 1st exposure to task during 1st visit 2)2nd exposure to task after Nap/Wake condition during 1st visit 3)3rd exposure to task after 2 day delay, on 2nd Visit. Nap group shows overall lower arousal ratings when combined across the 3 conditions (p=0.03).

There was a significant change in arousal rating from post-2nd exposure to the task to post-3rd exposure (p=0.003) (Figure 8).

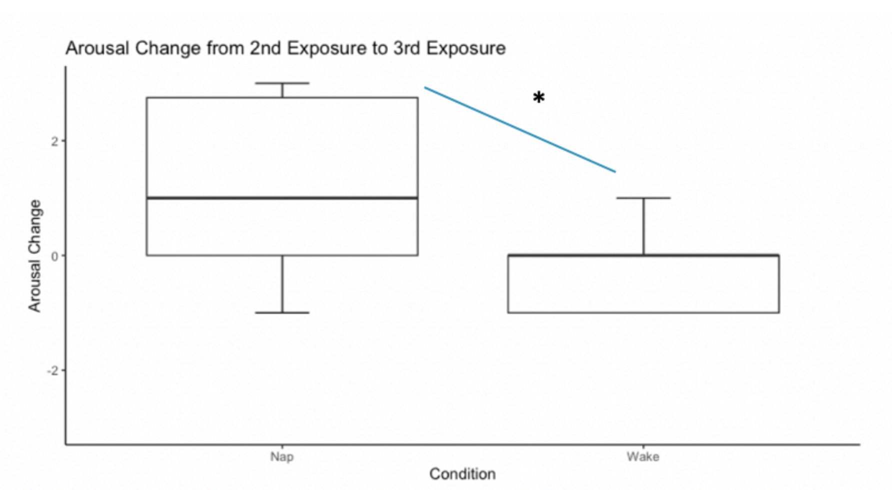

Figure 8: Box plot of Arousal Change score from post- 2nd to post-3rd task exposure. Wake group shows a slightly higher valence change compared to Nap (p=0.006).

Valence

No baseline differences for valence ratings were present and there were no significant overall main effects. (Figure 9). There was a trend towards lower overall Valence ratings by the Nap group compared to the Wake group.

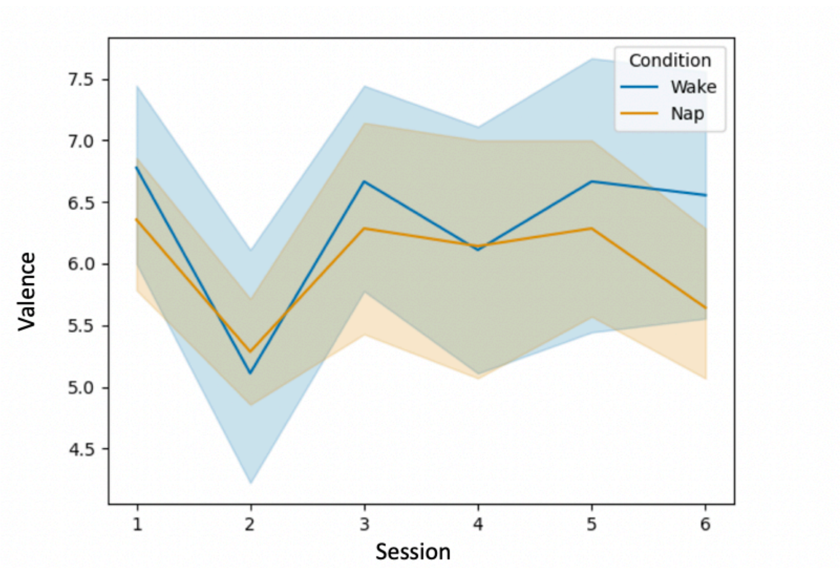

Figure 9: Line plot of valence scores across 6 time points: pre-post 1st exposure 1, pre-post exposure 2, and pre-post exposure 3. While both groups show a decrease over sessions, the main effects of session and condition are not significant.

However, there was a significant change in valence rating from post-2nd exposure to the task to post-3rd exposure (p=0.05) (Figure 10).

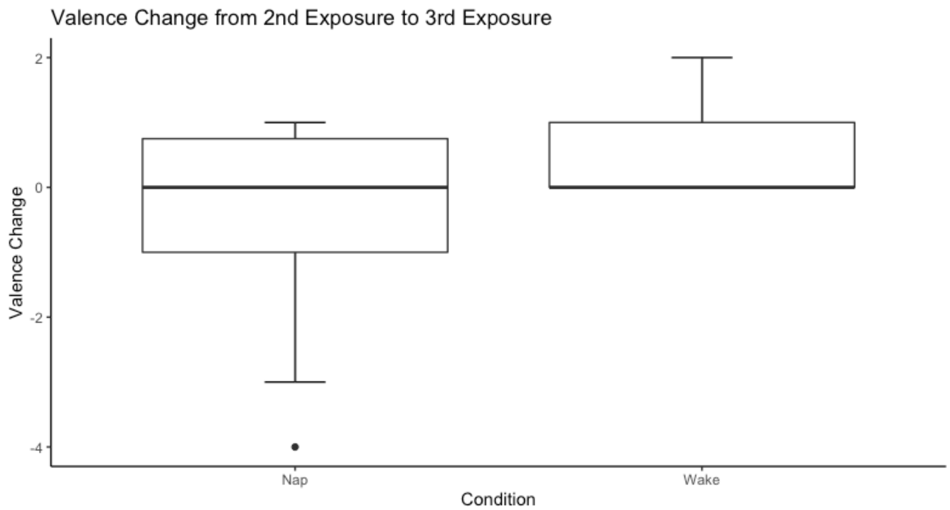

Figure 10: Box plot of Valence Change score from post- 2nd to post-3rd task exposure. Wake group shows a slightly higher valence change compared to Nap (p=0.05).

Social Status

No baseline differences in social status ratings were present. Both groups showed a trend towards decreasing over sessions (p=0.09), with the Wake group showing a greater decrease (Figure 11).

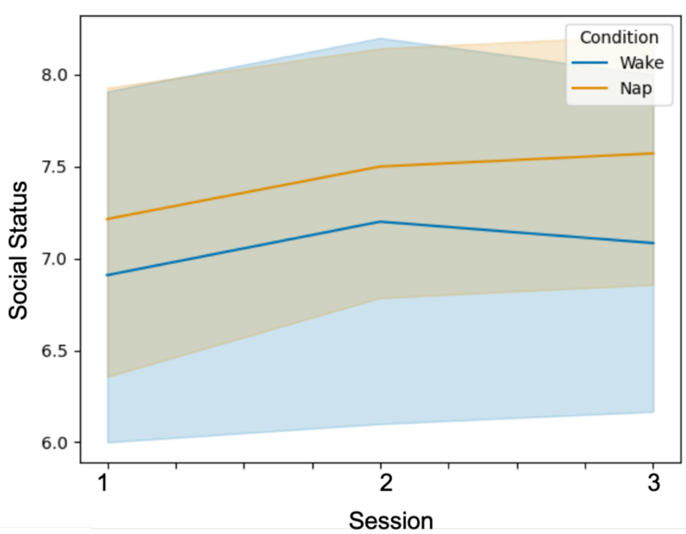

Figure 11: Line plot of social status scores post exposure 1, post exposure 2, and post exposure 3. Main effects of session and condition are not significant but show a trend towards higher Nap group ratings (p=0.09).

Daily Discrimination

A linear regression model showed a significant relationship between daily discrimination and heart rate, with higher social discrimination scores correlating to a raise in heart rate from the first judgment task exposure to the 3rd exposure (R=0.45, p=0.028) (Fig.12).

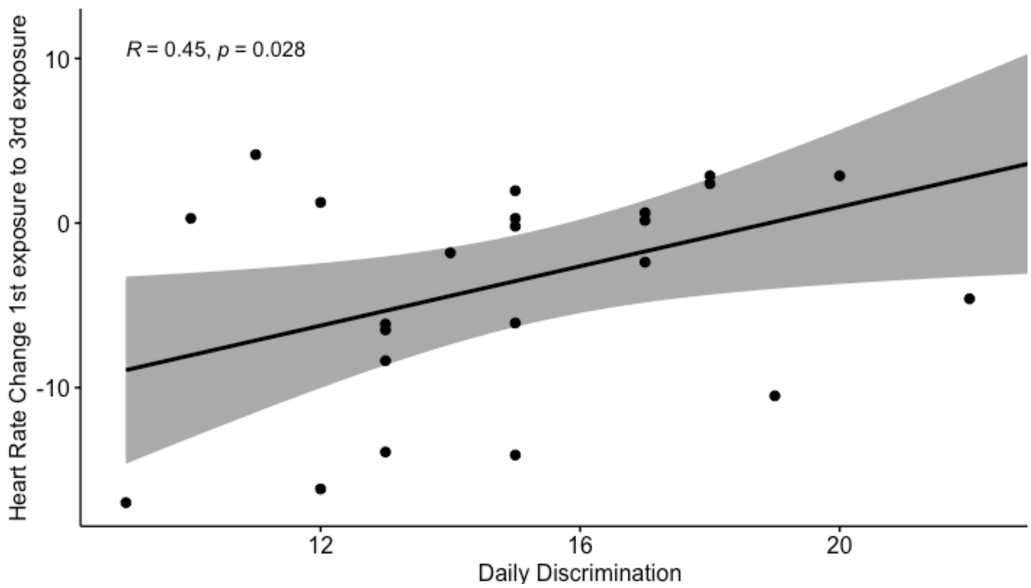

Figure 12: Daily discrimination from 1st to 3rd task exposure (R=0.45, p=0.028).

Sleep

Sleep efficiency, percent of time slept of the time in bed was 84.87% for our Nap group, with an average total sleep time of 104 minutes (out of a 120 minute opportunity). (Table 1). We did not see significant relationships between REM and subjective or physiological measures. However, we found a negative relationship between Valence rating after the 3rd exposure to the task (2 day delay) and higher total sleep time, with a higher valence rating correlating with higher total sleep time. (R=-0.61, p=0.02).

Table 1: Sleep metrics

Sleep Efficiency	Total Sleep Time (Min)	Minutes in REM	Percent REM	Minutes in Stage 1	Minutes in Stage 2	Minutes in Stage 3	Wake After Sleep Onset
84.87%	104	31.64	29.73%	12.5	47.89	12.39	11.57

Discussion

In this study, our aim was to determine whether sleep, through emotional regulation, helped buffer the negative effects resulting from a negative social judgment experience. Despite the emotional regulation thought to occur during sleep, some of our results do not follow this theory. Although not significant, heart rate and valence responses showed a pattern towards the Wake group having lower reactivity to the social judgment task. A similar pattern was seen for valence ratings, where Wake showed a slight significant increase in valence ratings compared to Nap. This includes an almost significant difference score from post 2nd task exposure to post 3rd task exposure (p=0.05). Interestingly, Arousal and Social Status ratings showed a trend towards better outcomes for the Nap group. With regard to physiology, there are studies which suggest that sleep may in fact amplify emotional experiences. Overall, a night of sleep, compared to a day of wake, preserves negative responses to emotional images and the experience of watching a scary movie (Baran et al., 2012). Negative emotional components of scenes are enhanced by a period of sleep, compared to wake (Payne et al., 2008). Age might also play a role. Young adults show a higher preservation of skin conductance response compared to older adults when viewing negative images before and after sleep (Jones et al., 2016). Given that our sample consisted of a young adult college student sample, those findings would support the trends seen for heart rate, skin conductance, and valence. However, given the trends for a nap benefit in arousal and social status, it is possible that emotional regulation may take a longer period of time to affect certain measures. In this case, the Sleep to Forget Sleep to Remember theory would predict that if the emotional tone was not reduced over one sleep period, with each additional period of sleep, some of these measures would reach a sleep benefit through a gradual decrease of emotional tone (van der Helm & Walker, 2009).

Some limitations of our study were a result of limited data collection time as a result of the COVID-19 pandemic. Due to being an underpowered sample, a larger sample for each group could add significance to some of the trends observed. Procedure-wise, the ability to compare participants in the Nap group who only underwent the modified Trier Task interview and not the social judgment task, would help to differentiate between the benefit of sleep for a stressful experience vs one meant to involve judgment. A future study would also look at other factors which could influence this emotional regulation, such as the difference between receiving judgment from an ethnicity in-group or out-group individual.

Given the negative effect that a form of social judgment, discrimination has on ethnic minorities, this could help elucidate whether groups experience physiological responses to judgment differently. Overall, my results suggest that sleep may help preserve physiological response to emotional experiences differently from subjective responses. Further work is required to determine possible contributors to these differences.

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