CLARIFYING THE CONTRIBUTIONS OF WORRY AND RUMINATION IN PREDICTING SUBJECTIVE SLEEP OUTCOMES

by

JOSHUA TUTEK

KENNETH L. LICHSTEIN
MARTHA R. CROWTHER
JAMES D. GEYER
HEATHER E. GUNN
MATTHEW A. JARRETT

A DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Psychology
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2019

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ABSTRACT

Harvey's (2002) cognitive model of insomnia posits that subjectively experienced poor sleep and sleep-related impairment during the day arise from negatively toned cognitive activity consisting of worry and rumination. Although these processes are often treated as interchangeable, evidence suggests that they constitute distinct constructs, and the need for clarifying their individual properties in driving self-reported sleep problems has been highlighted. This study investigated whether worry and rumination differentially predict sleep disturbance and sleep-related impairment in an online population-based sample. Hierarchical regression models entered the cognitive process variables in a stepwise fashion to assess their relative strength in explaining sleep outcomes after controlling for demographics, circadian factors, health status, and self-estimated sleep parameters. Separate analyses were conducted using sleep-specific and general trait measures of worry and rumination. In the sleep-specific analysis, only worry significantly predicted sleep disturbance after all covariates were entered, whereas rumination was entered after worry in the model predicting sleep-related impairment. In the analysis of general worry and rumination, each variable significantly predicted both sleep outcomes. Worry was a stronger predictor of sleep disturbance, whereas rumination was a stronger predictor of sleep-related impairment. Findings suggest a role for rumination separate from that of worry in perpetuating daytime impairment attributed to poor sleep. The results also highlight a need to more closely examine how cognition and other factors contribute to daytime symptomology in insomnia.

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
F	Fisher's F ratio: the ratio 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	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 predictors in a model
ΣR^2	Cumulative squared multiple correlation coefficient: the accumulation of the proportion of variance in an outcome variable accounted for by currently entered and all previously entered predictors
ΔR^2	Change in squared multiple correlation coefficient: the incremental change in the proportion of variance in an outcome variable accounted for by an additional predictor(s) entered into a model

$<$	Less than
$>$	Greater than
$=$	Equal to
$\geq$	Greater than or equal to

ACKNOWLEDGMENTS

I am grateful to Kenneth Lichstein, the chairman of this thesis, for sharing his knowledge of the sleep literature and assisting in the construction of my project's research design. I would also like to thank my committee members, Martha Crowther, James Geyer, Heather Gunn, and Matthew Jarrett, for their suggestions during my dissertation proposal. Additionally, I am thankful to my family back home and fellow graduate students for their support during the dissertation process. Finally, I thank the workers from the Amazon Mechanical Turk who contributed their time and data to my project, as well as the University of Alabama for the use of Qualtrics as a platform for distributing my study and collecting data over the web.

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CHAPTER 1

INTRODUCTION

Sleep is fundamental to health and wellbeing, and its dysregulation can be observed broadly across psychiatric disorders (Harvey, 2008; Harvey, Murray, Chandler, & Soehner, 2011) and chronic medical conditions associated with morbidity and mortality (Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011; Gangwisch, 2009; Kochanek, Murphy, Xu, & Arias, 2014; Knutsson, 1988; Reiter et al., 2007). Moreover, complaints of insufficient or disturbed sleep are currently a prominent public health problem. About 25% of adults report dissatisfaction with their sleep, and insomnia is among the most common presenting problems in primary care settings (Morin & Benca, 2012). An extensive literature has thus sought to identify contributors to subjective sleep disturbance or poor sleep quality, as well as consequent sleep-related impairment in functioning. These complex, often nebulously defined constructs are considered definitive markers of chronic insomnia that are implicated in a range of physical and psychological outcomes (Buysse et al., 2010; Harvey, Stinson, Whitaker, Moskovitz, & Virk, 2008; Hossain et al., 2005; Hyyppä & Kronholm, 1989; Yu et al., 2011).

In attempting to delineate relevant influences on self-defined poor sleep, researchers have noted that it is not necessarily associated with polysomnography- or actigraphy-assessed sleep pattern (Buysse et al., 2008; Landry, Best, & Liu-Ambrose, 2015; Morin, Belleville, Bélanger, & Ivers, 2011; Rosa & Bonnet, 2000). Personal assessments of quantitative sleep parameters recorded using daily diaries produce stronger correlations with sleep quality ratings than

analogous objective recordings (Buysse et al., 2008; Morin et al., 2011), with insomnia patients displaying a consistent tendency to underestimate their actual sleep duration and overestimate their latency to sleep onset (Adam, Tomeny, & Oswald, 1986; Carskadon et al., 1976). Moreover, successful treatment for insomnia typically results in markedly greater improvement on subjective sleep measures compared to objective ones (Engle-Friedman, Bootzin, Hazlewood, & Tsao, 1992; Friedman et al., 2000).

The observed discrepancy between objective and subjective estimates in poor sleepers has led to the conclusion that insomnia is essentially a personal experience of inadequate sleep based on self-report (Tang & Harvey, 2004). In light of this, Harvey (2002) proposed a cognitive model of insomnia in which excessive negatively toned cognitive activity, operating both during the night and throughout the day, acts as a principal force driving the experience of sleep disturbance and resulting functional impairment. According to the model, negative cognition triggers physiological arousal and emotional distress, which in turn elicit selective monitoring of the internal and external environment for negative information pertaining to sleep, which invariably results in a distorted perception of deficits in sleep and daytime performance. This entire cascade is theorized to function cyclically, with selective monitoring and distorted sleep perception fueling further cognitive activity in a feedback loop that can ultimately culminate in real detriments. Erroneous beliefs about sleep and unhelpful safety behaviors (e.g., spending excessive time in bed to make up for supposed sleep debt) are also presumed to play a role in exacerbating maladaptive thought patterns (Harvey, 2002).

Negatively toned mental activity lies at the center of the cognitive model of insomnia, and its significance has since been confirmed in both experimental and correlational studies, conducted using both clinical and population-based samples (Jansson-Fröjmark, Harvey, Lundh,

Norell-Clarke, & Linton, 2011; Kaplan, Talbot, & Harvey, 2009; Harvey, 2004; Hiller, Johnston, Dohnt, Lovato, & Gradisar, 2015). In the original model conceptualization, Harvey (2002) describes negative sleep cognition as being comprised of worry and rumination, two thought processes that are often conflated or treated as interchangeable in sleep research (Carney, Harris, Falco, & Edinger, 2013; Hiller et al., 2015). Evidence from the broader psychological literature suggests that there is indeed significant overlap between these constructs, in that they both involve repetitive, perseverative thinking characterized by self-focus and difficulty redirecting attention away from negative stimuli (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Yet although worry and rumination are correlated within individuals, they are statistically distinguishable from one another and have important theoretical differences (Fresco, Frankel, Mennin, Turk, & Heimberg, 2002; Nolen-Hoeksema et al., 2008). Worry has been described as future-oriented, concentrating on the anticipation of uncertain, threatening events or circumstances that have not yet occurred (Borkovec, Robinson, Pruzinsky, & DePree, 1983). By contrast, rumination is a response to current distress that involves repeatedly going over one's past experience to gain insight and infer the causes of problems. Engagement in worry is associated with anxiety, whereas a ruminating response style has been studied more closely in the context of depression (Nolen-Hoeksema et al., 2008), both psychological conditions that are highly comorbid with sleep problems (Morin & Benca, 2012). Although there is still debate over whether worry and rumination are truly distinctive entities, they are individually accruing empirical support as predictors of sleep disturbance and will both likely continue to be relevant in studies of sleep-related thought content in the future (Jansson-Fröjmark et al., 2011).

Most examinations of cognition involving sleep thus far have tended to focus on worry, consistently observing that greater intrusive preoccupation with sleep is linked to greater

experience of sleep problems (Hiller, 2015). In a large population-based study, Jansson-Fröjmark and colleagues (2011) found that a measure of sleep-specific worry predicted sleep quality. Also, experimental manipulations that increase or decrease worry elicit corresponding changes in self-reported sleep estimates, suggesting that worry plays a causal role in sleep disturbance rather than merely occurring as its by-product (Gross & Borkovec, 1982; Hall, Buysse, Reynolds, Kupfer, & Baum, 1996; Lichstein & Fanning, 1990). Comparatively little research has concentrated on the role of a ruminating response style in perpetuating sleep complaints, but several survey studies have observed an association (Carney, Edinger, Meyer, Lindman, & Istre, 2006b; Thomsen, Mehlsen, Christensen, & Zachariae, 2003; Zawadzki, Graham, & Gerin, 2013), including a recent investigation suggesting that rumination is a mediator between depressed mood and poor sleep quality (Slavish & Graham-Engelend, 2015). In one of the first of these studies, Carney and colleagues (2006b) concluded that ruminative content in poor sleepers specifically focuses on negative daytime symptoms (e.g., dysphoria, inattention, fatigue), as opposed to the self, which is a focal point of depression-specific rumination.

Studies examining sleep-related worry and rumination concurrently to determine whether they operate as independent processes are scant. The first such investigation was conducted by Carney, Harris, Moss, and Edinger (2010), and assessed participants diagnosed with insomnia on self-reported sleep outcomes, as well as worry and rumination severity. Factor analysis supported the two constructs' independence, and rumination correlated with poorer sleep quality, less sleep efficiency, and more time awake after sleep onset, even after controlling for depression. Surprisingly, no main effect was observed linking worry to sleep variables, although the authors acknowledged that the general questionnaire used to assess worry may have been too broad in its content to be directly associated with sleep disturbance. A follow-up study sought to generate an

insomnia-specific rumination questionnaire and validate it in a large undergraduate sample, as well as in clinical participants diagnosed with comorbid insomnia and depression (Carney et al., 2013). The resulting measure was psychometrically robust and predicted both insomnia symptom severity and daytime fatigue. Furthermore, factor analysis revealed that all of the items of the new rumination questionnaire and those of a worry questionnaire loaded onto two separate factors, suggesting the independence of the measures. However, worry was assessed using the same general (not insomnia-specific) instrument as in Carney and colleagues' (2010) previous report. These studies provide some support for the independence of worry and rumination, but clarifying their unique properties in driving sleep dysfunction have been highlighted as an important topic for further exploration (Hiller et al., 2015).

One way in which worry and rumination may differ is in the relative strength of their associations with perceived sleep disturbance at night versus sleep-related deficits during the day. Even though insomnia is commonly thought of as a nighttime disorder consisting of compromised sleep quantity or quality, the consequent detriments in daytime functioning (e.g., sleepiness, lack of concentration) are a prominent source of concern in their own right for people with sleep problems (Carney et al., 2013; Hossain et al., 2005). In keeping with this, Harvey's (2002) cognitive model conceptualizes insomnia as a 24-hour disorder maintained equally by daytime and nighttime thought activity. Although the processes at work are proposed to be largely similar across the 24-hour period, Harvey (2002) acknowledges that the specific details of harmful thought content may vary during the day versus at night. This raises the possibility that worry and rumination could have distinctive roles in maintaining insomnia symptomology that occurs at different times of day.

Previous studies have emphasized that rumination about insomnia tends to involve repetitive thinking about daytime mental and physical symptoms (Carney et al., 2006b, 2010, 2013). These reports have correlated rumination questionnaires with measures of sleep pattern and general sleep quality, but it seems plausible that rumination would be differentially relevant to the experience of sleep-related impairment during the day, compared to disturbed sleep itself. As previously noted, rumination involves relentlessly scouring one's experience with the goal of understanding why distress has occurred (Nolen-Hoeksema et al., 2008). Individuals who endorse greater sleep-related daytime tiredness, irritability, and other symptoms likely do so because they are predisposed by a ruminative response style to dwell upon their negative states and conclude that they arose from sleep that was poor. Because worry is anticipatory by nature and concerns future outcomes (Borkovec et al., 1983), it would presumably be a somewhat less important process for functional deficits experienced in the present as an individual goes about their day. Conversely, compromised quality or quantity of the nighttime sleep bout might be more closely tied to worry than rumination, because it is impossible to reflect upon sleep "in the moment" while it is occurring. Rather, sleep disturbance may either be anticipated as an impending, uncontrollable event (e.g., "tonight I will not be able to stay asleep again"), or alternatively experienced in terms of its repercussions for future functioning (e.g., "I am taking too long to fall asleep tonight, which means I will never get enough rest by morning"). It is thus reasonable to expect that worry would surpass rumination as the cognitive process most active in perpetuating perceived inadequacies of the actual sleep bout.

Distinguishing worry and rumination in this way could have important implications for insomnia conceptualization and treatment. For example, differentiated pathways to insomnia that involve either anxiously anticipating future sleep-related adversity or becoming absorbed in

functional impairments automatically attributed to poor sleep may warrant different approaches to psychotherapeutic intervention. In discussing their finding that worry and rumination were independent among insomnia patients, Carney and colleagues (2010) argue that strategies targeting worry to improve sleep have already been formulated (e.g., Carney & Waters, 2006; Harvey, Tang, & Browning, 2005). However, there is a paucity of rumination-targeting strategies, which could prove useful as adjuncts to traditional cognitive behavioral therapy for insomnia (CBT-I) for improving treatment outcomes or extending treatment efficacy across a broader range of patients (Carney et al., 2010). Establishing whether worry and rumination are truly autonomous processes that relate to sleep problems in different ways is an essential first step in evaluating whether it would be useful to develop insomnia interventions that address them both.

Measures with rigorously validated item content tapping sleep disturbance and sleep-related impairment are now available in the form of twin brief item inventories (Yu et al., 2011), allowing researchers to assess the relative contributions of worry and rumination in predicting each construct. Moreover, these relationships are now examinable using questionnaires that measure worry and rumination as thought processes that revolve specifically around sleep content (Jansson-Fröjmark et al., 2011; Carney et al., 2013), or more broadly as traits that pervade general functioning (Meyer, Miller, Metzger, & Borkovec, 1990; Treynor, Gonzalez, and Nolen-Hoeksema, 2003).

In modeling cognitive processes' prediction of sleep outcomes, efforts should be made to obtain a pure estimate of the associations of interest by controlling for extraneous and potentially distorting factors. These include demographics that are relevant to sleep such as gender and age (Lichstein, Durrence, Riedel, Taylor, & Bush, 2004), as well as indicators of socioeconomic status such as annual household income and education level (Grandner et al., 2010). It

additionally remains unclear whether the influence of negative cognition on insomnia symptomology persists apart from factors reflecting the human circadian rhythm that are known to have implications for sleep quality, such as intrinsic preference for morning or evening activity (chronotype; Adan et al., 2012, Barclay, Eley, Buysse, Archer, & Gregory, 2010), and behavioral regularity in daily schedules (Carney, Edinger, Meyer, Lindman, & Istre, 2006a; Monk, Reynolds, Buysse, DeGrazia, & Kupfer, 2003). General physical and mental health status may also be considered, given that poor sleep is related to various health comorbidities (Cappuccio et al., 2011; Gangwisch, 2009; Harvey et al., 2011; Kochanek et al., 2014; Knutsson, 1988; Reiter et al., 2007). Finally, cognitive processes' relation to sleep disturbance and sleep-related impairment may even persist when controlling for self-estimates of habitual quantitative sleep. Compelling evidence suggests that merely conceiving of oneself as having sleep problems predicts greater sleepiness, fatigue, and psychological distress after accounting for diary-assessed daily sleep parameters (Ustinov et al., 2010), and that individuals who report sleep problems often do not report congruous deficits in the amount of sleep they actually obtain (Lichstein, 2017).

Present Study

The present study sought to clarify the comparative contributions of two forms of negatively toned cognitive activity, worry and rumination, in predicting self-reported sleep disturbance and sleep-related impairment among the general population. Both worry and rumination were hypothesized to explain significant variance in each of the two outcomes after controlling for demographics, circadian factors comprising chronotype and work schedule regularity, facets of overall health, and self-reported sleep parameters. Moreover, worry was expected to be the stronger predictor of nighttime sleep disturbance, whereas rumination was

expected to be the stronger predictor of sleep-related impairment during the day. Hypotheses were tested using measures of sleep-specific worry and rumination. Additional exploratory analyses were conducted to determine whether the same pattern of results was observed when older, more established measures of general (i.e., not sleep-specific) worry and rumination were substituted to predict outcomes.

CHAPTER 2

METHOD

Participants

Adults were recruited online from around the United States via the Amazon Mechanical Turk (MTurk), a web-based crowdsourcing service through which workers complete Internet-based tasks such as filling out surveys in exchange for small monetary rewards from requesters who advertise their tasks on the site. Each worker has an account with a unique identification number used to receive instructions and compensation from the requester anonymously. Requesters can thus interact with their workers without collecting names or personal contact information. MTurk has been used extensively in the social sciences, and has been shown to recruit valid research samples that are often more representative of the general population than in-person convenience samples (Berinsky, Huber, & Lenz, 2012; Buhrmester, Kwang, & Gosling, 2011). Given the number of predictors in the main analysis (measures of sleep-specific worry and rumination, 17 controlled covariates), power analysis indicated that approximately 180 participants would need to be recruited for .80 statistical power to detect a moderately sized effect, assuming an α level of .025 (Faul, Erdfelder, Buchner, & Lang, 2009). Because two separate, identical models predicting sleep disturbance and sleep-related impairment were run, a more conservative α error probability was specified for power analysis in lieu of the default .05 level. The author continued recruiting as many eligible participants from MTurk as funds would allow in order to maximize power, even after the quota of 180 individuals had been reached. To

be eligible for the study, participants needed to be at least 18 years of age; report no formal diagnosis of an organic sleep disorder that might confound study results (breathing-related sleep disorder, narcolepsy, restless legs syndrome); and report no regular participation in night shift work, which is highly associated with dysregulation of the sleep-wake cycle (Burch, Yost, Johnson, & Allen, 2005). Eligible participants were additionally required to provide a correct answer to each of five validity items interspersed with the survey's item content, and to spend at least 10 minutes completing the study before submitting their results.

Measures

Sleep disturbance and sleep-related impairment. Despite its ubiquity in the literature, investigators have noted that the sleep quality construct is vaguely conceptualized and accessed using a variety of self-report measures, which may provide retrospective or prospective estimates, and may target sleep characteristics broadly or only insofar as they pertain to insomnia severity (Harvey et al., 2008; Morin et al., 2011; Yu et al., 2011). The sleep disturbance (SD) and sleep-related impairment (SRI) item banks were developed as part of the Patient-Reported Outcomes Measurement Information System (PROMIS), an initiative funded by the National Institute of Health to create health self-assessment tools through rigorous, state-of-the-art psychometric methodology. They were designed to yield estimates of unidimensional severity in their respective constructs, and their validity has been confirmed in both clinical and normative samples (Buysse et al., 2010). However, the PROMIS item are administered and scored online through an elaborate software system that is unwieldy for survey research. Short forms of each item bank are thus available, and they correlate strongly with their corresponding full instruments (Yu et al., 2011). Furthermore, the SD and SRI short forms were found to have better measurement precision in a large population-based sample than the Pittsburgh Sleep

Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) and the Epworth Sleepiness Scale (ESS; Johns, 1991) respectively, which are the most widely used measures of self-reported sleep quality and sleep-related impairment (Yu et al., 2011). Each of the two PROMIS short forms consists of 8 questions summed together to produce a total raw score. Raw values are subsequently converted to *t* scores based on the distribution of the validation sample.

Demographic and health information. A custom survey was administered to collect data on demographic factors including gender (coded 0 = male; 1 = female for analysis), age in years, weight and height to compute body mass index (BMI), annual income level (0 = Less than $10,000; 1 = $10,000 to $19,999; 2 = $20,000 to $29,999... 10 = $100,000 to $149,999; 11 = $150,000 or more), and education level (0 = No formal schooling; 1 = Preschool to 8th grade; 2 = Some high school with no diploma; 3 = High school diploma or equivalent; 4 = Some college credit with no degree; 5 = Trade/technical/vocational training; 6 = Associate degree; 7 = Bachelor's degree; 8 = Master's degree; 9 = Doctoral degree). For screening purposes, the form also prompted respondents to indicate whether they had received a diagnosis of breathing-related sleep disorder, narcolepsy, or restless legs syndrome from a health professional, as well as whether their current occupation regularly requires working night shifts.

Circadian preference and work regularity. The survey contained a single question assessing chronotype, which presented participants with the following prompt inspired by item 19 from the Morningness-Eveningness Questionnaire (Horne & Östberg, 1976): "One hears about 'morning' and 'evening' types of people (morning larks and night owls). Which of these types do you consider yourself to be?" Participants identified their circadian preference on a 7-point ordinal scale (0 = Extreme morning type; 1 = Moderate morning type; 2 = Slight morning type; 3 = Neither type; 4 = Slight evening type; 5 = Moderate evening type; 6 = Extreme evening

type). Regularity in work activity was also assessed using a single question asking whether respondents adhere to a regular daily work schedule, regardless of whether they are self-employed or work primarily as homemakers (0 = No; 1 = Yes).

Overall health status. Overall quality of health was assessed using the EuroQol-5 Dimension-5 Level (EQ; Herdman et al., 2011). The EQ contains five items prompting respondents to rate their health on five different domains: mobility, ability to perform self-care, ability to perform usual activities, severity of pain/discomfort, and severity of anxiety/depression. Items are scored from no problems (1) to extreme problems (5). The validity of the EQ has been established by its convergence with other widely known global measures of health in large samples spanning several countries (Devlin & Brooks, 2017).

Quantitative sleep parameters. Participants completed a form prompting them to provide estimates of their typical nightly sleep parameters. These included total sleep time (TST), the amount of time it takes to fall asleep after bedtime (sleep onset latency; SOL), the total amount of time spent awake during the night between initiating sleep onset and final awakening (wake after sleep onset; WASO), the amount of time between final awakening and rising from bed (terminal wake time; TWAK), and the amount of time spent napping during the day (NAP). To account for potential variability in sleep pattern across the calendar week, participants provided separate estimates of sleep parameters for weekdays and weekends. A weighted average for each sleep parameter was computed for analyses by multiplying the weekday estimate by five, multiplying the weekend estimate by two, summing the products, and dividing the sum by seven.

Sleep-specific worry. The Anxiety and Preoccupation About Sleep Questionnaire (APSQ; Jansson-Fröjmark et al., 2011; Tang & Harvey, 2004) was designed to index the

intensity of worry specifically related to sleep problems, with an emphasis on capturing both nighttime and daytime worry in accordance with Harvey's (2002) conceptualization of insomnia as a 24-hour phenomenon. The measure has demonstrated strong internal consistency and appropriate correlations with sleep quality, anxiety, pre-sleep arousal, and sleep-related beliefs, as well as the ability to distinguish between three sleep status groups (good, poor, insomnia disorder) in a large population-based sample (Jansson-Fröjmark et al., 2011). Its item content was found to comprise two latent factors pertaining to sleep's perceived controllability and to the anticipated consequences of poor sleep. Although the original APSQ's 10 items were rated on a 10-point scale (Tang & Harvey, 2004), the version validated by Jansson-Fröjmark and colleagues (2011) contained items scored on a 5-point scale of agreement and summed to yield a total score. This version of the scale was used in the present study.

Sleep-specific rumination. The Daytime Insomnia Symptom Response Scale (DISRS; Carney et al., 2013) was created to assess ruminative tendencies specific to the consequences of poor sleep. The scale contains eight items from the Symptom-Focused Rumination Subscale of the Response Styles Questionnaire, a general measure of ruminative responses in depression (Bagby, Rector, Bacchiochi, & McBride, 2004; Nolen-Hoeksema & Morrow, 1991), as well as 12 additional items generated and evaluated by experts in insomnia research. The resulting 20-item questionnaire prompts participants to rate their frequency of thinking about sleep-relevant symptoms. Carney and colleagues (2013) validated the DISRS in both an undergraduate student sample and a clinical sample of participants meeting diagnostic criteria for both insomnia and depression, finding that it possessed high internal consistency, was appropriately correlated with general worry, insomnia severity, and depression, and also continued to predict insomnia after controlling for depression.

General worry. The Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990) is the most commonly used self-report measure of trait worry (Topper, Emmelkamp, Watkins, & Ehring, 2014). It contains 16 statements prompting respondents to specify how typically they experience worry symptoms or difficulty controlling their worrying when they encounter usual tasks and situations. The original validation study demonstrated that the PSWQ displayed appropriate convergent and divergent validity with related constructs, and could adequately distinguish respondents who met criteria for generalized anxiety disorder from those with subclinical generalized anxiety symptoms, no anxiety symptoms, or post-traumatic stress disorder symptoms (Meyer et al., 1990).

General rumination. The Ruminative Response Scale (RRS; Treynor et al., 2003), and the Response Styles Questionnaire (Nolen-Hoeksema & Morrow, 1991) on which it is based, are the most commonly used self-report measures of trait rumination (Topper et al., 2014). The RRS contains 22 statements that are typical of thought patterns displayed by individuals with a ruminative response style. Participants indicate how often they think about various negative aspects of their experience (e.g., personal shortcomings, physical or cognitive symptoms) when they are feeling sad, down, or depressed. Treynor and colleagues (2003) developed the RRS by refining item content from its predecessor (the Response Styles Questionnaire) to be less confounded with general depression symptomology. They observed strong psychometric properties in the finalized measure, as well as a two-factor structure consisting of reflective pondering and brooding (Treynor et al., 2003).

Procedure

A brief description of the study and a link to an online survey form containing the measures (hosted by Qualtrics) were posted on the MTurk website from August 2018 until the

end of data collection in October 2018. Only MTurk workers residing in the United States were able to view the post. When workers clicked the link, they were first presented with an information page detailing study procedures. Typing their MTurk ID at the bottom of the page and clicking "continue" signified their consent to participate in the study. Participants subsequently completed all study measures in a random order (SD short form, SRI short form, demographic and health survey, EQ, estimates of quantitative sleep pattern, APSQ, DISRS, PSWQ, RRS). The Qualtrics form was configured such that answering all individual questions was compulsory to complete submission, ensuring that there were no missing data on any measures. Next, participants viewed a conclusion page informing them of the study's purpose and hypotheses, and presenting them with the opportunity to withdraw their data from analyses if desired. After viewing this page, participants submitted their completed Qualtrics survey.

Three validity checks were used during measure administration to facilitate the collection of quality data. To protect against random responding, five validity items with self-evident correct responses (e.g., "If I am paying attention, I will click 'Disagree' for this item.") were interspersed among the measures' content. To help ensure that participants spent a minimally adequate amount of time considering their responses, the Qualtrics Timing feature tracked the amount of time between when participants initiated the study and when they submitted their completed form. A timer displayed on each webpage of the survey allowed respondents to keep track of the elapsed time since they started. Finally, to negate the confounding impact of ordering effects, all study measures were administered to participants in a random order generated using the Qualtrics Randomizer feature.

The Qualtrics form contained approximately 110 questions in total. Participants were compensated $3.25 for completing the study via MTurk's anonymous payment system. When the

data were downloaded, each participant was assigned a randomly generated identification number for use in the study, and their MTurk identification number was deleted. Submitted forms were reviewed to determine whether participants met eligibility requirements for the study (see criteria outlined in the Participants section above). Those not meeting criteria were excluded from analyses. After sampling ended, all data were transferred from the downloaded online survey form into SPSS (version 24.0) for statistical analysis.

CHAPTER 3

RESULTS

Descriptive Statistics

A total of 619 participants consented to study procedures on MTurk and submitted their completed survey form via Qualtrics. Submissions from 32 individuals were excluded due to incorrect responding on one or more of the five validity items. An additional 10 individuals were subsequently excluded for spending less than 10 minutes completing the entire survey, according to Qualtrics' Timing feature. Of the 577 participants remaining, 118 were screened out for reporting that they experience the following (some excluded participants reported more than one condition, and are counted in more than one of the displayed totals): breathing-related sleep disorder (n = 47), narcolepsy (n = 9), restless legs syndrome (n = 48), and regular engagement in nightshift work (n = 54). The analyzed sample thus comprised 459 MTurk workers from the United States. Table 1 displays demographic and health characteristics for the final sample.

Table 1

Sample Demographic and Health Characteristics (N = 459)

Variables		***N***	**%**
Gender			
	Male	260	56.6
	Female	198	43.1
	Genderfluid	1	0.2
Race			
	American/ Alaskan Native	5	1.1
	Asian	28	6.1
	Black	37	8.1

	Hispanic/ Latino	19	4.1
	White/ Non-Hispanic	358	78.0
	Multiracial	12	2.6
Annual Household Income			
	≤ $19,999	58	12.7
	$20,000 - $39,999	128	27.9
	$40,000 - $59,999	122	26.6
	$60,000 - $79,999	59	12.9
	$80,000 - $99,999	43	9.4
	≥ $100,000	49	10.7
Highest Education			
	Less than High School	5	1.1
	High School Diploma/ Equivalent	57	12.4
	Some College Credit, No Degree	106	23.1
	Associate Degree/ Vocational Certificate	68	14.8
	Bachelor's Degree	186	40.5
	Master's Degree	33	7.2
	Doctoral Degree	4	0.9
Regular Work Schedule			
	Yes	376	81.9
	No	83	18.1
Employment Status			
	Employed for Wages	303	66
	Self-Employed	90	19.6
	Homemaker	24	5.2
	Student	13	2.8
	Retired	6	1.3
	Out of Work	20	4.3
	Unable to Work	3	0.7
Relationship Status			
	Married/ Domestic Partner	163	35.5
	Committed Partner	70	15.3
	Divorced	17	3.7
	Separated	3	0.7
	Single, Never Married	206	44.9

	Median	***M***	***SD***
Age (years)	33.00	35.33	10.38

Body Mass Index		25.49	27.24	7.68
Chronotype			3.65	1.93
Health Status				
	Mobility		1.22	0.58
	Self-Care		1.13	0.50
	Usual Activities		1.32	0.70
	Pain/ Discomfort		1.61	0.78
	Anxiety/ Depression		2.01	1.10
Sleep Parameters (minutes)				
	TST		421.35	80.63
	SOL		30.47	34.56
	WASO		13.31	28.13
	TWAK		18.04	52.70
	NAP		12.75	24.33

Note: Percentages may not sum to 100% due to rounding error. Chronotype = ordinal scale assessing circadian preference from 0 (extreme morning) to 6 (extreme evening); Health Status = domain scores on the EuroQol-5 Dimension-5 Level, which measure health problems on a scale from 1 to 5 of increasing severity; TST = total sleep time; SOL = sleep onset latency; WASO= wake after sleep onset; TWAK= terminal wake time; NAP = daytime napping.

The present study aimed to demographically approximate the United States general population in order to broadly estimate the relationships of interest. Several differences were observed in recruited participants relative to current data for the total population (Bureau of Labor Statistics, 2019; Centers for Disease Control and Prevention, 2017; U.S. Census Bureau, 2018a, 2018b). For instance, the population comprises lower proportions of males (49.2%), non-Hispanic whites (60.7%), people possessing at least a Bachelor's degree (30.9%), and people with household income totaling less than $60,000 (median = $57,652). Nevertheless, the MTurk sample appeared to be fairly successful at approximating population data for median age (38.0 years) and BMI (28.2), as well as proportions of unmarried adults over age 18 years (49.0%) and people who are out of work (4.0%). Mean self-reported sleep parameters were also largely consistent with expectations for a normative sample, with the exception of SOL. Average SOL in

the sample (30.47 minutes) was higher than what is considered typical for healthy adults, nearly reaching the recommended clinical cutoff for diagnosing insomnia (31 minutes; Lichstein, Durrence, Taylor, Bush, & Riedel, 2003; Lichstein et al., 2004).

Table 2 provides descriptive statistics for administered questionnaires. All of the scales displayed strong internal consistency among individual items ($\alpha > .90$; Nunnally, 1978), as well as skewness and kurtosis values suggesting acceptable normality in their distributions (within ± 2.00; George & Mallery, 2016). Table 3 displays zero-order bivariate correlations among all variables included in the main analyses. Measures of worry and rumination displayed the anticipated robust positive associations with the SD and SRI short forms (r's > .45). However, the cognitive process measures consistently showed stronger correlations with sleep-related impairment than with sleep disturbance. Worry and rumination were also associated with each other, whether they were assessed using sleep-specific or general measures. Although the two rumination questionnaires (DISRS and RRS) expectedly demonstrated a large correlation (r = .80), sleep-specific worry on the APSQ was unexpectedly correlated more strongly with the DISRS (r = .69) and RRS (r = .62) than with the PSWQ, its counterpart worry measure (r = .56).

Table 2

Descriptive Statistics of Administered Questionnaires

Variables	*M*	*SD*	Min	Max	Skewness	Kurtosis	α
SD short form*	50.60	10.21	28.9	76.5	-.10	-.21	.94
SRI short form*	51.29	10.70	30.0	80.0	-.15	-.66	.94
APSQ	21.49	10.36	10	50	.58	-.68	.95
DISRS	39.24	13.53	20	80	.36	-.69	.96
PSWQ	47.56	18.26	16	80	.08	-1.10	.97
RRS	41.64	14.67	22	82	.42	-.81	.95

Note: Min = minimum score; Max = maximum score; SD = sleep disturbance; SRI = sleep-related impairment; APSQ = Anxiety and Preoccupation About Sleep Questionnaire; DISRS = Daytime Insomnia Symptom Response Scale; PSWQ = Penn State Worry Questionnaire; RRS = Ruminative Response Scale.
*Values represent *t* scores derived from the score distribution of the validation sample reported by Yu and colleagues (2011).

Table 3

Bivariate Correlations for Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. SD Short Form	-																						
2. SRI Short Form	.77*	-																					
3. Age	-.05	-.17*	-																				
4. Gender	.22*	.14	.12	-																			
5. Body Mass Index	.02	.06	.18*	.06	-																		
6. Annual Household Income	-.09	-.14	.05	.06	.01	-																	
7. Education Level	-.03	-.08	.10	.04	.02	.24*	-																
8. Chronotype	.20*	.24*	-.11	.02	.04	-.10	-.04	-															
9. Regular Work Schedule	-.07	-.13	.07	.21*	-.03	.16*	.13	-.16*	-														
10. Mobility	.12	.18*	.19*	.01	.06	-.13	-.03	-.05	-.14	-													
11. Self-Care	.11	.22*	-.07	-.05	-.01	-.08	-.07	.04	-.15	.37*	-												
12. Usual Activities	.29*	.34*	-.02	.07	-.02	-.16*	-.12	.11	-.17*	.46*	.47*	-											
13. Pain/ Discomfort	.30*	.36*	.13	.07	.06	-.14	-.09	.02	-.12	.52*	.39*	.43*	-										
14. Anxiety/ Depression	.45*	.52*	-.15	.06	-.03	-.12	-.11	.18*	-.12	.13	.24*	.32*	.25*	-									
15. TST	-.32*	-.24*	-.13	-.05	-.07	-.05	.0003	-.05	-.08	.05	.08	-.03	-.11	-.13	-								
16. SOL	.38*	.25*	-.08	.03	-.003	-.03	-.05	.13	-.06	-.01	-.01	.10	.16*	.24*	-.48*	-							
17. WASO	.30*	.18*	.05	.09	-.02	-.06	-.02	.06	-.02	.02	-.05	.06	.07	.11	-.06	.18*	-						
18. TWAK	.09	.09	.03	-.07	.001	-.13	-.02	.09	-.08	-.003	-.01	.04	-.01	.04	-.09	.12	.29*	-					
19. NAP	.18*	.29*	.06	.12	.12	-.02	-.04	.08	.04	.03	.02	.15	.06	.16*	-.15	.03	.04	.06	-				
20. APSQ	.68*	.77*	-.17*	.09	-.02	-.09	-.04	.15	-.09	.17*	.19*	.34*	.33*	.51*	-.24*	.30*	.13	.07	.23*	-			
21. PSWQ	.51*	.59*	-.13	.22*	-.03	-.06	-.05	.10	-.03	.10	.11	.23*	.23*	.58*	-.11	.12	.09	-.03	.15*	.56*	-		
22. DISRS	.52*	.72*	-.16*	.17*	.002	-.15	-.05	.16*	-12	.19*	.21*	.33*	.33*	.54*	-.10	.15	.08	.01	.25*	.69*	.62*	-	
23. RRS	.48*	.61*	-.19*	.13	-.02	-.09	-.02	.12	-.07	.16*	.20*	.29*	.28*	.60*	-.07	.15	.09	-.02	.17*	.62*	.66*	.80*	-

Note: Variables 10-14 represent health domain scores on the EuroQol-5 Dimension-5 Level, which measure health problems on a scale from 1 to 5 of increasing severity; SD = sleep disturbance; SRI = sleep-related impairment; Chronotype = ordinal scale assessing circadian preference from 0 (extreme morning) to 6 (extreme evening); TST = total sleep time; SOL = sleep onset latency; WASO= wake after sleep onset; TWAK= terminal wake time; NAP = daytime napping; APSQ = Anxiety and Preoccupation About Sleep Questionnaire; PSWQ = Penn State Worry Questionnaire; DISRS = Daytime Insomnia Symptom Response Scale; RRS = Ruminative Response Scale.
*$p < .001$.

Regression Analysis

To test hypotheses about how worry and rumination differ in their relation to sleep disturbance and sleep-related daytime impairment, hierarchical block regression was pursued to isolate the incremental variance explained by each cognitive process in predicting sleep outcomes. Separate but identical models were constructed to predict the SD and SRI short forms. In each model, four consecutive blocks of covariates were initially entered to account for extraneous variance. Block 1 comprised demographics measured on a continuous or dichotomous categorical scale (age, gender, body mass index, annual household income level, and education level). One participant who identified as gender fluid was excluded pairwise to allow for dichotomous examination of gender. Block 2 comprised self-identified chronotype and adherence to a regular work schedule. Block 3 comprised health status as assessed by the five

individual item scores of the EQ (mobility, self-care, usual activities, pain/discomfort, anxiety/depression). Block 4 comprised self-estimated sleep parameters (TST, SOL, WASO, TWAK, and NAP).

On Blocks 5 and 6, worry score and rumination score were considered for model entry in a stepwise fashion. Assuming that either predictor explained a significant increment in outcome variance after controlling for all covariates, the one whose inclusion offered the largest increment was entered first, and the second predictor was only added if it significantly improved model fit. A threshold of $p = .025$ ($p = .05$ divided by 2) for the partial regression coefficient of each of the two cognitive process variables was specified for stepwise entry. To address multicollinearity, predictors on any step of the model were not entered if they would result in tolerance falling below .40 for any of the other predictors. The primary analysis consisted of models that considered sleep-specific measures of worry and rumination (APSQ and DISRS) for entry on Blocks 5 and 6. To explore whether the same pattern of results occurred for general measures of worry and rumination, the models were replicated by replacing the sleep-specific measures with the PSWQ and RRS on the final blocks.

Sleep-specific worry and rumination. Table 4 describes results of analyses predicting sleep disturbance and sleep-related impairment from sleep-specific worry and rumination, including cumulative variance and unique incremental variance accounted for by each successively entered block of predictors, as well as partial regression coefficients and tolerance for individual predictors in the final models. The hierarchical model predicting the SD short form was significant, $R^2 = .58$, $F(18, 440) = 33.61$, $p < .001$. In keeping with hypotheses, the APSQ significantly predicted sleep disturbance after accounting for all covariates, and entered the model on Block 5, $\Delta R^2 = .16$, $p < .001$. However, rumination on the DISRS was non-significant

in the context of the other predictors ($p > .025$), and thus was not entered on a final block. In the final model, female gender ($\beta = .13$, $p < .001$), greater anxiety/depression ($\beta = .11$, $p < .01$), less TST ($\beta = -.12$, $p < .01$), greater SOL ($\beta = .09$, $p < .05$), greater WASO ($\beta = .18$, $p < .001$), and greater sleep-specific worry ($\beta = .51$, $p < .001$) significantly predicted greater sleep disturbance.

The hierarchical model predicting the SRI short form was also significant, $R^2 = .71$, $F(19, 439) = 56.84$, $p < .001$. Contrary to hypotheses, rumination on the DISRS was weaker than worry on the APSQ in predicting sleep-related impairment, though both variables significantly contributed to predicting the outcome. The APSQ entered the model first on Block 5, $\Delta R^2 = .21$, $p < .001$, and the DISRS subsequently entered on Block 6, $\Delta R^2 = .03$, $p < .001$. In the final model, younger age ($\beta = -.07$, $p < .05$), greater BMI ($\beta = .05$, $p < .05$), evening chronotype ($\beta = .08$, $p < .01$), greater pain/discomfort ($\beta = .08$, $p < .05$), less TST ($\beta = -.10$, $p < .01$), greater WASO ($\beta = .08$, $p < .01$), greater NAP ($\beta = .07$, $p < .05$), greater sleep-specific worry ($\beta = .45$, $p < .001$), and greater sleep-specific rumination ($\beta = .28$, $p < .001$) significantly predicted greater sleep-related impairment.

Table 4

Hierarchical Block Regression Models Predicting Sleep Outcomes Using Sleep-Specific Measures of Worry and Rumination

	SD Short Form						SRI Short Form					
Predictors	**ΣR^2**	**ΔR^2**	***B***	***SE B***	**β**	**Tolerance**	**ΣR^2**	**ΔR^2**	***B***	***SE B***	**β**	**Tolerance**
Block 1 - Demographics	.06	.06***					.08	.08***				
Age			.02	.03	.02	.79			-.08	.03	-.07*	.78
Gender			2.66	.67	.13***	.89			.66	.59	.03	.87
Body Mass Index			.02	.04	.01	.94			.08	.04	.05*	.94
Annual Household Income			-.07	.11	-.02	.88			-.06	.10	-.02	.87
Education			.10	.19	.02	.91			-.09	.17	-.01	.91
Block 2 - Circadian Factors	.10	.04***					.13	.05***				
Chronotype			.34	.17	.06	.91			.45	.15	.08**	.91
Regular Work Schedule			-.65	.88	-.03	.86			-.78	.77	-.03	.86
Block 3 - Health Status	.30	.21***					.40	.27***				
Mobility			-.17	.71	-.01	.60			-.04	.61	-.002	.60
Self-Care			-.55	.77	-.03	.69			.65	.67	.03	.69
Usual Activities			.58	.58	.04	.60			-.02	.51	-.001	.60
Pain/ Discomfort			.56	.53	.04	.59			1.11	.46	.08*	.59
Anxiety/ Depression			.99	.35	.11**	.68			.61	.32	.06	.63
Block 4 - Sleep Parameters	.42	.12***					.47	.07***				
TST			-.02	.01	-.12**	.68			-.01	.004	-.10**	.68
SOL			.03	.01	.09*	.67			-.01	.01	-.04	.67
WASO			.07	.01	.18***	.87			.03	.01	.08**	.87
TWAK			-.01	.01	-.03	.87			.003	.01	.01	.87
NAP			-.01	.01	-.01	.88			.03	.01	.07*	.87
Block 5 - APSQ	.58	.16***	.50	.04	.51***	.60	.68	.21***	.47	.04	.45***	.44
Block 6 - DISRS^							.71	.03***	.22	.03	.28***	.44

Note: *B*, *SE B*, β, and Tolerance are given for the final models comprising all of the entered predictors. Variables in Block 3 represent health domain scores on the EuroQol-5 Dimension-5 Level, which measure health problems on a scale from 1 to 5 of increasing severity; Chronotype = ordinal scale assessing circadian preference from 0 (extreme morning) to 6 (extreme evening); TST = total sleep time; SOL = sleep onset latency; WASO = wake after sleep onset; TWAK= terminal wake time; NAP = daytime napping; APSQ = Anxiety and Preoccupation About Sleep Questionnaire; DISRS = Daytime Insomnia Symptom Response Scale.
^The DISRS would not have achieved significance after APSQ's entry in the final model predicting SD short form (β = .05, $p > .025$). Thus, it was not entered into the model.
*$p < .05$, **$p < .01$, ***$p < .001$.

General worry and rumination. Table 5 describes results of exploratory analyses predicting sleep disturbance and sleep-related impairment from general trait worry and rumination. The pattern of results for the regression models built using general cognitive process measures differed somewhat from that of the models built using the sleep-specific measures, conforming more closely to hypotheses. General worry was a stronger predictor than general rumination in the hierarchical model predicting the SD short form, $R^2 = .49$, $F(19, 439) = 22.21$, $p < .001$. The PSWQ was added first on Block 5, $\Delta R^2 = .06$, $p < .001$, and the RRS was

subsequently entered on Block 6, $\Delta R^2 = .01$, $p < .01$. In the final model, female gender (β = .10, $p < .01$), evening chronotype (β = .08, $p < .05$), less TST (β = -.17, $p < .001$), greater SOL (β = .15, $p < .001$), greater WASO (β = .19, $p < .001$), greater general worry (β = .24, $p < .001$), and greater general rumination (β = .15, $p < .01$) significantly predicted greater sleep disturbance.

Conversely, general rumination was a stronger predictor than general worry in the hierarchical model predicting the SRI short form, $R^2 = .58$, $F(19, 439) = 31.76$, $p < .001$. The RRS was added first on Block 5, $\Delta R^2 = .08$, $p < .001$, and the PSWQ was subsequently entered on Block 6, $\Delta R^2 = .03$, $p < .001$. In the final model, younger age (β = -.12, $p < .001$), evening chronotype (β = .11, $p < .01$), greater pain/discomfort (β = .14, $p < .001$), less TST (β = -.15, $p < .001$), greater WASO (β = .09, $p < .01$), greater NAP (β = .14, $p < .001$), greater general rumination (β = .26, $p < .001$), and greater general worry (β = .25, $p < .001$) significantly predicted greater sleep-related impairment.

Table 5

Hierarchical Block Regression Models Predicting Sleep Outcomes Using General Measures of Worry and Rumination

	SD Short Form						SRI Short Form					
Predictors	**ΣR^2**	**ΔR^2**	***B***	***SE B***	**β**	**Tolerance**	**ΣR^2**	**ΔR^2**	***B***	***SE B***	**β**	**Tolerance**
Block 1 - Demographics	.06	.06***					.08	.08***				
Age			-.02	.04	-.02	.79			-.13	.04	-.12***	.79
Gender			1.98	.75	.10**	.85			.47	.72	.02	.85
Body Mass Index			.02	.05	.01	.94			.08	.05	.05	.94
Annual Household Income			-.07	.13	-.02	.88			-.12	.12	-.03	.88
Education			.18	.21	.03	.91			.03	.20	.004	.91
Block 2 - Circadian Factors	.10	.04***					.13	.05***				
Chronotype			.42	.19	.08*	.91			.58	.18	.11**	.91
Regular Work Schedule			-.80	.97	-.03	.86			-1.35	.93	-.05	.86
Block 3 - Health Status	.31	.21***					.40	.27***				
Mobility			-.01	.78	-.001	.60			.16	.74	.01	.60
Self-Care			-.31	.85	-.02	.68			.89	.81	.04	.68
Usual Activities			1.23	.64	.08	.60			.75	.61	.05	.60
Pain/ Discomfort			1.04	.58	.08	.60			1.95	.55	.14***	.60
Anxiety/ Depression			.71	.44	.08	.52			.58	.42	.06	.52
Block 4 - Sleep Parameters	.42	.12***					.47	.07***				
TST			-.02	.01	-.17***	.69			-.02	.01	-.15***	.69
SOL			.05	.01	.15***	.67			.004	.01	.01	.67
WASO			.07	.01	.19***	.87			.03	.01	.09**	.87
TWAK			.0003	.01	-.002	.87			.01	.01	.04	.87
NAP			.01	.02	.03	.90			.06	.01	.14***	.90
Block 5 - PSWQ / RRS^	.48	.06***	.14	.03	.24***	.48	.55	.08***	.19	.03	.26***	.46
Block 6 - RSS / PSWQ^	.49	.01**	.10	.04	.15**	.46	.58	.03***	.15	.03	.25***	.48

Note: *B, SE B*, β, and Tolerance are given for the final models comprising all of the predictors. Variables in Block 3 represent health domain scores on the EuroQol-5 Dimension-5 Level, which measure health problems on a scale from 1 to 5 of increasing severity; Chronotype = ordinal scale assessing circadian preference from 0 (extreme morning) to 6 (extreme evening); TST = total sleep time; SOL = sleep onset latency; WASO = wake after sleep onset; TWAK= terminal wake time; NAP = daytime napping; PSWQ = Penn State Worry Questionnaire; RRS = Ruminative Response Scale.

^In the model predicting SD short form, PSWQ was stepwise entered on Block 5 and RRS was stepwise entered on Block 6. In the model predicting SRI short form, RRS was stepwise entered on Block 5 and PSWQ was stepwise entered on Block 6.

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

CHAPTER 4

DISCUSSION

Worry and rumination each exhibited robust correlations with subjective sleep disturbance and sleep-related daytime impairment. Contrary to hypotheses, sleep-specific worry was stronger than sleep-specific rumination in predicting both outcomes after controlling for demographics, circadian preference and work schedule regularity, health status, and self-reported sleep parameters. Rumination accounted for enough additional information to be entered into the model predicting sleep-related impairment after worry, but not into the model predicting sleep disturbance. In an exploratory analysis substituting general trait measures of thought processes, general worry and rumination both significantly predicted sleep outcomes after controlling for all covariates. Consistent with hypotheses, worry was observed to be the stronger predictor of sleep disturbance, whereas rumination more strongly predicted sleep-related impairment.

Worry's unequivocal superiority in predicting nighttime sleep disturbance after accounting for a host of other factors suggests that continued attempts to develop and refine interventions targeting worry could be fruitful for improving insomnia treatment. In keeping with this, one recent study tested the efficacy of implementing a daytime stimulus control procedure (30 minutes of time- and place-restricted worrying each day) in individuals with high trait worry, finding that the experimental intervention produced significant reductions in worry and insomnia severity relative to a control condition (McGowan & Behar, 2013). Future investigations could test whether similar procedures add meaningfully to treatment benefits when they are applied in

tandem with conventional nighttime behavioral recommendations regarding sleep. Nevertheless, the present findings also raise questions as to whether the relatively new APSQ constitutes a "pure" measure of the sleep worry construct, given that it displayed stronger correlations with two measures of rumination than with another more established measure of worry. It is notable that the original studies administering the APSQ did not report using any measures of general worry or ruminative cognition to generate its item content or assess its validity (Jansson-Fröjmark et al., 2011; Tang & Harvey, 2004). Further efforts to develop instruments assessing sleep-specific worry could focus on achieving appropriate convergent and discriminant validity with other thought process questionnaires.

In any case, results of analyses conducted with both sleep-specific and general cognitive process measures suggest that rumination plays an independent role alongside worry in perpetuating perceived daytime functional impairment from poor sleep. Interventions seeking to decrease ruminative fixation on tiredness, fatigue, irritability, and other sleep-related symptoms may thus have distinctive benefits for treating insomnia. Behavioral activation is a psychotherapeutic strategy that has shown promise for reducing depressive rumination by increasing the likelihood of positive reinforcement from the environment, distracting from depression symptoms, and eliciting periods of respite from negative emotion that facilitate novel approaches to problem solving (Jacobson, Martell, & Dimidjian, 2001; Nolen-Hoeksema et al., 2008). Perhaps by encouraging the pursuit of positive activities during the day that distract attention from sleep-related symptoms, behavioral activation could augment the effects of traditional CBT-I aimed at improving nighttime sleep quality.

Mindfulness skills may be another useful approach for diminishing ruminative thinking over daytime insomnia impairment. In contrast with the unremitting negative evaluation of

experience that characterizes a ruminative response style, mindfulness involves attending to the present moment with an attitude of openness and acceptance (Bishop et al., 2004; Nolen-Hoeksema et al., 2008). Cultivating mindfulness has been observed to produce reductions in rumination in both community samples (Deyo, Wilson, Ong, & Koopman, 2009) and patients with depression (Ma & Teasdale, 2004; Perestelo-Perez, Barraca, Peñate, Rivero-Santana, & Alvarez-Perez, 2017), and it has also recently been applied to treating insomnia (Ong et al., 2014; Ong, Ulmer, & Manber, 2012). One investigation of follow-up data from a protocol combining mindfulness meditation with CBT-I (Ong, Shapiro, & Manber, 2009) found that although several treatment benefits were maintained for sleep over a 12-month period, only daytime sleepiness was observed to consistently display significant correlations with level of mindfulness at post-treatment, 6 months, and 12 months. Nocturnal insomnia symptoms displayed no such relation with mindfulness. The authors speculate that mindfulness skills are especially relevant to daytime sleep symptoms because heightened mindful awareness of present circumstances is antithetical to feeling tired or sleepy, or because mindful acceptance diminishes distress over perceived daytime tiredness (Ong et al., 2009). Future studies could investigate rumination as a mediating mechanism through which mindfulness skills training diminishes daytime insomnia symptomology.

The present findings also revealed that all measures of negatively toned cognitive activity (particularly those assessing rumination) displayed stronger correlations with sleep-related impairment than with sleep disturbance itself. Worry and rumination thus appear to be more instrumental in driving the interpretation of sleep's negative implications for functioning than in driving perceived deficits of actual sleep. Accordingly, greater attention should be directed toward how cognitive processes and other factors maintain insomnia during the day. Even

though insomnia is commonly conceptualized as a 24-hour disorder comprising both daytime and nighttime symptomology (Harvey, 2002), core components of CBT-I such as sleep restriction (Spielman, Saskin, & Thorpy, 1987) and stimulus control (Bootzin, Epstein, & Wood, 1991) concentrate primarily on altering behavior in the nighttime period with the aim of consolidating the sleep bout by increasing sleep efficiency and diminishing pre-sleep arousal. A recent meta-analysis (van Straten et al., 2018) concluded that results from 87 clinical trials strongly support CBT-I's efficacy for improving sleep quality and diary-assessed sleep parameters. However, the authors note that there is insufficient evidence to conclude that CBT-I improves daytime functioning, and they recommend that future insomnia studies seek to assess daytime variables such as fatigue and social activity in greater detail. Although CBT-I reliably improves subjective sleep quality and quantity, fully addressing insomnia requires corresponding changes in patients' experience of difficulties throughout the rest of the 24-hour period. Increased investigation of processes that are especially active in maintaining the daytime impairments ascribed to poor sleep could open new possibilities for more comprehensively treating the disorder.

Several limitations of the present study must be acknowledged. Firstly, all variables (including quantitative sleep parameters) were assessed using single-time point, retrospective self-estimates. Sleep is a phenomenon that varies considerably within an individual across time (Bei, Wiley, Trinder, & Manber, 2016), and the usefulness of collecting multiple nights of data in order to reliably estimate the sleep period has been noted (Gaines et al., 2015; Short, Arora, Gradisar, Taheri, & Carskadon, 2017; Wohlgemuth, Edinger, Fins, & Sullivan, 1999). Furthermore, sleep parameters were assessed in the present study using custom-worded questions, rather than a previously validated questionnaire. Future studies might seek to confirm cognitive

processes' prediction of outcomes after controlling for sleep parameters assessed prospectively across multiple nights, using both validated self-report (sleep diaries) and objective measures (actigraphy). Researchers could additionally explore temporal changes in worry and rumination severity over repeated measures, as well as how such fluctuations relate to changes in sleep quality and daytime impairment.

The present findings are also limited by the nature of the recruited sample, which comprised Internet users who completed measures online via a crowdsourcing website. At minimum, accessing the study required proficiency in Internet use and engagement in Amazon's online marketplace, which likely compromises how closely participants represent the general populace. Predictable demographic biases were observed relative to the United States population, and the mean self-estimated SOL was higher than what would be expected among normative sleepers. Additionally, analyzing a population-based sample limits the applicability of findings to clinical pathology and treatment. New studies could explore the comparative contributions of worry and rumination to predicting insomnia symptomology in clinical patients, as well as how the cognitive processes might be distinctively impacted by different approaches to intervention.

Despite these limitations, the present study used well-validated questionnaires to investigate how worry and rumination uniquely contribute to predicting subjective nighttime sleep disturbance and daytime sleep-related impairment after statistically accounting for a host of relevant covariates. Furthermore, the associations were tested in a dataset collected from around the United States that was subjected to validity checks and screening criteria. The findings build upon previous efforts to explore whether the core processes described in Harvey's (2002) cognitive model of insomnia have distinctive properties in perpetuating subjectively experienced sleep symptomology (Carney et al., 2010, 2013; Hiller et al., 2015).

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APPENDIX A: IRB APPROVAL AND REVISIONS

THE UNIVERSITY OF ALABAMA
Office of the Vice President for
Research & Economic Development
Office for Research Compliance

March 22, 2018

Joshua Tutek
Department of Psychology
College of Arts and Sciences
Box 870348

Re: IRB # 18-OR-116, "Worry and Rumination in Self-Reported Sleep Problems"

Dear Mr. 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 written documentation of informed consent and waiver of one element of informed consent. 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 March 19, 2019. If your research will continue beyond this date, please complete the relevant portions of the IRB Renewal Application. If you wish to modify the application, please 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, please complete the Request for Study Closure form.

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

Good luck with your research.

Sincerely,

[redacted]

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

358 Rose Administration Building | Box 870127 | Tuscaloosa, AL 35487-0127
205-348-8461 | Fax 205-348-7189 | Toll Free 1-877-820-3066

Participant Information Page

Study title: Attitudes, Thoughts, and Behavior in Relation to Sleep and Health
Investigator: Joshua Tutek, MA (Doctoral Student)
Institution: University of Alabama

You are invited to participate in a research study. This study is called "Attitudes, Thoughts, and Behavior in Relation to Sleep and Health" The study is being done by Joshua Tutek, M.A., 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 looking at how personal styles of thinking and feeling relate to people's health, especially their sleep at night and tiredness during the day.

Why is this study important or useful?
This study could help determine whether people who report certain patterns of thinking and feeling also have better sleep at night, or less problems during the day caused by bad sleep.

Why have I been asked to be in this study?
You have been asked to participate in this study as a person in the United States over 18 years of age, who has a registered account on the Amazon Mechanical Turk (MTurk).

How many people will be in this study?
Up to 600 MTurk workers are expected to participate.

What will I be asked to do in this study?
If you meet criteria to be in this study (you live in the U.S. and are at least 18 years old) and you agree to participate, you will fill out the following series of questionnaires in a random order. The forms begin on the next page of this Qualtrics form.

1. A Demographic and Health Survey asking questions about your demographic profile (e.g., your age, gender, race, height, weight), your work/school schedule, your level of education and income, your household makeup, health diagnoses you may have received from a healthcare professional, and medication or drug use.
2. A questionnaire asking you to describe the usual timing characteristics of your sleep period on weekdays and weekends.
3. Three questionnaires asking your typical level of sleep disturbance and insomnia, as well as sleep-related problems you may have during the day.

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4. A questionnaire asking how much depression, anxiety, or stress you normally experience.
5. Three questionnaires asking how much you tend to worry, become preoccupied, or see something as a catastrophe.
6. Two questionnaires asking how much you tend to focus on negative things and have trouble directing attention away from them.
7. A questionnaire asking about how much you are present and engaged in your daily life, and able to accept your experiences.
8. A questionnaire asking you to rate your overall health in several areas.
9. A questionnaire asking about your level of involvement in a religious or spiritual system.

How much time will I spend being in this study?
Completing all the questionnaires in the study will take you about 75 minutes.

Will being in this study cost me anything?
The only cost involved in this study is your time.

Will I be compensated for being in this study?
You will be paid $3.25 for participating in the study within 4 days of completion via MTurk's autopayment system. A Conclusion Page appearing at the very end of this Qualtrics form (after all questionnaires have been completed) will present a randomly generated code that you must record on the study description page on the MTurk website in order to receive payment.

What checks are in place to ensure that workers provide quality data?
1. Several validity questions have been mixed in randomly with the regular questionnaire items. These questions have obvious right answers (e.g., "If I am paying attention, I should select answer choice D below"). This is intended to ensure that participants do not answer randomly.
2. Additionally, the duration of the full survey form, from start to finish, is electronically timed. This is intended to ensure that workers spend an adequate amount of time on the overall survey (e.g., at least 20 minutes) before submitting, paying attention to their responses.
3. Finally, the order of questionnaires' presentation is randomized for each respondent to help account for the effects of ordering or test fatigue that comes with filling out a long form.

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. The questions you will encounter are no more distressing or offensive than anything you might encounter in a routine health or opinion survey.

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 (besides receiving $3.25).

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What are the benefits to science or society?
The results of this study may help determine whether there is a connection between certain thought patterns and better sleep or general health. Such information may be helpful to clinicians who are treating individuals who suffer from sleep problems, and looking to incorporate new strategies in their treatment approach.

How will my privacy be protected?
You will be asked a number of questions about your personal characteristics (e.g., height, weight, race, education), attitudes or beliefs, and health. 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 at any time before submitting your completed form.

How will my confidentiality be protected?
The only piece of personally identifying information you will submit to investigators with your data is your MTurk worker ID number. The data file containing your ID and data will be stored in a safe place. Once data collection for this study has ended, a random number code will be generated to represent your data. At this point, your MTurk ID will be deleted, thereby eliminating any possibility of your data being linked back to you.

What are the alternatives to being in this study? Do I have other choices?
As an MTurk worker, you may choose to participate in or not participate in any of the studies posted by requesters on the MTurk website.

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. Please note that you must complete the study to receive compensation.

The University of Alabama Institutional Review Board ("the IRB") is the committee that protects the rights of people in research studies. The IRB may review study records from time to time to be sure that people in research studies are being treated fairly and that the study is being carried out as planned.

Who do I call if I have questions or problems?
If you have questions about the study right now, please contact Joshua Tutek at uacircadiansleepstudy@gmail.com or contact his faculty advisor, Dr. Kenneth Lichstein, at lichstein@ua.edu BEFORE PROCEEDING. Mr. Tutek or Dr. Lichstein may also be contacted if you have questions about the study later on.

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If you have questions about your rights as a person in a research study, call Ms. Tanta Myles, the Research Compliance Officer of the University of Alabama, at 205-348-8461 or toll-free at 1-877-820-3066.

You may also ask questions, make suggestions, or file complaints and concerns through the IRB Outreach website at http://osp.ua.edu/site/PRCO_Welcome.html or email the Research Compliance office at participantoutreach@bama.ua.edu.

After you participate, you are encouraged to complete the survey for research participants that is online at the outreach website or you may ask the investigator for a copy of it and mail it to the University Office for Research Compliance, Box 870127, 358 Rose Administration Building, Tuscaloosa, AL 35487-0127.

Typing your MTurk worker ID below signifies your consent to be in this study. To receive compensation, *make sure you type your ID correctly*.

I have reviewed this form. I have had a chance to ask questions. I agree to take part in the study.
[ ]

I understand and agree to continue

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Conclusion Page

You have completed the study. The purpose of our study is to determine how certain thought patterns, especially worrying and ruminating, are associated with sleep problems during the night and related issues during the day. We think that worry may be a stronger force in driving sleep problems at night, and rumination may be a stronger force in driving sleep-related daytime symptoms. This could be important for treating sleep problems.

You were not informed of the full purpose of the study on the information page you read at the beginning, because knowledge of this information may have influenced your responses to questions. Now that you are aware of the full purpose of this study, you have the option to withdraw your data before submission if your feelings on participating have changed.

If you DO NOT wish to have your data used, you may select the WITHDRAW option below before clicking Submit. If you still agree for your data to be used, select "My data may be used for this study" before clicking Submit.

When you click Submit, you will be presented with a webpage displaying a randomly generated code. **You must input this code *exactly as it appears* on the MTurk page describing this study in order to receive your $3.25 payment for participating**. After inputting your code, you should receive payment via MTurk's auto-pay system within 4 days.

No personally identifiable information (MTurk ID numbers) will be saved at the end of the study. Instead, your data will be assigned a randomly generated ID in order to maintain confidentiality.

If you have questions about the study, please contact Joshua Tutek at uacircadiansleepstudy@gmail.com or his supervisor Dr. Kenneth Lichstein at lichstein@ua.edu.

If you have questions about your rights as a person in a research study, call Ms. Tanta Myles, the Research Compliance Officer of the University of Alabama, at 205-348-8461 or toll-free at 1-877-820-3066.

You may also ask questions, make suggestions, or file complaints and concerns through the IRB Outreach website at http://osp.ua.edu/site/PRCO_Welcome.html or email the Research Compliance office at participantoutreach@bama.ua.edu.

[ ] My data may be used for this study

[ ] WITHDRAW my data from this study

SUBMIT

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