

THE ASSOCIATION BETWEEN CHRONOTYPE AND
NONRESTORATIVE SLEEP

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ABSTRACT

Nonrestorative sleep (NRS), characterized by a lack of refreshment upon awakening, has received little attention in the sleep literature even though it can occur and cause impairment apart from other sleep difficulties associated with insomnia. The Restorative Sleep Questionnaire (RSQ; Drake et al., 2014) is one of the first validated self-report instruments for investigating NRS severity, presenting new opportunities to explore what factors predict and perhaps contribute to unrefreshing sleep. The present study sought to determine whether inherent circadian preference for morning or evening activity, known as chronotype, predicted restorative sleep in 164 college undergraduates who completed daily RSQs over two weeks. Participants who endorsed greater orientation to evening activity on the morningness-eveningness questionnaire (Terman, Rifkin, Jacobs, & White, 2001) reported significantly less average restorative sleep across their full sampling period, and this association was maintained after accounting for demographic factors, number of sleep-relevant psychiatric and medical diagnoses, sleep diary parameters, self-reported status as an insomniac, and ratings of sleep quality. Furthermore, when analyses were conducted separately for weekday and weekend RSQ scores, eveningness significantly predicted NRS above extraneous variables only during the workweek, not during Saturday and Sunday. These findings have implications for the developing conceptualization of NRS, and continue the work of elucidating the interconnections between common sleep disturbances and the circadian system.

DEDICATION

This thesis is dedicated to my mother, Sara Exposito, who continually offered me her encouragement, prayer, and love during the formulation of the project, even in the midst of her own struggles.

LIST OF ABBREVIATIONS AND SYMBOLS

- B Unstandardized regression coefficient: the proportion of unit change in an outcome variable associated with one raw unit of change in a predictor variable
- β Standardized regression coefficient: the proportion of unit change in an outcome variable associated with one standardized unit of change in a predictor variable
- d Degrees of freedom: the number of values free to vary after certain restrictions have been placed on the data
- F Fisher's F ratio: the ration of variance explained by a model to variance unexplained, taking into account the number of predictors in the model and the sample size
- M Mean: the sum of a set of values divided by the number of values in the set
- N Total number of individual cases
- SD Standard deviation: the extent to which an average individual value deviates from the central tendency of a group of values; a measure of the amount of dispersion among values
- $SE B$ Standard error of the regression coefficient: a measure of the extent to which the sample estimate of the regression coefficient in the model can be assumed to accurately reflect the true, unknown value of the coefficient
- p Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
- r Pearson product-moment correlation: a measure of the degree of association between two variables
- R^2 Squared multiple correlation coefficient: the proportion of the variance in an outcome variable that is collectively accounted for by all predictor variables in a model
- $<$ Less than

$>$ Greater than

$=$ Equal to

\geq Greater than or equal to

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CONTENTS

ABSTRACT	ii
DEDICATION	iii
LIST OF ABBREVIATIONS AND SYMBOLS	iv
ACKNOWLEDGMENTS	vi
LIST OF TABLES	viii
1. INTRODUCTION	1
2. METHOD	7
a. Participants	7
b. Measures	8
c. Procedure	10
3. RESULTS	13
4. DISCUSSION	19
REFERENCES	24
APPENDIX A: IRB Approval	30

LIST OF TABLES

1. Sample Demographic, Sleep, and Health Characteristics.....	13
2. Bivariate Correlations for Study Variables.....	15
3. Hierarchical Block Regression Predicting RSQ-D Score.....	16

CHAPTER 1

Introduction

Approximately 10% of the population experiences sleep problems characteristic of insomnia and consequent impairment in daytime health and functioning (Ohayon, 2002). In the criteria for insomnia disorder, the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; American Psychiatric Association, 2013) describes nonrestorative sleep (NRS), a commonly occurring complaint of poor sleep quality that leaves the individual feeling unrested upon awakening despite adequate sleep duration. NRS occurring in isolation without other sleep difficulties is sufficient for a diagnosis of other specified insomnia disorder, indicating that NRS is viewed as a freestanding component of insomnia.

However, the majority of insomnia research has focused on difficulty initiating or maintaining sleep (Stone, Taylor, McCrae, Kalsekar, & Lichstein, 2008), symptoms that are readily assessable through quantitative sleep parameters recorded using sleep diaries or polysomnography (PSG; Edinger, Ulmer, & Means, 2013; Lichstein, Durrence, Taylor, Bush, & Reidel, 2003). Investigators have even established explicit numeric thresholds for amount of time spent awake in bed that denote pathological levels of difficulty initiating sleep, maintaining sleep, or awakening too early in the morning (American Psychiatric Association, 2013; Lichstein et al., 2003). By contrast, NRS is a subjective experience that cannot be directly observed and quantified via sleep behaviors, and even though it continues to be considered a distinctive feature of insomnia diagnosis, there has been no consensus on a standard definition of NRS among

researchers (Stone et al., 2008; Wilkinson & Shapiro, 2012). This lack of strong characterization is reflected in the dearth of validated assessment instruments aiming to capture NRS symptomology. Vernon, Dugar, Revicki, Treglia, and Buysse (2010) sought to determine which self-report sleep questionnaires contain content related to NRS, operationalized as items prompting for information about an individual's sleep experience (e.g., "sleep quality"), or degree of morning or daytime refreshment. They found no full measures designed to assess NRS specifically. Though several instruments contained one or two items meeting the investigators' criteria for NRS content, Vernon et al. (2010) noted that individual items from a general sleep measure may not adequately encapsulate all of the facets of a complex phenomenon like NRS.

Given the limitations in its conceptualization and measurement, it may be tempting to regard NRS as merely a vaguely defined epiphenomenon of other sleep or health disturbances. NRS is indeed more common among those with sleep onset and maintenance insomnia, organic sleep disorders, psychiatric disorders, and certain medical illnesses such as fibromyalgia and chronic fatigue syndrome (American Psychiatric Association, 2013; Jackson & Bruck, 2012; Ohayon, 2005; Spaeth, Rizzi, & Sarzi-Puttini, 2011; Stone et al., 2008, Unger et al., 2004). However, this position is contradicted by findings that NRS complaints occur even in otherwise healthy individuals without a disturbed sleep pattern, as confirmed by both sleep diaries (Ohayon & Roth, 2001) and PSG (Roth et al., 2010). Data from the National Comorbidity Study suggest that 7% of people with insomnia report NRS in the absence of other sleep symptoms (Roth et al., 2006). Furthermore, in a large phone-based prevalence study (Ohayon, 2005), people with only an NRS complaint more frequently reported daytime impairment (irritability, as well as physical and mental fatigue) than those with either difficulty initiating or difficulty maintaining sleep occurring alone. Participants with isolated NRS symptoms also consulted a physician about their

sleep twice as often as those with only sleep initiation or maintenance problems. This not only suggests that NRS can exist independently of other sleep issues, but also that it may be a more pertinent target for intervention, making the need to establish a uniform scientific definition and valid means of assessing NRS all the more pressing.

Recently, Drake et al. (2014) published a self-report measure aiming to assess subjective NRS severity, defining NRS as a “feeling of being unrefreshed upon awakening regardless of sleep quality and quantity” (p. 734). To guide the development of the Restorative Sleep Questionnaire (RSQ), the investigators initially convened focus groups of normal and “problem” sleepers and panels of sleep researchers to explore different facets of NRS and generate questions for the scale. Subsequent administrations of the finished product confirmed that the RSQ possessed adequate psychometric properties (Drake et al., 2014). Given that NRS can cause distress independently of measurable disturbance in sleep behaviors, and that it has only recently become accessible in the form of a robust self-report measure, new research possibilities abound for identifying factors that may precipitate or perpetuate unrefreshing sleep.

The circadian sleep rhythm, a physiologically regulated propensity for sleep and waking across the 24-h day, may constitute one such influence on NRS. This intrinsic drive to periodically initiate and terminate sleep is evident in numerous bodily processes, including daily oscillations of core body temperature and secretion of the neurohormone melatonin (Benloucif et al., 2005; Lack & Lushington, 1996; Lewy, Cutler, & Sack, 1999). Individuals vary in terms of their endogenous circadian preference for the timing of sleep and wakefulness, falling along a continuum from strong inclination for evening activity to strong inclination for morning activity. This largely innate and stable disposition is known as chronotype. “Evening types” experience peak physical and mental performance in the evening, and are comparably tired and inactive at

the beginning of the day. “Morning types” conversely thrive during the early hours, gradually losing energy until they experience a nadir in alertness and performance during the night. Accordingly, evening types consistently prefer to go to bed and awaken late and morning types prefer to go to bed and awaken early with respect to the timetable of the external environment (Adan et al., 2012; Duffy et al., 1999; Kerkhof & Van Dongen, 1996; Taillard, Philip, Bioulac, Chastang, & Diefenbach, 2001; Wittmann, Dinich, Mellow, & Roenneberg, T., 2006).

Evening chronotype has been linked to a range of psychiatric and medical health problems, cognitive performance deficits, and maladaptive behaviors (Adan, Natale, Caci, & Prat, 2010; Fernández-Mendoza et al., 2010; Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002; Goldstein, Hahn, Hasher, Wiprzycka, & Zelazo, 2007; Kitamura et al., 2010; Lemoine, Zaweija, & Ohayon, 2013; Merikanto et al., 2013; Urbán, Magyaródi, & Rigó, 2011). Much of this research has focused on adolescent and college-aged populations, as this demographic is prone to eveningness and may be especially vulnerable to functional impairment as a result of it (Adan et al., 2012; Carskadon, 1990). Evening types’ heightened vulnerability to an array of difficulties is believed to arise from societal expectations that individuals achieve maximal alertness and productivity in most social and occupational roles from morning until early evening. Those who favor nighttime activity must therefore endure greater desynchrony between their natural sleep preferences and socially imposed sleep schedules (termed “social jet lag”), leading to increased tiredness and impairment during the day (Wittmann et al., 2006). Several studies have indeed suggested that daytime sleepiness or fatigue are more common among evening types, although the observed associations are not always significant (Chung & Cheung, 2008; Soehner, Kennedy, & Monk, 2011; Taylor, Clay, Bramoweth, Sethi, & Roane, 2011; Tzischinsky & Shochat, 2011). Evening types have also been found to be more likely to suffer from sleep initiation difficulties

and morning sleepiness (Taillard et al., 2001), to endorse dysfunctional beliefs about their sleep (Adan, Fabbri, Natale, & Prat, 2006), and to report suffering from insomnia (Merikanto et al., 2012).

It is reasonable to expect that evening types might also experience their previous sleep bout as less restorative. All items on the RSQ query about participants' feelings shortly after they awaken in the morning and start their day (Drake et al., 2014), a time when evening types may struggle most against their personal sleep preferences in order to begin functioning in their various responsibilities. This could be a particularly salient issue for college-aged youths, who are learning to conform their sleep-wake routine to academic and extracurricular schedules in the absence of parental control. At least one study found that evening type college students were significantly more likely than neutral or morning types to identify as nonrestorative sleepers, although presence of NRS was determined using only a single self-developed item (Fernández-Mendoza et al., 2010). Moreover, the relation between eveningness and NRS was stronger than that between chronotype and any other measured sleep difficulty. There is a need to replicate this association using a validated NRS measure that comprehensively evaluates the construct.

The present study investigated chronotype's association with NRS, as measured using the newly validated RSQ, in a sample of college undergraduate students who continuously reported on their restorative sleep upon waking for two weeks. Because evening orientation has been associated with a variety of health and sleep detriments in past research, it was hypothesized that greater eveningness on the well-established Morningness-Eveningness Questionnaire (MEQ; Horne & Östberg, 1976; Terman, Rifkin, Jacobs, & White, 2001) would predict lower restorative sleep on the RSQ. The author also examined chronotype's relation to NRS after accounting for extraneous factors, including demographics, number of physical and mental health diagnoses,

and quantitative sleep impairment. Moreover, given evidence that individuals who merely perceive themselves as insomniacs may experience greater fatigue and distress regardless of actual health problems or pathological sleep parameters (Ustinov et al., 2010), and because conceptualizations of NRS have historically been conflated with sleep quality in the literature (Stone et al., 2008; Vernon et al., 2010), this study sought to confirm that chronotype correlates with NRS independently of subjective self-reported insomnia status and sleep quality ratings. The association between MEQ and RSQ was predicted to endure after controlling for the influence of all such covariates. Finally, data were analyzed separately for weekday and weekend RSQs to investigate potential differences in the nature of chronotype's relation to NRS between days on which students must adhere to a class schedule and days in which they are presumably more free to pursue their own preferred sleep-wake routine. The association was predicted to be stronger on weekdays than on weekends.

CHAPTER 2

Method

Participants

The research sample consisted of undergraduate students participating in the study to fulfill psychology coursework requirements at the University of Alabama. Preliminary power analysis revealed that approximately 150 cases would be required to detect a correlation between MEQ and RSQ scores of moderate effect size, given the number of variables examined in the primary analysis and assuming an alpha level of .05 (Faul, Erdfelder, Buchner, & Lang, 2009). To be eligible for the study, students needed to be at least 17 years old; report no recent experience of major life events impacting sleep; possess no current diagnosis of breathing-related sleep disorder, narcolepsy, parasomnia, restless legs syndrome, or substance/medication-induced sleep disorder; and report no use of recreational drugs (other than marijuana), sedative-hypnotic medications, or other medications reported by Schweitzer (2010) as disturbing to sleep (e.g., antidepressants and antipsychotics, cardiovascular drugs, certain antihistamines). Participants who did not respond correctly to either of two validity questions interspersed with the items of the demographic and health survey (“I would like to receive credit for this study”; “Do you attend the University of Alabama?”) were screened out as well. Finally, students were excluded if they reported participating in regular nighttime shiftwork, which has been associated with both increased circadian dysregulation (Burch, Yost, Johnson, & Allen, 2005) and NRS (Ohayon & Roth, 2001).

Measures

Demographic and Health Survey. An investigator-designed survey form was used to collect demographic information, including gender (coded as 0 for male and 1 for female for analyses), age, race, height, weight, drug or medication use, and whether the respondent's occupation requires shiftwork. As a simple health assessment, individuals were also prompted to list all current sleep, medical, and mental health diagnoses they had received from a health professional. Sleep disorder diagnoses that participants listed were used for screening purposes. Each reported medical diagnosis and mental health diagnosis not classified as a sleep disorder in the *DSM-5* (American Psychiatric Association, 2013) was weighted from 1 to 3 points according to the degree of impairment the participant believed that it caused to his or her sleep (Not impairing or mildly impairing; Moderately impairing; Severely impairing). Weights of individual diagnoses within the mental health and medical domains were then summed together for each category, yielding two variables estimating the severity of sleep-relevant health issues. Finally, the survey form assessed participants' self-identification as insomniac using the following single item: "I am an insomniac" (Strongly disagree; Disagree; Undecided; Agree; Strongly agree). Responses were coded as scores of 1, 2, 3, 4, and 5 respectively.

Sleep Diaries. Participants completed the Consensus Sleep Diary-Core (CSD-C; Carney et al., 2012) each day for two weeks to yield averaged estimates of typical sleep period parameters. The CSD-C was developed by insomnia experts in collaboration with focus groups of disordered and healthy sleepers to provide a standard, minimally sufficient set of items for sleep diary-based research. Information collected by the CSD-C includes sleep onset latency (SOL) and wake time after sleep onset (WASO), and allows for the computation of several other conventional indexes of quantitative sleep impairment such as latency between final awakening

and rising from bed (terminal wake time; TWAK), total sleep time (TST), and sleep efficiency (SE; the percentage of time in bed that is spent sleeping). The diary also asks participants to rate the quality of their prior sleep period on a 5-point scale (Very poor; Poor; Fair; Good; Very good). To account for daytime sleep, the CSD-C was slightly modified in the present study to prompt for the amount of time spent napping during the day (NAP).

Morningness-Eveningness Questionnaire. Though there are several assessment tools used to investigate chronotype, the MEQ (Horne & Östberg, 1976) was the first self-report instrument developed for this purpose and it continues to be the most widely used measure (Adan et al., 2012). The MEQ has strong internal consistency and retest stability over a 2-month period (Adan & Natale, 2002; Chelminski, Ferraro, Petros, & Plaud, 1997; Neubauer, 1992). Scores on the MEQ are also reliably correlated with autonomic biomarkers of endogenous circadian phase, even after accounting for bed times and wake times (Duffy, Dijk, Hall, & Czeisler, 1999; Kerkhof & Van Dongen, 1996; Griefahn, Künemund, Golka, Thier, & Degen, 2002).

Circadian preferences for sleep and activity were assessed using an updated version of the original MEQ. Terman et al. (2001) rephrased question stems and item choices from Horne and Östberg's (1976) instrument in order to conform to contemporary American vernacular. Additionally, continuous graphic scales were replaced by discrete item choices for some questions. Terman et al.'s (2001) MEQ otherwise retains the same content and scoring of the 19 items from the original measure. This newer version of the MEQ also displays the point values corresponding to response choices for each item so that participants can calculate their own total score after completing the questionnaire. These point values were omitted from the form administered to participants in this study. Total scores on the MEQ range from 16 to 86, with

higher scores indicating greater morningness orientation and lower scores indicating greater eveningness.

There are specified ranges of scores on the MEQ to categorize individuals into five circadian types: definitely morning, moderately morning, neither type, moderately evening, and definitely evening (Horne & Östberg, 1976; Terman et al., 2001). For the purposes of the current study, chronotype was treated as a continuous variable based on participants' raw score, rather than relying on these discrete categorical labels.

Restorative Sleep Questionnaire. The RSQ comprises nine items focusing on states in the period shortly following wake time (e.g., tiredness, refreshment, mental alertness). Administrations of the RSQ in three samples found that the measure has excellent internal consistency, retest reliability, and convergent and divergent validity with related constructs. Additionally, it can adequately distinguish between healthy sleeping individuals, patients with insomnia, and insomnia patients with NRS in the absence of PSG-defined sleep problems (Drake et al., 2014). There are two versions of the instrument: a form completed on a daily basis (RSQ-D), and a form that prompts individuals to consider how they felt when waking up over the past 7 days (RSQ-W). Participants repeatedly completed the daily version of the form over two weeks to compute an average score of NRS severity. Total scores on the RSQ-D are calculated by taking the average of the completed questionnaire items, subtracting one, and multiplying the answer by 25. Scores range from 0 to 100, with higher scores indicating more restorative sleep.

Procedure

Undergraduate students enrolled in introductory psychology courses viewed a brief description of the study posted on the psychology subject pool website. Interested parties clicked on a link to an information page detailing study procedures and confidentiality. After participants

typed their name and email address on the form and submitted it to the researchers to signify their consent to participate, they were assigned personal ID numbers for use throughout the study. Participants were then emailed a link to a secure web portal used to administer study materials, where they logged in with their ID number and email address to complete the demographic and health survey and the MEQ online at a time of their choosing. Once participants had submitted their completed measures, those who did not meet eligibility criteria based on the information they provided in their demographic survey were screened out of the study, receiving course credit for their participation. Those who did meet criteria were transferred into the second phase of the study. They received an email informing them that they would begin completing the RSQ-D and CSD-C each day upon awakening over a two-week sampling period, beginning at a date specified in the message. Participants were scheduled to begin completing their daily measures no later than a week after they had submitted their demographic survey and MEQ. Two weeks of sleep parameter data were collected because multiple sleep diary recordings are often necessary to account for daily fluctuations in sleep timing or amount, and in some cases sleep parameters must be examined for two to three weeks to ensure acceptable temporal stability of an individual's sleep profile (Wohlgemuth, Edinger, Fin, & Sullivan, 1999). Multiple RSQ assessments were similarly collected in order to account for potential variation in restorative sleep across time.

For 14 days beginning at the start of their scheduled sampling period, students received automated daily emails at 9:00 a.m. reminding them to complete measures for their previous sleep bout and awakening. The emails contained a link to the web portal hosting online versions of the RSQ-D and sleep diary. Participants were free to log in to the portal to complete their measures earlier in the morning before receiving the email reminder. Submitted diaries were

automatically checked for omitted or incongruous responses to ensure that they were completed correctly, and both questionnaires were time-stamped to reveal whether they have been completed at the appropriate date and time. Although participants were encouraged to fill out their measures as soon as possible after waking, responses received by 11:59 p.m. of the target day were accepted. Participants needed to complete at least 10 days worth of both the RSQ-D and CSD-C during their sampling to receive course credit at the end of the period, or they were dropped from the study. This ensured that all individuals included in the final analysis had provided 10 to 14 days of data to compute average sleep parameter, sleep quality, and restorative sleep estimates. However, participants submitted the two measures independently of one another, meaning that on occasion they would only submit one of them for a day and thus not have perfect one-to-one correspondence for the full two weeks. Participants continuously entered and circulated through the study throughout the fall 2015 academic semester. After data collection ended, all data were transferred from the online web portal into SPSS (version 23.0) for statistical analysis.

CHAPTER 3

Results

A total of 303 students signed up for the study on the subject pool website and completed the demographic survey and MEQ. Based on their submitted responses, 76 participants were screened out because they did not meet eligibility criteria. Accordingly, 227 participants were transferred into the second part of the study in which they completed the RSQ-D and CSD-C over two weeks. An additional 63 individuals failed to complete both measures for at least 10 days during their sampling and were dropped from the study. The final analyzed sample thus comprised 164 students. Table 1 summarizes sample demographic, sleep pattern, and health characteristics.

Table 1

Sample Demographic, Sleep, and Health Characteristics

Variables	<i>N</i>	<i>%</i>
Gender		
Male	36	22.0
Female	128	78.0
Race		
White	147	89.6
Black	8	4.9
Latino	6	3.7
Asian	2	1.2
Multiracial	1	0.6
Participants with Health Diagnoses		
≥1 Medical Diagnoses	11	6.7

≥1 Mental Health Diagnoses	5	3.0
	<i>M</i>	<i>SD</i>
Age (years)	18.50	0.93
BMI	23.98	7.37
Sleep Parameters (minutes)		
SOL	23.47	19.64
WASO	10.20	12.19
TWAK	25.74	26.68
TST	464.96	54.44
NAP	20.22	32.29
SE (% time in bed sleeping)	89.40	6.46
Insomniac Status (5-point scale)	1.81	0.91
Sleep Quality (5-point scale)	3.70	0.60

Note: Medical/Mental Health Diagnoses = number of participants who reported having received at least one medical or mental health diagnosis from a health professional; BMI = body mass index; SOL = sleep onset latency; WASO = wake time after sleep onset; TWAK = terminal wake time; TST = total sleep time; NAP = daytime napping; SE = sleep efficiency.

Overall, the sample's distribution of scores on the MEQ ($M = 46.41$, $SD = 8.09$) and RSQ-D ($M = 54.79$, $SD = 13.84$) were fairly consistent with median values for the two scales (51 and 50 respectively) and reflected what might be expected in a normative young adult population. Students' mean MEQ was somewhat skewed toward eveningness, which is consistent with findings that eveningness is most pronounced in late adolescence (Adan et al., 2012). The bivariate relationships among all study variables were examined and are displayed in Table 2. In keeping with hypotheses, lower MEQ (denoting greater circadian preference for evening activity) was significantly correlated with lower average RSQ-D ($r = .31$, $p < .001$). Only average sleep quality rating demonstrated a stronger zero-order correlation with RSQ-D than MEQ ($r = .56$, $p < .001$). However, lower sleep quality was also linked to higher SOL ($r = -.27$, $p < .01$), higher WASO ($r = -.24$, $p < .01$), and lower sleep efficiency ($r = .25$, $p < .01$) recorded via sleep diaries, whereas RSQ-D score only showed a negative association with the

daytime napping diary parameter ($r = -.18, p < .05$). Furthermore, sleep quality was not significantly related to chronotype ($r = .15, p > .05$).

Table 2

Bivariate Correlations for Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. RSQ-D	--														
2. Age	.05	--													
3. Gender	-.25**	-.22**	--												
4. BMI	.10	.01	.02	--											
5. Medical Diagnoses	-.06	-.09	.13	.00	--										
6. Mental Health Diagnoses	-.16*	-.09	.09	-.11	.46***	--									
7. SOL	-.02	-.11	.15	.06	.05	.01	--								
8. WASO	-.03	-.03	.19*	-.02	.04	.06	.57***	--							
9. TWAK	.04	.14	.07	.04	.01	-.01	.20*	.16*	--						
10. TST	.13	-.09	.05	-.03	-.02	-.02	-.08	-.18*	-.19*	--					
11. SE	.04	-.04	-.17*	-.05	-.05	-.05	-.72***	-.70***	-.68***	.35***	--				
12. NAP	-.18*	-.01	.09	-.03	.11	.02	.05	.07	-.09	-.22**	-.03	--			
13. Insomniac Status	-.17*	.04	.02	.01	.07	-.02	.13	.07	.02	.06	-.14	.06	--		
14. Sleep Quality	.56***	.03	-.01	.00	.04	-.04	-.27**	-.24**	.01	.15	.25**	-.07	-.37***	--	
15. MEQ	.31***	.16*	-.25**	.03	-.20*	-.09	-.13	-.14	.04	-.02	.10	-.17*	-.15	.15	--

Note: BMI = body mass index; Medical/Mental Health Diagnoses = count of diagnoses received from a health professional, each weighted from 1 to 3 points according to its perceived degree of sleep impairment (Not impairing or mildly impairing; Moderately impairing; Severely impairing); RSQ-D = average restorative sleep questionnaire (daily version) over 10 to 14 days; Body Mass Index = BMI; SOL = sleep onset latency; WASO = wake time after sleep onset; TWAK = terminal wake time; TST = total sleep time; NAP = daytime napping; SE = sleep efficiency, MEQ = morningness-eveningness questionnaire.

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

Hierarchical block regression was subsequently used to isolate the increment in variance uniquely shared by chronotype and NRS. Five consecutively entered sets of covariates were included in the final hierarchical model predicting restorative sleep: Block 1 comprised

demographics, though race was excluded due to an insufficient number of non-White participants in the sample (age, gender, and body mass index; BMI); Block 2 comprised health problems (total counts of medical and mental health diagnoses, each weighted according to how much the participant believed that the diagnosis contributed to poor sleep); Block 3 comprised quantitative sleep parameters (SOL, WASO, TWAK, TST, SE, and NAP); Block 4 comprised participants' self-identification as an insomniac; and Block 5 comprised their average sleep quality rating across their two-week sampling period. MEQ score, the primary predictor of interest, was entered on Block 6.

Table 3 displays cumulative and unique variance accounted for by each successively entered block, as well as the partial regression coefficients for predictors in the final model. All five models achieved significance, but only the demographic, insomniac status, sleep quality, and chronotype blocks added significant increments in outcome variance explained. Confirming predictions, MEQ was significantly related to RSQ after accounting for all previously entered covariates, $\Delta R^2 = .03, p < .01$. In the final hierarchical model, $R^2 = .48, F(14, 149) = 9.80, p < .001$, gender ($\beta = -.24, p < .001$), sleep quality ($\beta = .60, p < .001$), and chronotype ($\beta = .18, p < .01$) significantly predicted RSQ score. Female gender, poorer sleep quality, and greater eveningness were associated with less restorative sleep. Notably, quantitative sleep variables did not produce any significant associations with the outcome in the final model.

Table 3

Hierarchical Block Regression Predicting RSQ-D Score

Variables	ΣR^2	ΔR^2	<i>B</i>	<i>SE B</i>	β
Block 1 - Demographics	.07**	.07**			
Gender			-8.06	2.13	-.24***
Age			-.67	.94	-.05

BMI			.15	0.11	.08
Block 2 - Health Diagnoses	.09**	.02			
Medical Diagnoses			.53	1.6	.02
Mental Health Diagnoses			-3.70	2.26	-0.11
Block 3 - Sleep Parameters	.14*	.05			
SOL			.07	.09	.11
WASO			.13	.13	.12
TWAK			-.01	.08	-.02
TST			.02	.02	.07
NAP			-.04	.03	-.09
SE			-.09	.56	-.04
Block 4 - Insomniac Status	.17**	.03*	.75	1.02	.05
Block 5 - Sleep Quality	.45***	.29***	13.74	1.58	.60***
Block 6 - MEQ	.48***	.03**	.31	.11	.18**

Note: B , $SE B$, and β are given for the final model comprising all predictors. BMI = body mass index; Medical/Psychiatric Diagnoses = count of diagnoses received from a health professional, each weighted from 1 to 3 points according to its perceived degree of sleep impairment (Mild; Moderate; Severe); RSQ-D = average restorative sleep questionnaire (daily version) over 10 to 14 days; SOL = sleep onset latency; WASO = wake time after sleep onset; TWAK = terminal wake time; TST = total sleep time; NAP = daytime napping; SE = sleep efficiency, MEQ = morningness-eveningness questionnaire.

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

To explore whether the relation between eveningness and NRS differs for weekdays versus weekends, average RSQ scores were also calculated separately for questionnaires completed on Monday through Friday and for those completed on Saturday and Sunday (timestamps on submitted RSQs indicated the dates on which they had been filled out by students). All participants in the sample completed between 6 and 10 RSQs on weekdays, and between 1 and 4 RSQs on weekends. For the one individual who had only 1 weekend RSQ available, that value was used as the weekend RSQ score in lieu of an average. Weekend and

weekday RSQs were correlated separately with MEQ. As predicted, the correlation between MEQ and RSQ was larger on weekdays ($r = .32, p < .001$) than on weekends ($r = .20, p < .05$). Additionally, two full hierarchical models were used to predict weekend RSQ and weekday RSQ with the same series of variables described above in the analysis of overall average RSQ. Entered on Block 6 after 13 other predictors, MEQ significantly predicted RSQ on weekdays, $\Delta R^2 = .03, p < .01$, but was not significant in the model predicting RSQ on weekends, $\Delta R^2 = .01, p > .05$.

CHAPTER 4

Discussion

Greater eveningness on the MEQ was associated with lower restorative sleep on the RSQ-D. Although the observed relation was of modest size, it remained significant after controlling for 13 covariates comprising demographic information, medical and psychiatric health diagnoses, quantitative sleep pattern, insomnia identity, and sleep quality. The variance shared by chronotype and NRS thus appears to be unique in the context of a wide range of relevant factors. It was particularly impressive that MEQ and RSQ scores were correlated after controlling for sleep quality rating, given that both NRS and sleep quality are evaluative indexes based on the subjective interpretation of the sleeper. As noted previously, past research has often described restorative sleep in terms of sleep quality (Stone et al., 2008; Vernon et al., 2010), and *DSM-5* uses poor sleep quality to define NRS in its diagnostic criteria for insomnia disorder (American Psychiatric Association, 2013). Drake et al.'s (2014) RSQ represents a major departure from these previous conceptualizations of NRS by attempting to capture lack of refreshment from sleep *regardless* of its quality. The sizeable bivariate correlation between the RSQ and sleep quality rating in the present study suggests that there is still substantial overlap between the two constructs. However, RSQ was found to also correlate with chronotype, whereas sleep quality was not. This may illustrate an important point of distinction between Drake et al. (2014)'s formulation of NRS (referring strictly to waketime refreshment) and broader definitions of sleep quality, in that the former is partly a function of circadian processes

that are especially relevant at the start of one's day. By contrast, perhaps the appraisal of sleep's overall quality encompasses other factors, such as difficulty initiating sleep or maintaining sleep during the night (as indicated by sleep quality's observed associations with SOL, WASO and SE). Future research might further explore how the RSQ deviates from traditional conceptualizations of sleep quality, focusing on whether circadian activity preferences or misalignment between physiological and social sleep schedules are differentially meaningful to NRS symptoms.

The positive correlation between evening activity orientation and NRS adds to an already extensive literature linking eveningness to greater impairment across multiple health domains. It also builds upon previous work exploring the interconnections between circadian rhythmicity and sleep impairments associated with insomnia. Though insomnia disorder and circadian rhythm dysregulation are considered distinct problems with different underlying etiologies, it has long been suggested that circadian rhythms play a role in the development of chronic insomnia for at least a portion of cases with sleep onset or early morning awakening difficulties (Lack & Bootzin, 2003). A predisposition for morningness or eveningness also appears to have implications for certain types of insomnia symptomology (Fernández-Mendoza et al., 2010; Soehner, et al., 2011; Taillard et al., 2001). The present study makes progress in this area by linking chronotype to NRS, an elusive dimension of sleep disturbance that up until recently has been largely neglected in the literature, even though it continues to be considered an autonomous component of insomnia disorder (American Psychiatric Association, 2013; Roth et al., 2006). The analyzed sample was comprised of young, primarily healthy participants, but these findings may nevertheless have implications for clinical populations with markedly disturbed sleep, such as insomnia patients who suffer predominantly or exclusively from an NRS complaint.

MEQ uniquely explained RSQ variance on weekdays but not on weekends, which suggests that environmental influences constraining the timing of sleep and activity (e.g., class schedules that operate only during the workweek) are responsible for driving the association between eveningness and NRS. Evening type students thus appear to experience greater NRS than morning types primarily when their schedules are dictated by school demands, compared to when they are left to their intrinsic preferences on the weekends. This is in accord with Wittmann et al.'s (2006) assertion that diminished psychological wellbeing and higher substance consumption among evening types results from heightened social jet lag between biological and social schedules, rather than eveningness per se. To further investigate how work schedules and chronotype combinatively impact restorative sleep, new studies could use the RSQ-D to explore the trajectory of daily NRS across the week in various employment populations (students, nightshift workers, self-employed workers, the unemployed, etc.), while also determining whether participants' day-to-day NRS pattern is moderated by their circadian preference.

Because psychometrically sound assessment of NRS is novel, the observed correlations between RSQ and assessed variables other than MEQ score also provide potentially valuable information about factors that are pertinent to the study of NRS. Men were found to experience significantly more restorative sleep than women, which is consistent with previous epidemiological findings (Ohayon, 2005). Additionally, NRS severity was virtually independent of self-reported quantitative sleep (with the exception of a small zero-order relationship with daytime napping). This corroborates previous assertions that NRS is a distinctive phenomenon occurring apart from other insomnia symptoms (Ohayon, 2005; Ohayon & Roth, 2001; Roth et al., 2010), and attests to the RSQ's purported ability to detect NRS independently of quantitative sleep problems (Drake et al., 2014). RSQ was also negatively associated with greater self-report

of insomnia, and with total count of psychiatric diagnoses weighted according to their degree of sleep impairment, which is notable given that only 5 out of 164 participants reported one or more psychiatric diagnosis in the final research sample after screening criteria were applied.

There are limitations of the present study that must be acknowledged. Firstly, participants continually provided their sleep data over two-week periods throughout the fall term with no regard for environmental influences that would presumably impact sleep cycles, including daylight savings time, holiday breaks, university-wide exam periods, and largely nocturnal social events sponsored by the University of Alabama's prominent fraternity and sorority culture. Furthermore, college undergraduates enjoy greater freedom in planning their class and work schedules according to their personal preferences, thereby mitigating the need to engage in activity at non-preferred times while also increasing variability across individuals' daily routines. Given that eveningness is proposed to elicit impairment because of chronic circadian dysnchrony with a societally constructed timetable for activity (Wittmann et al., 2006), the association between chronotype and NRS may have been blunted by the greater flexibility in college students' schedules. Variable schedules may have had similar repercussions for the examination of weekday and weekend RSQs separately (i.e., some students might not have any substantial time commitments on some weekdays, thereby not conforming to the typical distribution of work days and days off throughout the week). Nevertheless, the persistence of these relationships in the midst of so many possible confounds testifies to their robustness.

In conclusion, eveningness was found to significantly and uniquely predict lower restorative sleep among a normative sample of college undergraduates, and this association was observed to be more relevant during weekdays (Monday through Friday), when academic time commitments fully take effect. Future research is needed to determine whether these findings

extend to more demographically diverse samples, as well as to clinical populations suffering from insomnia or other psychiatric, medical, and organic sleep disorders. Such research could clarify whether circadian mechanisms perpetuate NRS in the context of pathology, and whether circadian interventions may be harnessed to improve patients' quality of life. Investigators might also attempt to replicate current findings within a narrower specified timeframe in populations that are uniformly bound to a fixed schedule, such as high school students beginning class each weekday morning at a regular time during the school year, or dayshift workers functioning according to a standard 40-hr workweek. Such replications may reveal a stronger association between eveningness and NRS than that suggested by the current data.

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APPENDIX A: IRB APPROVAL AND REVISIONS

Office for Research
Institutional Review Board for the
Protection of Human Subjects

THE UNIVERSITY OF
ALABAMA
R E S E A R C H

August 5, 2015

Joshua Tutek
Dept. of Psychology
College of Arts & Sciences
Box 870348

Re: IRB#: 15-OR-237 "Chronotype and Nonrestorative Sleep"

Dear Josh Tutek:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your application has been given expedited approval according to 45 CFR part 46. You have also been granted the requested waiver of parental permission. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies

Your application will expire on August 3, 2016. If your research will continue beyond this date, complete the relevant portions of the IRB Renewal Application. If you wish to modify the application, complete the Modification of an Approved Protocol Form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, complete the appropriate portions of the IRB Request for Study Closure Form.

Please use reproductions of the IRB approved stamped information sheets to obtain consent from your participants.

Should you need to submit any further correspondence regarding this proposal, please include the above application number.

Good luck with your research.

Sincerely,


Carpantato T. Myles, MSM, CIM, CIP
Director & Research Compliance Officer



358 Rose Administration Building
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**UNIVERSITY OF ALABAMA
 INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS
 REQUEST FOR APPROVAL OF RESEARCH INVOLVING HUMAN SUBJECTS**

• **Identifying information**

	Principal Investigator	Second Investigator	Third Investigator
Names:	Joshua Tutek	Kenneth L. Lichstein	
Department:	Psychology	Psychology	
College:	Arts & Sciences	Arts & Sciences	
University:	The University of Alabama	The University of Alabama	
Address:	UA Box 870348	UA Box 870348	
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FAX:	(205) 348-8648		
E-mail:	jtutek@crimson.ua.edu	lichstein@ua.edu	

Title of Research Project: Chronotype and Nonrestorative Sleep

Date Submitted:	06/01/2015
Funding Source:	N/A

Type of Proposal	New	Revision	Renewal Please attach a renewal application	Completed	Exempt
			Please attach a continuing review of studies form		
			Please enter the original IRB # at the top of the page		

UA faculty or staff member signature:	
---------------------------------------	--

II. NOTIFICATION OF IRB ACTION (to be completed by IRB):

Type of Review: ___ Full board Expedited

IRB Action:

___ Rejected Date: _____
 ___ Tabled Pending Revisions Date: _____

Approved Pending Revisions Date: _____
 Approved-this proposal complies with University and federal regulations for the protection of human subjects.

Approval is effective until the following date: 8/3/2016

Items approved: Research protocol (dated _____)

Informed consent (dated _____)

Recruitment materials (dated _____)

Other walver, infosheet (dated _____)

Approval signature  Date 8-5-15

Participant Information Page

Study title: Chronotype and Nonrestorative Sleep
Investigator: Joshua Tutek, BA (Master's Student)
Institution: University of Alabama

You are invited to participate in a research study. This study is called "Chronotype and Nonrestorative Sleep." The study is being done by Joshua Tutek, who is a graduate student at the University of Alabama. Mr. Tutek is being supervised by Kenneth Lichstein, Ph.D., who is a professor of psychology at the University of Alabama. Mr. Tutek is not being paid for this study. He is not developing a product to be sold, and he has no conflicts of interest.

What is this study about? What is the investigator trying to learn?

This study is being done to look at the potential relationship between preferred timing of sleep and activity, sleep that does not feel restorative, and other aspects of health and sleep, such as usual bedtimes and waketimes.

Why is this study important or useful?

This study could help determine whether individuals who prefer to get sleep or become active at certain times of day are more likely to experience sleep that is unrefreshing.

Why have I been asked to be in this study?

You have been asked to be in this study as part of the Psych 101 subject pool.

How many people will be in this study?

About 200 people will participate in this study.

What will I be asked to do in this study?

If you meet criteria to be in this study (you speak English as a first language and you are at least 17 years old) and you agree to participate, you will receive an email within one week with instructions for completing Part 1:

Part 1 (1 Credit)

- Fill out a Demographic and Health Survey asking for personal information such as your demographics (age, gender, race), questions about your work and school schedules, any medical and mental health diagnoses you have, and medication and drug use.
- Fill out a questionnaire asking about your personal preferences for the timing of activities across the 24-hour day
- Fill out a questionnaire asking about common sleep problems you may be experiencing

Responses in Part 1 will be used to determine whether you meet criteria to continue to Part 2. If you do not meet criteria, you will not be able to take part in Part 2 of the study. If you do meet criteria, you will receive an email within one week with instructions for completing Part 2:

Part 2 (2 Credits)

- Fill out a brief questionnaire each morning for 2 weeks asking about how restored or refreshed you feel after awakening from sleep
- Fill out a brief questionnaire (sleep diary) each morning for 2 weeks about your sleep the previous night

If you participate in Part 2, we will send an email reminder to you each morning that you are scheduled to complete the two questionnaires.

How much time will I spend being in this study?

Completing the questionnaires for Part 1 of the study will take you about 30 minutes. Completing the daily questionnaires for Part 2 of the study will take you about 10 minutes each morning. Completing the entire study will take you about 3 hours over about 2 weeks.

Will being in this study cost me anything?

The only cost involved in this study is your time. It is estimated that the measures in this study will require 3 hours total for you to complete.

Will I be compensated for being in this study?

You will be given 3 credits for completing Part 1 and Part 2 of this study. If only Part 1 is completed, you will receive 1 credit. This credit will be posted after completion of all questionnaires. You may not participate in this study more than once.

Can the investigator take me out of this study?

The investigator may take you out of this study or ask you to start over if you miss more than 4 of EITHER of the daily questionnaires in Part 2. Both questionnaires must be completed as soon as possible each morning, but no later than midnight for the previous night's sleep. If EITHER questionnaire is completed after midnight, that questionnaire will be considered skipped and will count toward the 4 times that participants are allowed to miss. You may also be removed from the study if you choose to stay up all night on one or more nights during the two weeks in which you are completing the sleep diaries. You may also be removed from the study if you wait more than four weeks between completing Part 1 and beginning to complete the questionnaires for Part 2. Finally, you may be removed from the study if you respond inappropriately to the validity questions in measures (e.g., responding with "no" to a question asking if you are enrolled in college).

IF YOU ARE REMOVED FROM PART 2 OF THE STUDY FOR ANY OF THESE REASONS, YOU WILL NOT RECEIVE THE 2 CREDITS FOR PART 2.

What are the risks (dangers or harms) to me if I am in this study?

There are no known risks associated with participating in this study.

What are the benefits (good things) that may happen if I am in this study?

There are no direct benefits to you associated with participating in this study.

What are the benefits to science or society?

The results of this study will help determine whether there is a connection between sleep timing preferences and not feeling refreshed after sleeping. Such information may be helpful to clinicians treating individuals who suffer from sleep problems, especially those who report consistently feeling a lack of energy or alertness when they wake up.

How will my privacy be protected?

You will be asked a number of questions about your contact information, your physical characteristics (e.g., height, weight, ethnicity), and physical and mental health history. Because the questionnaires are all online, you may answer the questions in the privacy of your own home. If you are uncomfortable answering these questions, you may choose to end your participation in the study. If, during the course of this study, you express any intent to harm yourself or another person, the investigators are required to report this.

How will my confidentiality be protected?

For all the questionnaires you will use a participant ID number to identify yourself rather than your name. You should store your ID number in a safe place. Any correspondence that you have with the researchers will be through a Gmail account used only for this study. Only the principal investigator and his supervisor will have access to this account.

What are the alternatives to being in this study? Do I have other choices?

As you are in the Psych 101 subject pool, the alternative to being in this study is to participate in a different study or to choose the designated alternative assignment for course credit.

What are my rights as a participant in this study?

Taking part in this study is voluntary. It is your free choice. You can refuse to be in it at all. If you start the study, you can stop at any time. There will be no effect on your relations with the University of Alabama. Please note that you must complete the study to receive class credit.

The University of Alabama Institutional Review Board ("the IRB") is the committee that

