ABSTRACT

An Experimental Investigation of Sleep Restriction and Discrimination

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Inequalities of gender, sexual orientation, and race have spurred recent protests against discrimination. The resource depletion theory of discrimination argues that cognitive resources suppress the expression of internal prejudice, but that because cognitive resources are limited, discriminatory behavior may emerge when resources are depleted. We investigated whether sleep deprivation can affect cognitive resources and thus increase discriminatory behavior. 44 adults participated in a two-session study consisting of several cognitive and discrimination tasks. Participants were randomly assigned to bedtimes of either 10:30pm or 1:30am with wake times of 7:30am for four nights in between the two sessions. Sleep-restricted individuals showed more attentional lapses, higher mood disturbances, and greater subjective sleepiness. Sleep restriction also resulted in harsher ratings toward medical mistakes and female job applicants as well as a shooter task bias toward White-person stimuli. Interestingly, regardless of sleep, participants revealed an overall race bias toward Black-person stimuli in total shots fired.

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AN EXPERIMENTAL INVESTIGATION OF SLEEP AND DISCRIMINATION

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CHAPTER ONE

Introduction

Background on Discrimination

Inequalities of gender, sexual orientation, and race have spurred numerous movements in recent years (e.g., Black Lives Matter, Women's March, Pride). With the ever-increasing influence of social media, dissenting voices are heard now more than ever and political movements (and counter-movements) can be organized and mass public awareness spurred in as little as a few hours (Shirky, 2011). The root of these movements is to protest prejudice and discrimination. Prejudice refers to differential *assumptions* of people of a different group whereas discrimination refers to differential *actions* toward people of a different group (Jones, 2000). Though prejudice and discrimination are recognized as morally wrong, they persist in society, indicating a greater need to understand the mechanisms by which prejudice translates into discrimination.

Prejudice and discrimination are not new to our society, as evidenced by past protests (e.g., Women's Suffrage, Civil Rights). Human beings commonly prefer thoughts, ideas, and characteristics that are similar to their own, resulting in in-group bias, a favoritism on one's own in-group over the out-group (Mullen, Brown, & Smith, 1992). For example, people are more empathetic toward pain in others of their own race as compared to others of another race (Chiao & Mathur, 2010). Thus, one's biased thoughts (i.e. prejudice) can then lead to biased behavior (i.e., discrimination), whether it is conscious or unconscious.

People are now connected more than ever, a connection that deteriorates with stereotypes and the resulting differential treatment amongst various groups. For example, non-White minority races such as Hispanics and Blacks often endure skewed treatment in all aspects of the criminal justice system in comparison to Whites (Weitzer, 1996) and LGBTQ+ people experience forms of workplace discrimination that include being fired, denied employment, denied promotions, harassment, and unequal pay (Badgett, Lau, Sears, & Ho, 2007). Race also plays a role in occupational discrimination when reviewing an applicant's resume, likely from prejudices about a particular group of people in terms of their ability to do the job (Bertrand & Mullainathan, 2003). In regard to health, there exists racial and ethnic disparities in health care that result in poorer treatment and higher death rates for major diseases such as cancer, heart disease, and diabetes in ethnic minorities regardless of condition severity and socioeconomic status (Nelson, 2002). Racial and ethnic disparities also carry over into the educational system, with the educational gap between minority students (i.e., Black, Hispanic) and White and Asian students being partially explained by discriminatory behavior of the educators (Farkas, 2003). In addition to race and sexual orientation, obesity is an increasingly recognized factor that is associated with negative perceptions (Hebl, Ruggs, Singletary, & Beal, 2008) and overt discrimination (O'Brien, Latner, Ebneter, & Hunter, 2013). Thus, discriminatory behavior negatively affects many aspects of social, occupational, and health well-being (Slopen, Lewis, & Williams, 2016).

Measuring Discrimination

Objectively measuring biased behavior in a lab setting includes methods such as mock interviews, survey tasks, and reaction time tasks. Some methods involve interactions or exposure to a real or virtual person who differ in, for example, race or gender. For example, in mock interviews, a participant may interact directly or indirectly with confederates – actors who pose as other participants. In virtual studies, the studied variable can be manipulated by name or photo. One option is the Police Officer's Dilemma Task, a first-person shooter task that flashes an image of either an armed or unarmed White or Black male at random intervals of 500-1000 ms, during which the participant must decide to shoot or not shoot the stimuli within 850 ms (Correll, Park, Judd, & Wittenbrink, 2002). Participants show faster reaction times toward correctly shooting armed Black males, but also quicker reaction times toward correctly not shooting unarmed White males, indicating a potential racial bias (Correll et al., 2002). Other virtual methods include a resume rating task that requires occupational decision-making based on candidate resumes with ethnically diverse names (Bertrand & Mullainathan, 2003), a charity rating task that collects opinions on the success of a charity based upon the physical weight of the organizer as shown in a photograph (Hebl & Heatherton, 1998), and a medical error rating task that rates the severity of a medical mistake and the characteristics of the physician based on ethnically diverse physician names. Data consisting of body language (in live interactions), responses, and response times can provide insight into biases that manifest into discriminatory behavior.

Factors that Influence Discrimination

The translation of internal prejudices to external discriminatory behavior is complex, and can be influenced by intrinsic and extrinsic factors such as level of motivation, subconscious behaviors, and cognitive load (Swim, 2007). Motivation could be personal, such as actively not wanting to be discriminative toward others, and it could be enough to have an effect on the way that one ultimately behaves (Devine, Plant, Amodio, Harmon-Jones, & Vance, 2002). Impression management – the attempt to influence others' perception of oneself – can be conscious or subconscious, and those motivated by impression management can discriminate less if they interact with someone who displayed ethnic identification (e.g., wearing a baseball-style cap from a Hispanic Student Association) (Barron, Hebl, & King, 2011). Regarding subconscious behavior, people can feel a form of cognitive dissonance – the discomfort associated with contradicting beliefs and behavior – when their prejudice and unwillingness to discriminate conflict. Thus, people subconsciously form stereotypes as a form of justification of the dissonance between their thoughts and actions (Crandall, Bahns, Warner, & Schaller, 2011).

One of the most influential theories of how prejudice turns into discriminatory behaviors is based on availability of cognitive resources. The resource theory of discrimination argues that cognitive resources are required to suppress the expression of prejudice. However, cognitive resources are limited, and when they are depleted, discriminatory behavior may emerge (Gordijn, Hindriks, Koomen, Dijksterhuis, & Knippenberg, 2004). Use of self-control in decision-making is one factor that reduces that resource, making it increasingly likely that one will fail to exert self-control in future situations (Baumeister, Bratslavsky, Muraven, & Tice, 1998). For example, participants who have been exposed to a prior situation in which they exerted self-control (i.e., depleted) were more prone to dishonesty and temptation to cheat as opposed to non-depleted participants (Mead, Baumeister, Gino, Schweitzer, & Ariely, 2009). Another factor to consider in resource depletion is sleep. Some suggest that sleep is the recovery resource that replenishes the limited energy supply from which self-control draws in order to suppress certain discriminatory behaviors (Ghumman & Barnes, 2013). Similarly, others propose that sleep deprivation depletes resources to exert control over unethical behaviors (Barnes, Schaubroeck, Huth, & Ghumman, 2011). Past work has shown that discrimination triggers poor sleep quality (Slopen et al., 2016), but an emerging question is whether sleep restriction can trigger discrimination (Ghumman & Barnes, 2013). Previous research on sleep and discrimination has relied on self-reported measures of sleep, and there are no published studies that experimentally manipulated sleep duration to observe its causal effect on discrimination. The goal of this experiment was to fill this gap in the literature by testing whether short sleep increases discriminatory behaviors.

Sleep as a Cognitive Factor

Sleep loss may cause increased discrimination via impaired executive functioning, emotional processing, or self-control. Within the frontal lobe, the pre-frontal cortex (PFC) is known for executive functioning, which includes effortful processes such as decision-making, behavioral inhibition, and emotional regulation. The PFC works to integrate information from the other parts of the brain in order to interpret the stimuli and produce an appropriate response (e.g. forming a logical response after integrating multisensory stimuli and interpreting the initial reaction). Preliminary data suggest that as little as one night of sleep loss can impair executive functioning in the PFC (Nilsson et al., 2005). Furthermore, even recovery sleep following a night of total sleep deprivation does not fully restore impaired frontal lobe metabolic function (Wu et al., 2006).

Mood and affect are also negatively affected by poor sleep. Sleep-deprived adolescents and adults reported more negative affect compared to rested individuals (Talbot, McGlinchey, Kaplan, Dahl, & Harvey, 2010), potentially resulting from sleep deprivation's negative impact on the top-down control of emotions (Yoo, Gujar, Hu, Jolesz, & Walker, 2007). Furthermore, sleep deprivation affects people's ability to inhibit responses to negative stimuli (Anderson & Platten, 2011). Related to affect is emotional intelligence, defined as the ability to integrate emotional information with cognitive processing. Emotional intelligence is one aspect of executive functioning and its decreased effectiveness has been connected to sleep deprivation (Killgore et al., 2008). Sleep-deprived individuals with low emotional intelligence are more susceptible to problems with moral judgment (Killgore et al., 2007). Thus, a poorer ability to process emotional responses is a viable cognitive moderator between sleep and discrimination.

Sleep and Discrimination

There may be a bidirectional relationship between sleep and discrimination. On the one hand, studies show that experiencing discrimination negatively impacts sleep. In an extensive review on sleep and discrimination, people who reported experiencing some form of discrimination also experienced various forms of sleep disturbances, including insomnia, sleep onset latency, sleep quality, and fatigue (Slopen et al., 2016). The relationship between experiencing discrimination and experiencing sleep problems seems to be mediated by the psychological distress produced by experiencing discrimination (Vaghela & Sutin, 2016).

Alternatively, we hypothesize that the reverse can be true, that sleep can affect discrimination. Sleep deprivation is connected to increased prejudice via limited cognitive resources (Ghumman & Barnes, 2013). Sleepy individuals were more likely to rely on stereotypes to describe others (e.g., when writing a paragraph about a day in the life of a Muslim woman), and the more implicit bias they already had the more apparent the discrimination. In addition, sleep deprivation correlates with harsher sentencing by judges and increased police harassment of minorities (Cho, Barnes, & Guanara, 2016; Wagner, Barnes, & Guarana, 2015). Unaddressed, poor sleep may ultimately result in a cycle of increased negative behavior and poorer sleep. Targeting the latter issue would lead to potential reduction in discrimination and subsequent improvement of sleep, and so on. Thus, investigating whether sleep can affect prejudiced behavior would be a significant step toward discovering the cognitive basis of discrimination and breaking the cycle.

Measuring Sleep

Sleep can be measured both subjectively and objectively. Subjective sleep data are measured through questionnaires or sleep diaries. However, self-reported sleep data are limited by participants' ability to accurately recall and honestly report. People tend to overestimate how much sleep they actually get when comparing their self-reports with simultaneously-collected objective sleep data (King, Daunis, Tami, & Scullin, 2017; Lauderdale, Knutson, Yan, Liu, & Rathouz, 2008). Objective sleep data are better acquired using methods such as actigraphy wrist-watches. Actigraphy tracks movement and light and use a special algorithm to determine sleep. In healthy young adults, actigraphy has been validated relative to the gold-standard of sleep measures (in laboratory polysomnography; Meltzer, Walsh, Traylor, & Westin, 2012; Weiss, Johnson, Berger, & Redline, 2010), but has several ecological advantages. Actigraphy looks and works similar to a commercial Fit-Bit device. It functions as a watch, and is portable, waterproof, and worn on the non-dominant wrist. Importantly, participants may sleep in the comfort of their own beds, thereby eliminating any discomfort of sleeping in a laboratory. Additional value to the experimenter is that actigraphy is less expensive than polysomnography, allowing for simultaneous studies of multiple participants (King et al., 2017).

Experimental Design

Until now, research on sleep and discrimination has been correlational, and therefore we do not know whether the association is causal. It is important to examine sleep and discrimination outcomes using objective sleep measures and an experimental design. One consideration for the experimental design is whether to employ total sleep deprivation or partial sleep deprivation methods. When looking at college students – the population that one would most associate with total sleep deprivation (i.e., all-nighters) – even they do not frequently engage in total sleep deprivation. Many have “pulled an all-nighter” once, but few students regularly continue pull all-nighters (Thacher, 2008). By contrast, partial sleep deprivation to fewer than 6 hours/night is common (Bonnet & Arand, 1995).

Our study used a partial sleep deprivation experimental design. The 5-day study was designed to provide a baseline measure of sleep (e.g., sleep diary, PSQI) at Session 1 and allow for four consecutive nights of sleep duration manipulation that was monitored via actigraphy. Participants were randomly assigned to a partial sleep restriction condition (<6 hours/night) and a normal sleep condition (7-9 hours/night). Session 1 also provided a baseline for cognitive tasks, mood, and sleepiness. Session 2 again assessed cognitive tasks, mood, and sleepiness, but also incorporated several discrimination tasks. The discrimination tasks included an online survey and an E-prime task. The survey asked participants to rate medical errors, charities, and resumes. Variables of race, weight, and ethnicity were manipulated in each of these survey tasks, respectively. The E-prime task, or the Police Officer's Dilemma Task, was a first-person shooter task in which participants had to quickly react (e.g., shoot vs. not shoot) to Black and White stimuli who were either armed or unarmed.

Hypotheses

We expected the sleep-restricted condition to perform worse on cognitive measures (i.e. sustained attention task, working memory span task) compared to the normal sleep condition, indicating either less exertion of cognitive effort toward behavior control or a lesser ability to process incoming stimuli. Furthermore, we expected the restricted sleep condition to perform more poorly on the discriminatory measures (i.e. show increased discriminatory behavior). For the medical error, resume, and charity rating tasks, we predicted that more sleep deprived individuals would respond more negatively toward stimuli of a different race, ethnicity, and weight. In the context of the Police Officer's Dilemma Task, we predicted that an unarmed individual of a different race will be targeted more frequently and more quickly. In addition, for the same sleep-restricted condition we expected reaction times to be slower for targeting individuals of the same race, indicating that they are either more hesitant or take more time to deliberate before acting.

CHAPTER TWO

Materials and Methods

Participants and Overview of Design

44 Baylor University undergraduate students (ages 18-27) were recruited through campus flyers and social media advertisements. The study was advertised as a Sleep and Social Cognition study so as to not reveal the complete intention of the study to prevent any dishonest responses. Demographic information is presented in Table 1.

Variable	Normal Sleep (*n*=22)	Restricted Sleep (*n*=22)	Condition Main Effect
Age	20.32(1.43)	21.05(2.15)	t(42)= -1.32, *p*=0.19
Gender (% female)	68.2%	59.1%	χ(1)=0.393, *p*=0.755
SDS	16.23(4.64)	17.41(4.88)	t(42)=-0.82, *p*=0.42
PSQI Global	5.23(2.18)	5.45(2.59)	t(42)=-0.31, *p*=0.76
POMS1 TMD	91.23(11.77)	91.64(16.44)	t(42)=-0.095, *p*=0.925
KSS 1	5.24(1.48)	4.36(1.76)	t(41)=1.76, *p*=0.09
Sleep Diary (Sun)			
TST (min)	426.9(60.5)	419.9(67.01)	t(42)= -0.361, *p*=0.72
Bedtime	11:36PM (78.04)	12:05AM(79.12)	t(42)=1.27, *p*=0.211
SOL	22.0(27.52)	11.95(8.76)	t(42)=1.63, *p*=0.115
Caffeine (# bev)	0.95(1.05)	0.73(0.83)	t(42)= -0.80, *p*=0.428
WASO (#)	1.32(1.49)	0.73(0.98)	t(42)=1.55, *p*=0.13
WASO (min)	9.91(15.1)	6.14(10.36)	t(42)=0.97, *p*=0.339

Table 1. Demographics between sleep conditions. Includes everyone who completed the study (N=44).

Exclusion criteria included habitual self-reported poor sleep (< 7 hours per night) and clinically diagnosed sleep disorders. Figure 1 shows that the 5-day study consisted of two 1.5 hour in-lab experimental sessions – one on Monday and one on Friday. For the four nights between each session, participants were instructed to maintain a wake time of

7:30am and were randomly assigned to maintain a bedtime of either 10:30pm (normal sleep condition, up to 9 hours in bed) or 1:30am (restricted sleep condition, up to 6 hours time in bed). We randomly assigned 22 participants to each condition. A G*Power analysis indicates sufficient power (1 - β = .80) to detect a large effect size (d=.91) that would be comparable to other sleep restriction experiments (Alkozei et al., 2017; Faul, Erdfelder, Lang, & Buchner, 2007). Participants slept in their homes throughout the week, and we monitored sleep using wristband actigraphy. Participants were compensated $50 ($10 per day) for their participation. The study was approved by the Baylor University IRB and all participants signed informed consents prior to the study.

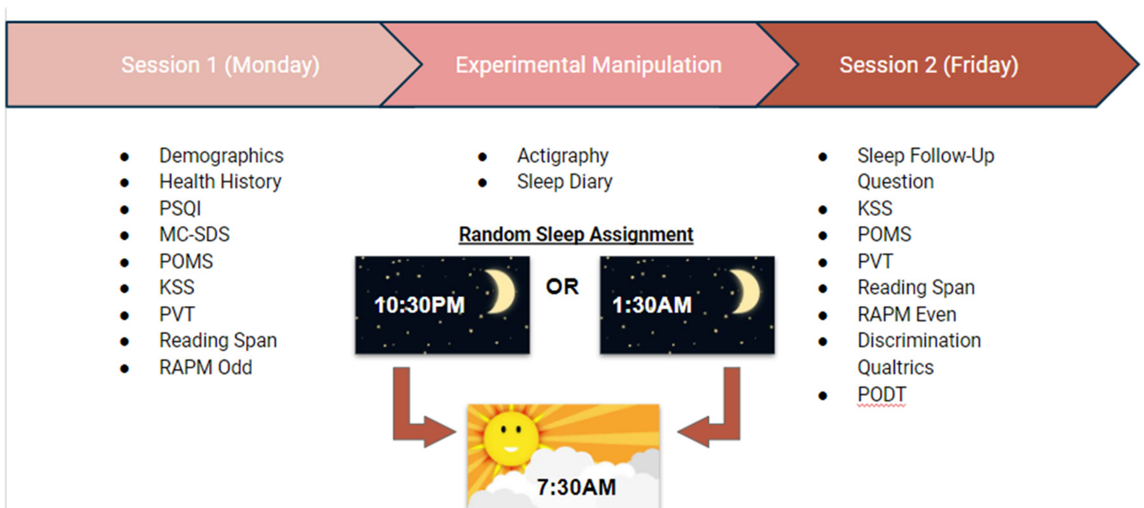

Figure 1. Experiment timeline with included tasks.

Sleep Materials

We measured sleeping using actigraphy, questionnaires, and sleep diaries. Actigraphy is measured by a device worn like a wristwatch that detects light and movement using accelerometer technology to indicate levels of physical activity and sleep. The device is worn on the wrist of the non-dominant hand. We used a device called the Actiwatch Spectrum Plus (Phillips Respironics Actiwach-2), because it has been tested to be a reliable sleep device when compared to the gold standard of PSG (Meltzer et al., 2012; Weiss et al., 2010). The device was set at factory recommended settings that defined epoch length as 15 seconds, wake onset as 40 activity counts, and sleep as periods of rest with 10 minutes without movement. Figure 2 is an example of actigraphy data obtained from an Actiwatch Spectrum Plus. Sleep is marked by the blue area with reduced physical activity (black lines) and light (yellow and blue lines).

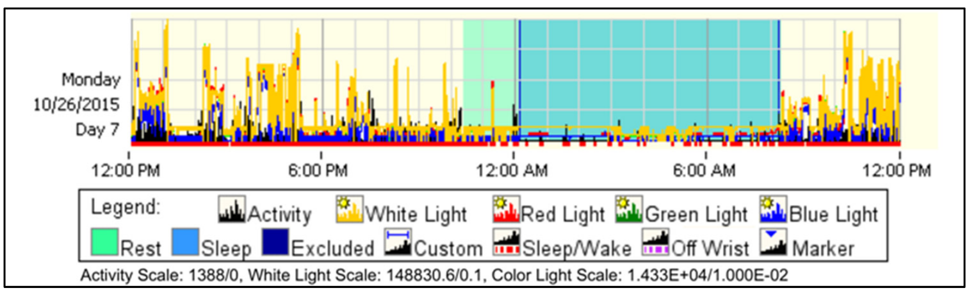

Figure 2. Example of a night of good sleep. The participant lightly rested at about 10:30PM (light green shaded area), and slept eight hours from 12:00AM to 8:00AM (blue shaded area).

Sleep questionnaires included the Pittsburg Sleep Quality Index (PSQI) and the Karolinska Sleepiness Scale (KSS). The PSQI consists of nine questions used to calculate a global score that indicates the quality of sleep reported over the past month (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The KSS is a single 9-point scale that determines current level of sleepiness (Akerstedt & Gillberg, 1990). Although we previously mentioned that sleep is often overestimated in self-reported measures despite the PSQI and KSS having been validated compared to PSG (Buysse et al., 1989; Kaida et al., 2006), we included these measures because the PSQI provides a general overview of their quality of sleep for the past month and the KSS is intended to be recorded as a subjective measure. The self-reported measures serve to supplement the objective actigraphy methods used to monitor the sleep manipulation. In addition to the questionnaires, participants self-reported their sleep the morning following each night during the week on a widely-used Consensus Sleep Diary (Carney et al., 2012). The Consensus Sleep Diary has been further validated in those with Insomnia Disorder (Maich, Lachowski, & Carney, 2016). For our experiment, the diary was modified to include daily caffeine consumption and the extent of adaptation (i.e., How difficult is it to follow your assigned sleep schedule: very hard, hard, fair, easy, very easy) to the assigned sleep condition. The extent of adaptation question provided additional information on how well and how quickly they adapted to their assigned condition to see if perceived difficulty resulted in perceived sleepiness and cognitive impairment.

Cognitive Materials

To measure sustained attention, we used the Psychomotor Vigilance Task (PVT). The PVT is a 10-minute reaction time task during which participants must press the space bar as soon as numbers (i.e. a millisecond counter) appear in a rectangular box in the center of the computer screen (Lim & Dinges, 2008). The numbers appear at varying, unpredictable intervals of time (ranging from 2-10 seconds) and participants receive feedback by seeing their reaction time (in milliseconds) in the box as soon as they hit the spacebar.

We used the Reading Span to measure working memory capacity (Daneman & Carpenter, 1980). The Reading Span involves a simultaneous primary letter span task and secondary reading comprehension task to reflect processing and storage abilities. On each trial, the participant reads a sentence on the screen and responds true if the sentence makes sense and false if it does not (e.g., Because she gets to the knife early, Amy usually gets a good parking spot. Answer: False). Following each sentence, participants are briefly shown a letter. Each section contains 4-6 trials (1 trial = 1 sentence and 1 letter), and at the end of each section participants must recall the letters in the order in which they were shown. Participants were required to maintain a minimum of 80% accuracy on sentence ratings to ensure that they were not simply focusing on memorizing the letters.

We administered the Raven's Advanced Progressive Matrices (RAPM) task as a measure of fluid intelligence (Raven, Raven, & Court, 1998). There are two separate versions of the RAPM – Odd and Even – which we divided between the two sessions. Each of the RAPM problems contained a 3x3 matrix of boxes. Each box contained a variation of a pattern, except for the bottom right box. The task is to choose the correct option to fill the bottom right box that correctly fits with the pattern of the rest of the matrix in both vertical and horizontal directions. Participants were allowed 10 minutes to solve as many trials as possible (18 possible).

Discrimination Materials

We used two virtual tasks to measure levels of discriminatory behavior. The first three tasks were compiled into a Qualtrics survey that included a medical error, charity, and resume rating task that manipulated race, weight, and ethnicity, respectively. Previous studies have manipulated weight (Hebl & Heatherton, 1998) and race (Bertrand & Mullainathan, 2003) to compare discriminatory behavior. We pre-tested each task on the Qualtrics survey with a pilot group (N=27 undergraduate students) to verify that there were no significant differences between the different stimuli except for the variable being manipulated. The fourth task was an E-Prime version of the Police Officer's Dilemma Task (PODT).

For the Qualtrics survey, the medical error task presented eight total reports of medical errors committed by physicians – four tasks were less serious errors (mean=6.39) and four were more serious (mean=6.94). Error severity was determined by the pilot test of 27 undergraduate students who read and rated a series of medical tasks from Not at all serious (1) to Extremely Serious (9). The means for the less and more serious error ratings were significantly different. The task manipulated race by having two of each error and changing only the physician names between each one (e.g. Dr. Jamal Johnson vs. Dr. Thomas Matson). After the presentation of the scenario, questions prompted participants to rate their opinion on the severity of the error, the severity of punishment the physician deserved, the level of compassion the participant had for the physician, the level of compensation the patient should receive, physician competence, and other physician characteristics (e.g., competence, professionalism, medical expertise, good quality of care, thoroughness).

The charity task presented four web advertisements for different fundraising events. Only two events were the same, and photos of the event organizer varied in weight by using a normal version and a version edited to increase the weight appearance (e.g. Mattie Smith – normal weight vs. Mattie Smith – overweight). The two remaining stimuli were a male control and a female control. The questions following the stimuli rated the professionalism of the web page, the predicted success of the fundraiser, indication of personal donation amount, and efficacy of the advertisement.

The resume task displayed five different resumes. The stimuli were pre-tested to verify that they were not perceived as significantly different save for the manipulated names. The different candidate names reflected a manipulation of religious affiliation as well as race and ethnicity (e.g. Ethan Hamilton vs. Hassam Abdullah) with one female applicant (Abigail Graham). Questions following each resume asked for ratings about the quality and successfulness of the applicant. Participants rated the applicant's level of qualification for a marketing position, level of successfulness, the strength of the applicant's skill set, and how good they thought the applicant was. In addition, participants indicated their willingness to hire the applicant and how much they liked the applicant. Additional questions asked for the qualification of each individual applicant for a specific position (e.g., How likely would you be to hire Ethan Hamilton for this job?). Lastly, participants chose who of the five applicants they would hire for three different neutral positions (e.g., Of all the candidates, who is most qualified for Job#1?).

The Police Officer's Dilemma Test (PODT) was administered on E-prime 2.0 software. The PODT is a task that measures reaction times on targeting armed versus unarmed citizens of different races (Correll et al., 2002). The objective of the PODT is to shoot (Q key) the armed target and not to shoot (P key) the unarmed target. Armed stimuli are holding either a revolver or a pistol, and unarmed stimuli are holding a silver aluminum can, a silver camera, a black cell phone, or a black wallet. Various empty scenes will continuously flash in 500-1000 ms intervals on the screen. After 1-4 empty scenes, one scene will appear that contains a stimulus (Figure 3). One trial consists of the series of empty scenes that end with a target stimulus. There are four types of stimuli (i.e., White-Armed, White-Unarmed, Black-Armed, Black-Unarmed) and 20 trials of each type (i.e., 80 total trials). Participants must react by shooting (Q) or not shooting (P) within 850 ms, and they receive a correct, incorrect, or too-slow feedback following each trial. The fast trials represent naturalistic circumstances – such as a police arrest – in which a rapid decision must be made despite perceptual ambiguity. The program records both reaction times and accuracy for correct hits (shooting the armed target or not shooting an unarmed target) and incorrect hits (shooting the unarmed targets or not shooting an armed target).

Figure 3. Example of an armed target. Stimuli may vary between White or Black males who are either armed or unarmed.

Additional Materials

To measure perceived levels of social approval, we administered the Marlowe-Crowne Social Desirability Scale (MC-SDS). The MC-SDS is a 33-item scale that measures how much participants care about what others think about them (Crowne & Marlowe, 1960). The goal of assessing social approval was to account for any results that may contradict our hypothesis (e.g. someone who cares about others' or the experimenter's opinions may rate the opposite of what they think).

The shortened version of the Profile and Mood States (POMS) is a 40-item scale that evaluates current emotional state (Grove & Prapavessis, 1993). Each item (e.g. tense, angry) is rated on a 5-point Likert scale (Not at all, A little, Moderately, Quite a Lot, Extremely) for the current moment. Mood evaluation is relevant for its association with sleep and its influence on cognition and behavioral control.

Procedure - Session One

Prior to Session 1, participants were asked to fill out the sleep diary for the night before the first session. Session 1 took place on Monday morning. Following the informed consent, we administered questionnaires including a demographics questionnaire, the PSQI, KSS, MC-SDS, and POMS. Next, they completed computerized tasks that included the PVT, Reading Span, and the Raven's Advanced Progressive Matrices.

At the end of Session 1, we reminded participants to maintain the sleep diary for the following four nights until their second session. Then, we gave them an actigraphy device called the Phillips Respironics Actiwatch Spectrum Plus to objectively track their sleep and wake times using actigraphy. Finally, we randomly assigned the participants to either a Normal Sleep condition (up to 9 hours in bed; bed time at 10:30 PM; wake time at 7:30 AM) or Restricted Sleep condition (up to 6 hours in bed; bed time at 1:30 AM; wake time at 7:30 AM). Assignment order was determined using the blocked random assignment method (blocks of 2, 4) and acquired using an online tool (https://www.sealedenvelope.com/simple-randomiser/v1/lists). To minimize the risk of experimenter bias, the researchers who interacted with the participants were masked to each participant's experimental condition. We accomplished masking by having a research staff member who would not be interacting with participants generate the random assignments and seal participants' condition assignments in envelopes. Only after participants completed Session 1, did a research staff member hand the participant an envelope with their condition with the instruction to open the envelope after leaving Session 1. Participants were explicitly instructed to not mention their assigned sleep condition to the experimenter as they were leaving or when they returned for Session 2. Lastly, we instructed participants not to nap during the week to prevent any form of recovery sleep.

Procedure - Session Two

To control for time of day effects, participants returned for Session 2 on Friday at the same time they came in on Monday (typically, 8:30am). During the second session, participants returned their sleep diary and actigraphy watch. They filled out the Sleep Follow-Up Question form, which asked them if they felt like they caught up on sleep (normal condition) or if they adapted to the restricted sleep (restricted condition). Next, they filled out the KSS and the POMS. Then they completed all of the computer tasks, in the following order: PVT, Reading Span, Raven's Standard Progressive Matrices (Even condition), the discrimination Qualtrics surveys, and the Police Officer's Dilemma Task. At the end of the session, we debriefed the participants and compensated them for their time. We downloaded actigraphy data at the end of each second session to keep research staff masked to participants' conditions.

CHAPTER THREE

Results

As illustrated in Table 1, as expected, the conditions did not differ significantly on any baseline visit assessments (i.e., measures acquired prior to random assignment). We next evaluated adherence to the sleep duration assignments. Adherence in the sleep restriction condition was defined as averaging ≤6.0 hours of sleep. Adherence in the normal sleep condition was defined as averaging 7-9 hours of sleep. Twelve participants were excluded for non-adherence to the sleep manipulation. Non-adherence to the sleep manipulation reduced the difference in average sleep time between conditions, which would have nullified any difference we would have seen due to sleep deprivation and thus would have made the sleep manipulation useless. Furthermore, because some of our tasks (e.g., Medical Error, PODT) investigated discrimination against the Black population, we excluded four Black participants to eliminate any opposing effects. See Table 2 for baseline demographic information for the remaining 29 participants after exclusion of non-adherent and Black participants. After exclusion, there were still no differences at baseline.

The sample size varies throughout the figures and tasks. In general, we excluded non-adherent participants and Black participants (n=29 remaining). However, we included the Black participants on the charity task and resume task because we did not manipulate White vs. Black on those tasks (n=31 remaining). Once participant in the normal sleep condition did not complete the Qualtrics survey and one participant in the normal sleep condition did not complete the PODT. However, the latter did not adhere to the sleep manipulation and thus was already excluded in all of the results.

Variable	Normal Sleep (*n*=16)	Restricted Sleep (*n*=13)	Condition Main Effect
Age	20.31(1.54)	20.46(1.56)	t(27)= 0.258, *p*=0.798
Gender (% female)	75%	53.8%	χ(1)=1.421, *p*=0.027
SDS	15.63(4.73)	18.08(5.01)	t(27)=1.352, *p*=0.188
PSQI Global	5.00(2.25)	4.92(3.04)	t(27)= -0.078, *p*=0.938
POMS1 TMD	89.88(12.21)	94.08(19.19)	t(27)=0.685, *p*=0.0.502
KSS 1	5.33(1.40)	4.15(1.91)	t(27)= -1.88, *p*=0.071
Sleep Diary (Sun)			
TST (min)	425.44(66.02)	435.38(58.5)	t(27)=0.424, *p*=0.675
Bedtime	11:31PM(88.13)	11.52PM(75.47)	t(27)=0.685, *p*=0.499
SOL	25.56(31.65)	11(8.07)	t(27)= -1.77, *p*=0.094
Caffeine (# bev)	1.19(1.11)	0.69(0.95)	t(27)= -1.275, *p*=0.213
WASO (#)	1.44(1.46)	0.69(0.95)	t(27)= -1.658, *p*=0.109
WASO (min)	8.13(10.43)	5.92(10.84)	t(27)= -0.556, *p*=0.583

Table 2. Demographics between sleep conditions. Excludes those who did not strictly adhere to the sleep manipulation and Black participants (n=29).

Session 2 cognitive outcomes are displayed in Table 3. Consistent with the sleep restriction literature (Banks & Dinges, 2007), there was a significant increase in the total lapses of attention on the PVT (defined as reaction times of >500ms) in the sleep restriction condition than in the normal sleep condition, $t(27)=2.324$, $p=0.028$. The detrimental cognitive consequences of sleep restriction, however, did not extend to working memory or fluid intelligence tasks (*p*s > .10; as predicted for fluid intelligence, but contrary to our prediction for working memory).

Variable	Normal Sleep (n=16)	Restricted Sleep (n=13)	Condition Main Effect
RAPM Total Correct	11.63(2.42)	11.54(3.31)	t(27)= -0.081, p=0.936
Reading Span Score	16.69(8.99)	16.38(7.91)	t(27)= -0.095, p=0.925
Reading Span Total	23.19(5.64)	23.15(4.49)	t(27)= -0.017, p=0.986
PVT Accuracy	81.81(3.12)	81.62(3.45)	t(27)= -0.161, p=0.873
PVT Reaction Times	287.49(33.39)	308.77(37.87)	t(27)=1.607, p=0.12
PVT Lapses	1.19(1.42)	2.69(2.06)	t(27)=2.324, p=0.028*

Table 3. Session 2 cognitive measure outcomes between sleep conditions. Excludes those who did not strictly adhere to sleep manipulation and Black participants (n=29).

In addition to lapses in sustaining attention, sleep restriction had pronounced detrimental effects on mood and sleepiness. Figure 4 illustrates that participants reported greater levels of sleepiness in the restricted sleep condition than the normal sleep condition, $t(27)=5.33$, $p<0.001$. Similarly, sleep restriction increased the level of mood disturbance (POMS) relative to the normal sleep condition, $t(27) = 2.51$, $p=0.018$.

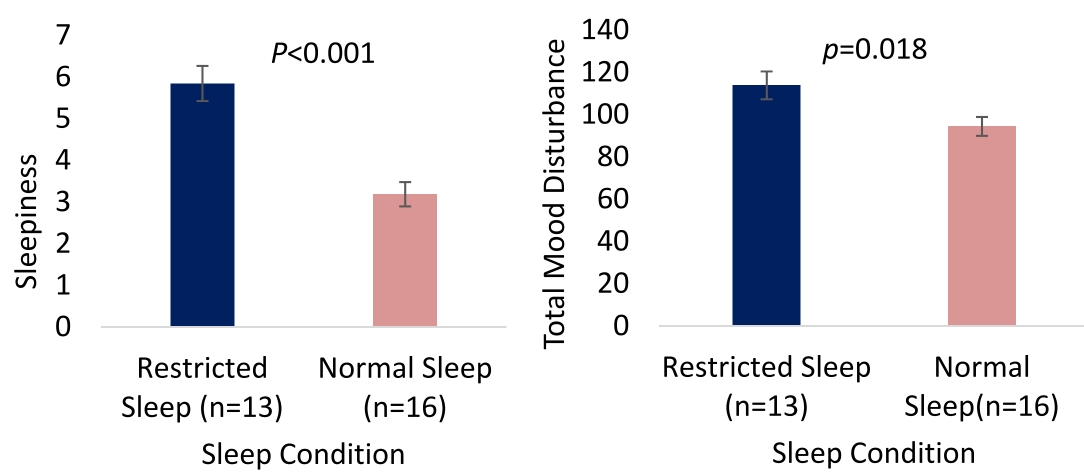

Figure 4. Subjective level of sleepiness and mood disturbance between the two conditions at Session 2. The conditions did not differ at the Session 1 baseline (see Table 1).

The discrimination outcomes were broken down into four different tasks: Medical Error, Charity, Resume, and Police Officer's Dilemma. For the medical error task, we created two composite scores for each race. The Mistake Evaluation composite score consisted of ratings of the seriousness of the mistake, physician punishment, level of compassion toward the physician, patient compensation, and mistake incompetence. The Physician Evaluation composite included ratings of physician qualities, such as competence, professionalism, medical expertise, quality of care, and thoroughness. There was no difference in evaluation of the physician between sleep conditions (ps > 0.10) However, Figure 5 illustrates that participants gave harsher ratings for the mistake evaluation following sleep restriction than normal sleep for both the White physician, $t(26) = -3.56$, $p=0.001$) and Black physician, $t(26) = -2.97$, $p=0.006$). In Figure 5, the sample size is 28 because we excluded non-adherents, Black participants, and the participant who did not complete the survey.

In the Charity Rating task, we examined composite scores for the charity and the webpage. The charity composite included ratings of how well the event would do and how successful the fundraiser would be. The webpage composite consisted of ratings of the professionalism and efficacy of the webpage advertisement. An overall composite score combined the charity and webpage composite with the amount participants were willing to donate. Ratings were significantly lower in the overall overweight scenario than in the thin scenario, $F(1,30)=11.85$, $MSE=0.375$, $p=0.002$. Interestingly, when we divided the sample by gender, female participants tended to have harsher overall ratings in the overweight scenario, $F(1,20)=6.91$, $MSE=0.387$, $p=0.016$. However, none of the composite scores to the overweight or other scenarios were significantly affected by sleep restriction (all *p*s > .10).

For the Resume Rating Task, we created composite scores for Skills and General for each variable. The Skills composite included the ratings of how qualified, successful, strong, and good the candidate was. The General composite score consisted of ratings of how much the participant liked the candidate and how willing they were to hire them. The data for the general composite score are illustrated in Figure 6. The data for the skills composite score reflected similar trends as the general composite score. The sample size for Figure 6 included Black participants but excluded non-adherents. Ratings did not differ across White Male and Arab Male conditions, or interact with the sleep manipulation (*p*s >.10). However, interestingly, sleep-restricted participants gave harsher ratings toward the female applicant in general than normal sleep participants, $t(29) = -2.24$, $p = 0.033$. When we divided the sample by gender, female participants in the sleep restricted condition significantly rated the female applicant more harshly than the normal sleep condition, $t(19) = -2.30$, $p = 0.033$. There was no difference between conditions for male participants, $p > 0.1$.

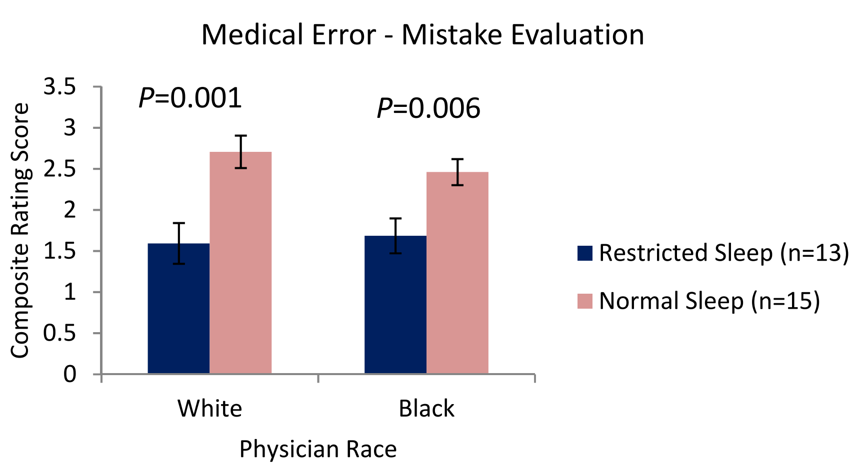

Figure 5. Main findings from Medical Error Task.

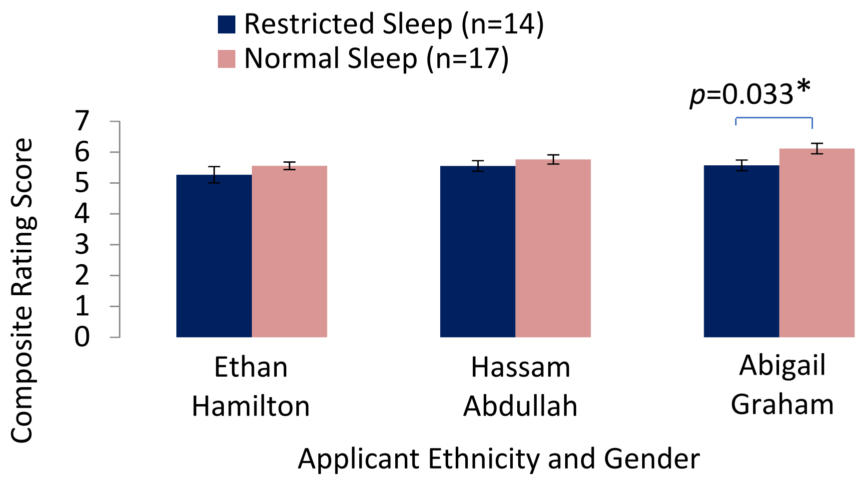

Figure 6. Main findings from Resume Task.

To analyze the Police Officer's Dilemma Task we separated accuracy, reaction times, and total number of shots. Though accuracy was not related to condition (*p*s > .10), when examining reaction times using repeated measures ANOVA, there was a trend for a three-way interaction between race (black, white), object (armed vs. unarmed), and sleep condition, $F(1, 26) = 4.20$, $MSE = 820.036$, $p = 0.051$. The data are shown in Figure 7. The sample size in Figure 7 has one less participant in the restricted sleep condition due to one participant having no data for one of the variables (i.e., they did not incorrectly shoot an unarmed Black stimuli throughout the entire task). The three-way interaction seemed to emerge because sleep restricted participants responded more quickly to White unarmed stimuli and Black armed stimuli, but follow-up tests of those comparisons were nonsignificant (*p*s > .05).

Next, we used signal detection analysis methods where we identified all shots fired regardless of accuracy (True Positive + False Positive = Predicted Condition Positive). A repeated measures ANOVA yielded a significant interaction between race and sleep condition with total shots fired, $F(1,27)=6.56$, $MSE=12.98$, $p= 0.034$) shown in

Figure 8. The sleep restricted condition fired more total shots at White stimuli compared to the normal sleep condition, an interesting result that is counter to traditional bias. Shots fired at Black stimuli did not significantly differ between sleep conditions. The same signal detection analysis revealed that, regardless of sleep condition, there were significantly more shots fired at Black stimuli than White stimuli, $F(1,28)=3105.71$, $MSE=20.15$, $p=0.014$), a result that is displayed in Figure 9.

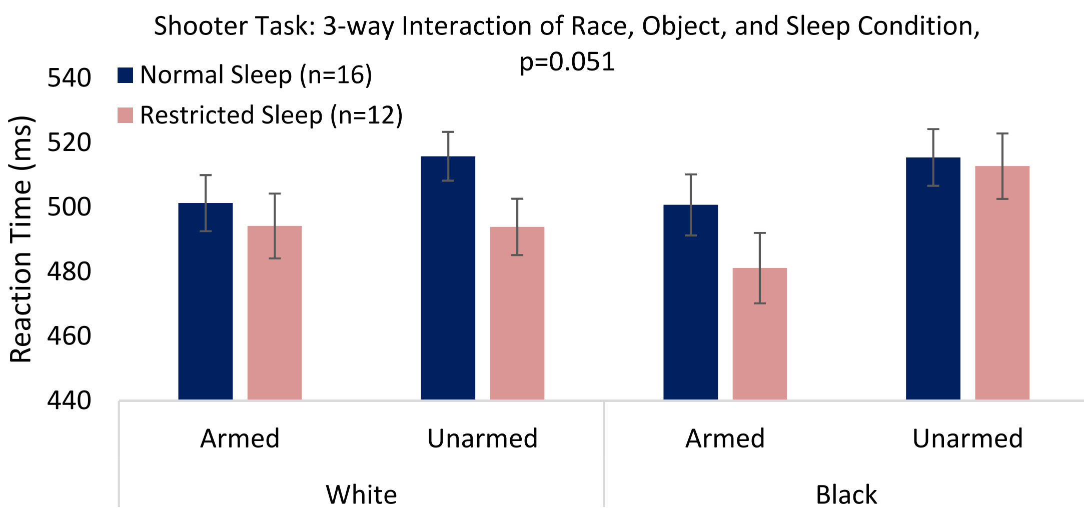

Figure 7. Repeated measures ANOVA showing a 3-way interaction in the Police Officer's Dilemma Task.

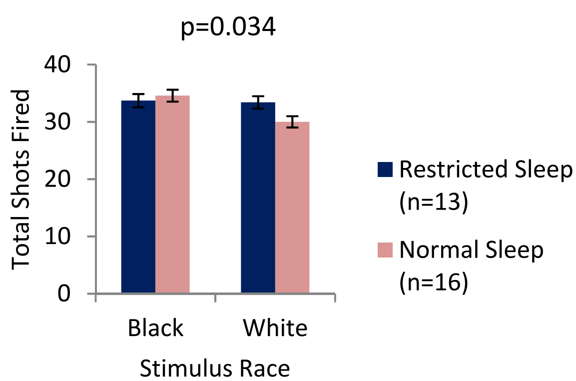

Figure 8. Repeated measures ANOVA showing an interaction between race and sleep condition in total shots fired.

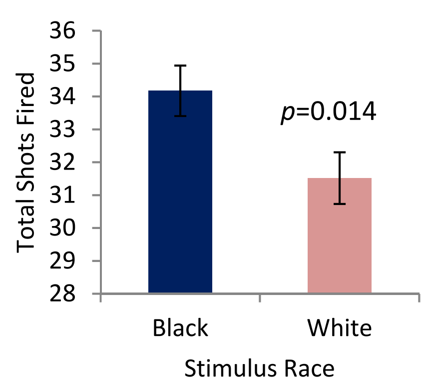

Figure 9. Repeated measures ANOVA showing the difference in total shots fired at Black vs. White stimuli, n=29

Data Analysis

In the analysis of the Medical Error task, increased negative ratings in the sleep restricted condition was mediated by the increased mood disturbance due to lack of sleep (significance disappeared after controlling for mood disturbance). Because we see the same result reflected across both races, there was not a racial bias as expected. Thus, we can conclude that negative mood may cause someone to impose harsher judgment than when the same person is well-rested regardless of race.

The charity task results showed no relationship with sleep restriction and obesity discrimination among the individual composite scores. However, the overall bias suggests that obesity discrimination exists beyond sleep. In addition, the overall bias continues to persist specifically among female participants. The results for the charity task indicate that participants will more negatively rate the overall success of a fundraiser and professionalism and efficacy of an advertisement if the representative is obese. Furthermore, they will also donate less money to the fundraiser if the representative is obese.

The negative rating of the female applicant between sleep conditions indicates harsher judgment of female applicants when one is sleep-deprived. When we divided the sample by gender to see if the results differed, the effect increased for female participants. In other words, female participants judged female applicants even more negatively when they were sleep-deprived than when they were well rested. In terms of the composite score, it means that female applicants are less likely to be liked and hired by employers if the employers are lacking sleep.

To further elucidate the findings of the PODT, the signal detection analyses looked at total shots fired, regardless of reaction time or accuracy. There was an interesting interaction with race and total shots fired, likely driven by the significant difference between sleep conditions regarding the White stimuli. Participants fired more shots at the White stimuli when sleep restricted compared to well-rested. Yet, the overall total shots regardless of condition (Figure 9) revealed that more shots are fired at Black stimuli in general. In terms of the resource depletion theory of prejudice, the deficit in attention as indicated by the PVT results could have contributed to the increased shots fired at Black stimuli compared to White.

CHAPTER FOUR

Discussion

General Discussion

Restricting someone's sleep results in a more negative reaction toward others. Not only are people moodier after sleep restriction, but they also are more willing to punish others for their mistakes (medical error rating task). However, the sleep-loss-induced negative reactions did not always correspond with predictions of prejudice (e.g., race, ethnicity, gender). In the following sections, we will consider under which contexts sleep restriction affects cognition, mood, and potentially ultimately, discriminatory behavior.

Contrary to our expectation, sleep restriction had limited effects on cognitive functioning. Though sleep restriction is not expected to impair intelligence, it is predicted to impair working memory (King et al., 2017). The lack of a negative effect of sleep restriction on working memory suggests that participants either were not resource depleted or that they compensated adequately for their resource depletion (e.g., with increased motivation). On the one hand, it limits the application of the resource depletion theory and executive control impairment as rationale to predict sleep-restriction-induced discrimination. Yet, the sleep restriction condition showed more than double the number of attention lapses in the PVT, which is a measure of sustained attentional resources. That tells us that participants were attempting to compensate for their sleep loss, but still showed lapses in their ability to do so. Furthermore, because attention is critical in daily life, whether it is in the classroom or out in the field, the finding of attention lapses in itself draws attention to the many potential repercussions of sleep restriction.

Sleep restriction may impair mood to an even larger degree than cognition (Pilcher & Huffcutt, 1996). Particularly with the Medical Error task, the lack of discrimination between the races of the physicians indicated a negative reaction in general, likely mediated by greater mood disturbance in the restricted sleep condition. It confirms the common sense acknowledgement that when one is moody, they are not the nicest person to the people around them. Whether the increase in mood disturbance is due to a decrease in top-down control of emotions after sleep restriction needs to be determined; but, if so, then the effect of sleep restriction on emotional control has negative repercussions regarding socializing and potential for perceived discriminatory behavior.

Our finding that individuals who are sleeping fewer than 6 hours/night rate medical errors more harshly has several implications. For example, a sleep deprived patient seems less forgiving of medical errors, and therefore, physicians who commit errors may face increased legal action if their patients are sleep-deprived. Given that illness is not often conducive toward sleep quality both physically and mentally, the risk of having a sleep-deprived patient is substantial.

Our findings also have implications for gender bias in the work force. Sleep restriction had no effect on ratings of male candidates (regardless of race), but it did detrimentally affect the female candidate. Thus, females still face obstacles when it comes to competing for jobs when potential employers are sleep-deprived (even when—or especially when—the person doing the hiring is also a female).

Lastly, the Police Officer's Dilemma Task touches on a sensitive issue in modern society. The faster response to Black armed stimuli between sleep conditions corresponds with existing biases seen in real world encounters. However, the faster reactions toward White unarmed stimuli between sleep conditions seem to contradict the traditional biases. When looking simply at the number of shots fired, there was a clear distinction between races: More shots fired at black persons than white persons. The finding that the shot is fired more often with Black people, regardless of accuracy, indicates a bias in taking that shot. The story, however, becomes more complicated when examining sleep restriction. Sleep restriction did not affect firing rates to black persons; but, sleep restricted individuals were more likely to fire shots at white persons. Though this pattern does not implicate sleep restriction in race-based discrimination, it does suggest a role for sleep restriction in increasing risk for violent responses.

Overall, sleep restriction leads to more negative reactions in our results. However, other factors make a difference if one is actively trying to not discriminate. We previously mentioned the idea of impression management, and it is possible that some of our results that were counter to the expected bias could be explained by an awareness of current biases and an active effort to not discriminate. Furthermore, the unexpected biases toward White stimuli in the PODT could reflect an overcompensation of impression management. On a lighter note, it may then be possible to generally overcome – or at least moderate – biased behavior with awareness and an active desire to not discriminate. Furthermore, other techniques have shown to reduce long-term biases, such as using targeted memory reactivation during sleep in conjunction with counter-stereotype training (Hu et al., 2015). Our results suggest that sleep restriction may necessitate a more active effort to overcome factors such as mood disturbance in one’s efforts to manage behavior.

Limitations

Adherence is a challenge when conducting a sleep restriction manipulation outside of a controlled sleep laboratory. At the end of Session 1, we emphasized the ability of the actigraphy device to monitor their bed times and wake times with high levels of accuracy in order to encourage adherence. Although the majority of the sample did adhere (>70%), several participants reported that it was difficult for them to go to bed early (in the Normal Control condition) due to difficulty falling asleep or too much homework. However, in previous in-lab sleep studies using polysomnography, participants were able to fall asleep beginning at 10:00 PM.

Another limitation of the study was the use of actigraphy rather than the gold-standard of sleep measurement: polysomnography (PSG). An in-lab study using PSG would have allowed for maximum control of bed and wake times and therefore eliminated the issue with adherence. However, using actigraphy allowed for the feasible collection of data from a greater number of participants and eliminated any sleep variation due to the discomfort of adjusting to an in-lab environment. It also allowed for a longer sleep manipulation, so they were assigned their sleep condition for four consecutive nights and therefore allowing time for the sleep restricted condition to build up sleep debt and for the normal control condition to catch up on sleep.

A potential limitation of the discrimination portion of the experiment was the lack of baseline measurement at Session 1. Without a baseline, we could not determine how much of the discrimination outcomes in the Session 2 session were due to varying levels of initial bias in addition to the sleep manipulation. However, the random assignment of participants into each condition should have accounted for any outstanding differences in the beginning, as it did with all other measures. Furthermore, with discrimination research it is imperative that the participant is not fully aware of the intent of the study, for they may not provide honest answers due to concern of the experimenter seeing their responses. Due to the nature of the discrimination tasks, providing a baseline measurement at Session 1 would have increased the chance of participants discerning the true purpose of the experiment and thus result in dishonest answers and nullifying the sleep manipulation. For that reason, we relied on random assignment to alleviate any differences in initial bias between the two conditions.

Conclusion

Less sleep means more negative reactions, both in general as well as directed toward a particular gender or race. The current study served as a first investigation into experimental sleep restriction and discriminatory behavior. Our data indicate that future research should focus on how sleep restriction impacts gender biases in the work force, ratings of physician medical errors, and gun violence toward White and Black individuals. If poor sleep continues to be a culprit in incurring discriminatory behaviors, then correcting sleep behaviorally, pharmacologically, and culturally will help society toward reaching the greater goal of equality.

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