THE EFFICACY OF MINDFULNESS-BASED MEDITATION IN ATTENUATING SLEEP DISTURBANCES AMONG HIGH TRAIT RUMINATORS

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INTRODUCTION

Insomnia ranks high among the most commonly reported health problems among adults in the U.S., in addition to being the most prevalent sleep disorder (Harvey, 2001). While approximately 10 – 15% of the general U.S. population meet criteria for a formal diagnosis of primary insomnia, as many as 30% report experiencing core symptoms such as difficulty initiating and maintaining sleep as often as five to thirty times a month (Center for Disease Control, 2011). With respect to its course, longitudinal, population-based studies suggest that almost 90% of diagnosed individuals remain symptomatic for as long as five years following onset, and that only about 50% achieve remission after 10 years (Janson, Lindberg, Gislason, Elmasry, & Boman, 2001; Mendelson, 1995). As such, researchers estimate the direct costs of the assessment, diagnosis, and treatment of insomnia at over $13 billion (Walsh & Engelhardt, 1999). Further, since rates of workplace absenteeism, diminished productivity, and injury are higher among individuals with insomnia, the gross economic burden of this disorder ranges between $60 and $90 billion a year (Kessler et al., 2011). Thus, research into the etiology and treatment of sleep disturbances carries significant public health implications.

Negative affect is widely recognized as a common precipitant of both subjective and objective sleep disturbances (Vandekerckhove & Cluydts, 2010). Data from neuroendocrinological studies suggest that heightened emotional reactivity to daily stressors trigger wake-promoting physiological processes such as elevated metabolic activity, diminished
heart-rate variability, and hypothalamic-adrenocortical (HPA) axis elevation (Bonnet & Arand, 1998; Rodenbeck, Heuther, Rüther, & Hajak, 1998; Vgontzas et al., 1998). HPA-axis over-activity in the form of increased corticotrophin-releasing-hormone (CRH) secretion is also correlated with sleep architectural impairments such as sleep fragmentation and diminished slow-wave sleep (Staner, Duval, Haba, Mokrani, & Macher, 2003). However, current cognitive models of insomnia posit that the processes by which negative emotions perseverate may represent a more critical etiological factor in the pathophysiology of insomnia than the emotions themselves (Espie, 2002). Data suggest that while poor sleepers are no more likely to experience negative emotions than are healthy sleepers, the former are less adept at dismissing them, and, thus, remained mired in a cycle of prolonged affective arousal (Harvey, 2005). However, few studies have attempted to discern the cognitive mechanisms responsible for sustaining the negative affect states complicit in sleep disruption. Since repetitive thought forms such as worry and rumination can derail adaptive emotional regulation and prolong negative affect states, they constitute one such mechanism.

WORRY: NATURE AND PROCESS

Broadly defined, repetitive thought refers to the process of recurrently focusing attention on the self and on the environment (Segerstrom et al., 2003). However, in the context of clinical psychology and hence this report, repetitive thought refers to the perseverative, intrusive activation of cognitive representations of psychological stressors (Watkins, 2008). This process of negatively valenced, cognitive arousal is the core feature of repetitive thought forms such as rumination and worry. However, despite such similarities in process, extant evidence suggests
that worry and rumination represent distinct cognitive mechanisms (Goring & Papageorgiou, 2008; Fresco, et al., 2002).

A characteristic feature of anxiety disorders such as generalized anxiety disorder (GAD), worry is defined as a cognitive coping mechanism triggered by a perceived threat, and involves recurrent, intrusive thoughts or images about the potential negative outcomes signaled by the threat (Borkovec, Robinson, Pruzinsky, & DePree, 1983). Commonly perceived functions of worrying among both clinical and healthy samples include problem-solving, preparation for the worst, and determining ways to avoid feared stimuli (Borkovec & Roemer, 1995). Data from an abundance of psychophysiological studies indicate that the actual process of worrying is associated with various indices of autonomic arousal such as high heart rate, low heart rate variability, and a high cortisol awakening response (Brosschot, Van Dijk, & Thayer, 2007; Schlotz, Hellhammer, Schulz, & Stone, 2004). Similarly, a wealth of data suggests that worry is not only correlated with a variety of negative emotional experiences, but is also predictive of future emotional distress (Calmes & Roberts, 2007; Llera & Newman, 2010). Thus, worry represents a perseverative thought mechanism by which cognitive manifestations of perceived threats as well as the associated emotional and physiological arousal are prolonged.

WORRY: IMPLICATIONS FOR SLEEP

Influential models, such as Borkovec and colleagues’ *Cognitive Avoidance Theory of Worry*, emerged from early insomnia research (1983). Thus, worry and insomnia have shared an almost inextricable research history. Initial impetus for the study of cognitive mechanisms in insomnia came from findings that cognitive factors may play a more central role in the
precipitation of insomnia than somatic problems. Now a landmark in the field, an early study by Lichstein and Rosenthal (1980) indicated that individuals with insomnia were 10 times more likely to attribute their insomnia to cognitive complaints such as worrying and difficulty controlling thoughts, than to somatic factors such as sweatiness and restless shifting. As theoretical and empirical models of worry as a repetitive thought construct were refined in the following decades, several research groups identified worry as a significant contributing factor to wake-promoting cognitive arousal (Harvey, 2002; Watts, Coyle, & East, 1994). Today, nearly all cognitive models maintain that individuals with insomnia engage in worrying in the pre-sleep period between going to bed and falling asleep, thus, delaying sleep onset (Harvey, 2005). Similarly, experimental studies indicate that pre-sleep worry induction is predictive not only of delayed sleep onset, but also of poor sleep continuity or intermittent awakenings during the sleep period (Hall, Buysse, Reynolds, Kupfer, & Baum, 1996).

However, a recent study on the role of repetitive thought forms in clinical insomnia exposed an important shortcoming in these models. Carney and colleagues (2010) assessed the impact of rumination, worry, depression, and anxiety on self-reported sleep difficulties in a sample of 210 patients with insomnia. Results indicated that patients with a higher tendency to ruminate in response to stress reported significantly greater levels of sleep disturbances such as poor sleep quality and intermittent awakening after sleep onset. Surprisingly, worry did not exert a main effect on sleep disturbance. As Carney and colleagues note, an alarming implication of these findings is that previous studies may have mischaracterized the repetitive thought processes observed in insomnia. In other words, rumination and not worry may serve as the key etiological agent behind wake-promoting cognitive arousal. Arguably, some of this confusion is attributable
to the inherent similarities between rumination and worry. Both rumination and worry involve negative-affect laden thoughts, and are repetitive and self-sustaining in nature (Watkins, 2008). Nevertheless, recent factor-analytic solutions of commonly used measures of these constructs suggest that despite similarities in process, rumination is a distinct cognitive mechanism (Fresco, Frankel, Mennin, Turk, & Heimberg, 2002; Goring & Papageorgiou, 2008).

RUMINATION: NATURE AND PROCESS

The response style theory conceptualizes rumination as style of responding to stressful stimuli by passively and repetitively focusing on the self or on negative mood and emotions (Nolen-Hoeksema & Morrow, 1991). Specifically, rumination involves an introspective analysis of negative thoughts and feelings as well as their causes. Thus, in contrast to worry which is typically triggered by future threats and uncertainties, rumination largely involves dwelling on past failures and self-punitive brooding for explanations of negative mood (Watkins & Moulds, 2005). Once activated, rumination is a self-sustaining process that is robust against other mechanisms competing for attention (Watkins & Brown, 2002). One theory suggests that ruminators consciously prolong the ruminative response, because they believe, albeit erroneously, that by ruminating about their problems they might better understand and eventually alleviate the associated distress (Lyubomirsky & Nolen-Hoeksema, 1993).

Notably, though early studies portray rumination primarily as a trait-level construct or tendency, more recent research suggests that levels of rumination may fluctuate on a daily basis within trait ruminators as a function of mood and affect states (Puterman, DeLongis, & Pomaki, 2010). Further, levels of state rumination may independently predict depressive symptomatology
in the absence of any trait-level differences (Moberly & Watkins, 2008). A few recent studies have established a relationship between sleep difficulties and both state and trait rumination.

RUMINATION: IMPLICATIONS FOR SLEEP

While interest in the causal role of worry in sleep impairments grew steadily since the 1980s, research on sleep and rumination began in the past decade. In 2003, Thomsen and colleagues administered self-report measures of trait rumination, depressed mood, and sleep quality to a non-clinical sample of Danish adults to assess the associations among these constructs. Their results indicated significant correlations between trait rumination and various indices of sleep quality including sleep onset latency, such that higher levels of trait rumination were associated with poorer sleep outcomes. Further, rumination was significantly associated with overall sleep quality even after controlling for the collinearity between rumination and depressed mood. Similarly, in a comparison of self-reported good and poor sleepers, Carney and colleagues (2006) found that poor sleepers reported significantly higher levels of trait rumination. Taken together, these studies offer convincing evidence that individuals with a ruminative response style are more likely to experience sleep difficulties than are individuals without such a cognitive vulnerability. However, due to the correlational nature of these data, neither study was able to establish a causal relationship between rumination and sleep disturbance. An equally plausible alternative explanation for the covariation between rumination and sleep disturbance is that the inability to fall asleep after going to bed may provide an opportunity for ruminative thinking. Thus far, only two studies have attempted to examine the impact of rumination on sleep by experimentally manipulating levels of rumination prior to bed.
Guastella and Moulds (2007) aimed to assess the effects of experimentally induced ruminative thoughts on sleep quality in a sample of 114 college students. Based on scores on a self-report measure of trait rumination, they divided their sample into two groups: high-ruminators and low-ruminators. Next, they randomly assigned participants in both groups to either a rumination condition or a distraction condition. Prior to going to bed on the night following a mid-term exam, participants in the rumination and distraction conditions respectively performed a rumination induction task or a standard distraction exercise. Upon waking the following morning, participants reported the quality of sleep they experienced the previous night. Analyses revealed that high-ruminators assigned to the rumination condition reported significantly poorer sleep quality than high-ruminators in the distraction condition and low-ruminators in either condition. In other words, ruminating prior to bed impaired sleep among those predisposed to a ruminative response style.

Similarly, a more recent study attempted to examine the association between experimentally induced rumination and objective sleep disruption (Zoccola, Dickerson, & Lam, 2009). In this study, a sample of young adults arrived at a laboratory one afternoon to complete a series of tasks in the following order: first, they completed a measure of trait-rumination; next, after a five-minute preparation window, they delivered a speech which was negatively evaluated by a panel of judges; finally, at the end of this session, participants received activwatches programmed to monitor sleep onset and duration. Participants wore the activwatches for a single night and completed paper-and-pencil based measures of sleep quality after waking the next morning. Activwatch data indicated a significant impact of both state and trait rumination on SOL,
such that participants who scored high on these measures of rumination reported significantly longer SOL.

MINDFULNESS: NATURE AND PROCESS

A natural extension of this research is the search for an intervention capable of attenuating the sleep interfering effects of rumination. Given its theoretical and empirical concordance with rumination, mindfulness-based meditation (MM) has emerged as a favorable candidate for such an intervention in recent years (Carney & Segal, 2005). A modern day adaptation of the ancient Buddhist practice of vipassana or insightful meditation, Kabat-Zinn’s (1994) mindfulness-based stress reduction (MBSR) program conceptualizes mindfulness as a cognitive style which fosters a present-focused, non-judgmental awareness of thoughts and emotions. In contrast to previous cognitive therapies which involve challenging or confronting maladaptive thoughts, mindfulness-based techniques such as MM focus on the recognition of thoughts as entities distinct in origin and nature from the self or objective reality. Accordingly, such decentering or perspective shifting allows for an adaptive, non-reactive acceptance of negative thoughts and feelings as well as of any distorted realities to which they allude (Segal, Williams, & Teasdale, 2002). Further, unlike behavioral relaxation techniques such as progressive muscle relaxation which aim to actively induce relaxation by tensing and relaxing a series of muscle groups, MM involves directing attention to bodily sensations that arrive in the moment (Ong, Shapiro, & Manber, 2008). Since its development, MM has been efficacious in the treatment of a number of medical conditions including chronic pain, fibromyalgia, GAD, and depression (Chiesa & Serretti, 2011).
MINDFULNESS: IMPLICATIONS FOR RUMINATION

Despite their diffuse application in a wide array of psychological contexts, mindfulness-based interventions are especially germane to rumination and depression for a number of reasons. First, rumination involves a perseverative analysis of discrepancies between current and desired mood states often leading to self-blame and self-criticism (Lyubomirsky, Tucker, Caldwell, & Berg, 1999). Theoretically, this aspect of rumination is contrary to the non-judgmental, non-reactive acceptance of ego-dystonic thoughts and emotions involved in mindfulness. Similarly, while rumination is often accompanied by attempts to suppress or avoid unwanted thoughts and emotions (Dickson, Reilly, & Ciesla, 2011), mindfulness is based on an open-minded willingness to experience all forms of thoughts and feelings (Segal et al., 2002).

Not surprisingly, multiple studies have demonstrated an association between the use of mindfulness and reductions in rumination. Kingston and colleagues (2007) found that adherence to mindfulness-based cognitive therapy was significantly correlated with reduced levels of rumination among outpatients with recurrent depression. Similarly, in a study on the effectiveness of mindfulness in treating affective symptoms, practicing MM led to a significant decrease in ruminative thinking even after controlling for reductions in negative affect (Ramel, Goldin, Carmona, & McQuaid, 2004).

This inverse association between rumination and mindfulness has key treatment implications for sleep difficulties. A substantial body of evidence suggests that individuals with sleep difficulties typically engage in thought suppression to minimize the cognitive arousal triggered by repetitive thought forms such as rumination (Ansfield, Wegner, & Bowser, 1996;
Allison G. Harvey, 2003). However, in a review of this literature, Harvey (2005) noted that most thought suppression techniques are not only ineffective but are also associated with poor sleep outcomes. Consistent with Wegner’s (1994) Ironic Process Theory, a number of intervention studies indicate that engaging in thought suppression prior to bed results in a paradoxical increase in cognitive load and thus cognitive arousal (Harvey, 2003). On the other hand, mindfulness, given its focus on acceptance and non-reactivity, may represent a more suitable technique for reducing rumination-related arousal.

A recent randomized controlled trial compared the effectiveness of MM to a somatic relaxation program composed of training in progressive muscle relaxation, diaphragmatic breathing, and guided imagery (Jain et al., 2007). Results indicated that participants who engaged in MM experienced a reduction in ruminative thoughts at a one month follow-up, while relaxation training had no effect. Further, data from multiple studies indicate that various distraction strategies, including engaging in pleasant activities, are only effective for a limited time period and under specific circumstances (Broderick, 2005; Hamilton & Ingram, 2001). On the other hand, by changing patients’ attitudes towards their thoughts to one of gentle acceptance, mindfulness helps cultivate a more holistic and enduring defense against the cycle of repetitive and automatic negative thinking (Teasdale et al., 2002).
MINDFULNESS: IMPLICATIONS FOR SLEEP

Two systematic reviews of the empirical literature on MBSR for sleep concluded that although this treatment offered promise in the management of insomnia, additional clinical trials were needed to satisfactorily establish efficacy (Lundh, 2005; Winbush, Gross, & Kreitzer, 2007). Despite relatively broad inclusion criteria, these reviews were only able to identify seven independent clinical trials, only four of which demonstrated statistically significant improvements in sleep outcomes following MBSR. Further, over half of these studies did not include a control group, and none of them employed an objective sleep outcome, such as PSG or actigraphy. However, additional data in support of MBSR have emerged from a few recent pilot studies.

Preliminary data from an ongoing evaluation (Ong, Shapiro, & Manber, 2008) of a six-week multi-component therapy which integrates MM with cognitive behavior therapy for insomnia (CBTI) suggest that MM may play a role in improving sleep. In this pilot study, 30 participants engaged in mindfulness-based interventions, including breathing and eating meditation, along with other components of CBTI, such as sleep restriction and stimulus control. Specifically, following a formal introduction to mindfulness-based meditation during the second week, participants were instructed to practice mindfulness-based exercises at home for the remainder of treatment. Analyses revealed a significant improvement in several diary-based sleep indices between pre- and post-treatment assessments, including sleep efficiency, number of awakenings, and total wake time. However, as this study did not include a control group, the independent effects of mindfulness on sleep outcomes could not be established.
Similarly, Gross and colleagues (2011) compared the efficacy of pharmacotherapy with eszopiclone (LUNESTA™) to that of an eight-week-long program which combined MBSR with sleep hygiene education. A sample of 30 adults with chronic insomnia, 20 of whom were randomly assigned to the MBSR group, provided self-reported as well as actigraphy-based sleep data at baseline, and at a follow-up assessment five months following treatment. Analyses revealed a significant improvement in actigraphy-based sleep onset latency between baseline and follow-up for the MBSR group, though other parameters such as total sleep time and sleep efficiency were unaffected. Similarly, scores on self-report questionnaires and diary-based sleep onset latency, total sleep time, and sleep efficiency also improved significantly from baseline to follow-up. Finally, there were no significant differences between the MBSR and pharmacotherapy groups on any sleep outcome at follow-up, suggesting that both groups achieved comparable efficacy.

Indirect evidence for the favorable effects of MM on sleep is also available in a recent clinical trial of mindfulness-based cognitive behavior therapy (MBCT), a novel therapeutic modality which combines cognitive behavior therapy with MM exercises described in MBSR. In this study, an Australian sample of 26 psychiatric outpatients who presented with mood and anxiety disorders engaged in an eight-week MBCT program. Following treatment, participants reported statistically and clinically significant improvements on an empirically validated measure of insomnia severity (Ree & Craigie, 2007).

Taken together, the above studies have yet to reliably establish the efficacy of MM in improving sleep due to obvious methodological limitations, such as modest sample sizes, quasi-
SUMMARY AND LIMITATIONS OF CURRENT FINDINGS

The extant literature offers preliminary evidence to suggest that a ruminative response style may be associated with sleep difficulties. However, a number of methodological shortcomings undermine the validity of these findings. First, since none of these studies included a state measure of rumination, it is impossible to determine whether participants actually experienced ruminative cognitions prior to bed time. While the study by Guastella and Moulds (2007) marked a significant advance in this direction, their protocol did not involve a manipulation check to confirm the effectiveness of the rumination induction task.

A second systemic problem in most current studies is their reliance on self-report measures of sleep. A substantial body of evidence suggests that participants in sleep studies often report sleep disturbances in the absence of any demonstrable disruption in objectively measured sleep (Parrino, Milioli, De Paolis, Grassi, & Terzano, 2009; Rosa & Bonnet, 2000). In a recent report, a panel of 25 sleep assessment experts specifically recommended the use of both self-report measures as well as objective assessment techniques such as actigraphy for future research (D. Buysse, Ancoli-Israel, Edinger, Lichstein, & Morin, 2006b). Such a multi-method approach can help improve protocol validity by reducing contamination due to perceptual or reporting biases.

A third limitation in these studies is the use of data from a single night of sleep assessment. Sleep researchers have long warned against a “first-night” effect on the reliability of
sleep measures in such studies owing to inadvertent participant reactivity to study protocols
(Toussaint, Luthringer, Schaltenbrand, & Carelli, 1995). Prior sleep studies have discovered that
participants typically experience longer sleep onset latencies, shorter total sleep periods, and
lower indices of sleep efficiency on the first night of these studies due to discomfort caused by
the demand characteristics of participation and other changes in their sleep environment (Selwa
et al., 2008; Suetsugi, Mizuki, Yamamoto, Uchida, & Watanabe, 2007). Further, based on its
review of sleep studies using actigraphy, the American Academy of Sleep Medicine (AASM)
recommends continuous actigraph measurement for at least three nights to account for between-
night variance (Rowe et al., 2008).

Finally, this literature has yet to adequately address the treatment implications of the
association between repetitive thought and sleep difficulties. Current non-pharmacological
treatments for insomnia, including cognitive behavior therapy for insomnia (CBTI), do not target
the impact of rumination on sleep (Carney et al., 2010). Although these treatments include a
cognitive restructuring module aimed at identifying dysfunctional beliefs or expectations about
healthy sleep, no study has addressed the impact of these interventions on repetitive thought.
Even recent efforts to integrate MM into CBTI (Ong et al., 2008) have focused exclusively on
sleep-based outcomes, and not on the efficacy of MM in attenuating the association between
repetitive thought and sleep.

Further, the majority of the evidence for the efficacy of mindfulness-based interventions
such as MM has emerged from treatment studies. A recent review of this literature revealed that
only a quarter of the 98 included studies measured patient adherence to therapeutic suggestions
such as practicing MM at home (Vettese, Toneatto, Stea, Nguyen, & Wang, 2009). Secondly, all
reviewed studies relied on correlation designs to assess the relationship between mindfulness and clinical outcomes. These methodological limitations have precluded treatment studies from inferring a reliable association between mindfulness and clinical improvement, since alternative explanations such as demand characteristics and common therapy factors cannot be ruled out. Experimental studies are therefore needed to fully delineate the mechanisms of change in mindfulness-based interventions.

THE PRESENT STUDY: SPECIFIC AIMS AND RESEARCH STRATEGY

The present study aimed to delineate the relationship between rumination and sleep difficulties, in addition to assessing the efficacy of mindfulness in attenuating this relationship. To ensure adequate variability on key study variables such as rumination and negative affect, a sample of high trait ruminators participated in the study. Baseline levels of depressive symptoms were also assessed to account for the covariance between depression and rumination. Participants were randomly assigned to one of two groups: a mindfulness group or a distraction group. Two studies were proposed.

Study 1 followed a naturalistic daily diary design to assess nightly levels of rumination and their association with various indices of sleep among participants regardless of group membership. To extricate the impact of rumination from other forms of negative repetitive thought, nightly levels of worry were also assessed. Using a multi-method approach to sleep assessment, sleep disturbances were not only self-reported by participants using a web-based sleep diary, but were also measured objectively using actigraph technology. While actigraphs offer reliable measurements of circadian rhythm variables such as total sleep time and number of
nocturnal awakenings, they fail to capture other pertinent sleep variables such as participants’ perceptions of sleep quality. Prior studies have consistently highlighted the role of perceived sleep quality in moderating the relationship between objective sleep parameters and daytime dysfunction (Ustinov et al., 2010). Use of sleep diaries in conjunction with actigraphy thus facilitates a more comprehensive assessment of sleep difficulties. Further, to avoid any first-night effects, participants were followed for a whole week, during which period they completed short, web-administered questionnaires just before going to bed each night and once again upon waking the following morning. This daily diary approach has been shown to minimize the recall biases that plague assessment via retrospective questionnaires while providing reliable data on night-to-night variability in sleep disturbances (Buysse et al., 2006b). Further, since various forms of dysphoric affect show considerable within-person variability over time even in short assessment intervals, more state-sensitive measures are warranted to adequately capture these constructs (Trull et al., 2008).

While Study 1 aimed to validate the association between repetitive thought and sleep impairment, Study 2 sought to assess the efficacy of MM in suppressing rumination and improving sleep. Hence, in Study 2, participants in the mindfulness and distraction groups engaged respectively in either an MM exercise or a relatively inert distraction induction just before going to bed. Study 2 began immediately after Study 1, and continued for another seven days. Thus, participants were enrolled in the study for a total of two weeks. Just as in Study 1, participants continued to report on daily levels of affect and repetitive thought using web-delivered questionnaires right before going to bed and immediately after waking.
For Study 1, I hypothesized that: (1) daily negative affect will be significantly associated with sleep onset and maintenance difficulties; (2) daily rumination and worry will also be predictive of sleep disturbances. With regard to Study 2, I hypothesized that participants in the mindfulness group will experience better sleep outcomes and lower levels of negative affect than those in the distraction group. The final hypothesis was that participants in mindfulness groups will experience better sleep outcomes and lower levels of repetitive thought during Study 1 than during Study 2.
PARTICIPANTS

Participants were recruited from a large survey study involving undergraduate college students enrolled in psychology courses at Kent State University (KSU). Specifically, participants who reported high levels of trait rumination (1.5 standard deviations above the mean) received electronic invitations to participate in the present study. A total of 112 participants met these criteria, 42 of whom agreed to participate in this study (see Appendix for a flowchart of this process). This sample was predominantly female (74%), while other demographic characteristics reflected those of the KSU student body (see Table 1).

PROCEDURE

On the first day of the study, participants arrived at the laboratory, provided informed consent, and completed a series of questionnaires designed to assess baseline levels of sleep difficulties and depressive symptoms. They were then randomly assigned, using a computerized algorithm, to either a mindfulness or a distraction group. Next, an experimenter informed them of their responsibilities during the daily diary phase of the protocol, in addition to familiarizing them with the nature and practice of the mindfulness and distraction exercises. Finally, before leaving the laboratory, participants received an actiwatch to take home with them for the duration of the study.
Study 1 (days one through seven): Starting the same day, participants in both groups began completing brief, roughly 10-minute long, questionnaires designed to assess daily levels of negative cognitions just prior to going to bed. Immediately after waking the following morning, participants reported the duration and quality of sleep they experienced the previous night. Participants completed this protocol for a period of seven days.

Study 2 (days eight through fourteen): As before, participants continued to complete electronic questionnaires before bed and upon waking during this phase of the study. However, after completing the nightly questionnaires, participants in the mindfulness and distraction groups also partook in a web-administered mindfulness- or distraction-induction task respectively. This experimental induction took roughly 8 minutes to complete. On the fifteenth day, participants returned to the lab for debriefing and compensation. As there are presently no empirically validated manipulation checks available for mindfulness or distraction inductions,

Table 1. Sample Characteristics (N = 42)

<table>
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<th>Mean (SD)</th>
<th>Median</th>
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<th>Maximum</th>
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<td>Gender (% Female)</td>
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<td>Race (% White)</td>
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<td>37.03 (9.94)</td>
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<td>22</td>
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</tbody>
</table>

Note. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory, Second Edition
participants completed a state measure of affect before and after the induction. Pre-to-post induction changes in affect provided a proxy for the efficacy of the induction tasks.

MEASURES

*The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, & Berman, 1989).*

The PSQI is a self-report instrument designed to assess the quality and pattern of sleep in adults across seven dimensions: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Responses are scored on a Likert-type scale from “0” to “3”, such that a “3” reflects the negative extreme on the scale. A global score of “5” or greater indicates a poor sleeper, who experiences serious difficulties in two areas of sleep quality or moderate difficulties in three areas. The PSQI achieved good internal consistency (α = 0.83) in the present study.

*The Beck Depression Inventory - Second Edition (BDI-II; Beck, Steer, Ball, & Ranieri, 1996):* The BDI-II is a 21-item self-report inventory used to assess various cognitive, affective, and somatic symptoms of depression, per *DSM-IV* criteria. Respondents indicate the severity of any existing symptoms on a Likert-type scale from “0” to “3” with higher scores indicating greater severity. Beck and colleagues report high internal consistency for the BDI-II among both clinical and non-clinical populations. In the present study, the BDI-II showed excellent internal consistency (α = 0.93).
REPEATED MEASUREMENTS

Daily versions of questionnaires assessing negative affect, repetitive thought, and self-reported sleep quality were adapted for use in this study from the following standardized instruments:

*The Response Style Questionnaire, Rumination Scale (RSQ: Nolen-Hoeksema & Morrow, 1991).* The RSQ is a self-report inventory designed to assess the presence and persistence of ruminative coping strategies in response to depressed mood. It consists of 25 items scored on a Likert-type scale ranging from 1 (almost never) to 4 (almost always), with higher scores indicating a greater propensity for rumination in response to depressed mood. Past research indicates that the RSQ offers a valid and reliable measure of trait rumination (Bagby, Rector, Bacchiochi, & McBride, 2004).

*The Penn-State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990).* The PSWQ is a 16-item self-report questionnaire designed to measure trait worry, including the pervasiveness, excessiveness, and uncontrollability of worry. Respondents rate the extent to which items are characteristic of their worry habits on a five-point Likert-type scale ranging from “not at all typical” to “very typical”.

*The Positive And Negative Affect Schedule-Expanded Form (PANAS-X; Watson & Clark, 1994).* An extended version of the PANAS, a widely used self-report measure that assesses various types of positive and negative affective states, the PANAS-X includes additional items that allow for the creation of subscales for the assessment of specific affect states. The present study used three of the four negative emotion subscales from the PANAS-X: sadness, fear, and...
hostility. Participants reported the extent to which they felt a particular affect state on five-point Likert-type scale ranging from 1 (“not at all”) to 5 (“extremely”).

Daily levels of negative affect, cognitions, and self-reported sleep quality were assessed using web-administered electronic questionnaires through Qualtrics, an internet-based software suite developed by Qualtrics Inc. (Provo, UT). Participants answered two sets of questionnaires: one set before going to bed, and a second set upon waking in the morning. Questionnaires in each set were continuously generated until all questionnaires were completed. Order of questions was randomized to reduce indiscriminate responding, and time stamps were recorded to eliminate questionnaires completed at times inconsistent with the study protocol. The electronic questionnaires assessed the following constructs:

Rumination. Daily levels of rumination were assessed using the brooding and reflective pondering scales (Treynor, Gonzalez, & Nolen-Hoeksema, 2003) of the RSQ (S Nolen-Hoeksema & Morrow, 1991). However, the items were modified to assess ruminative thoughts experienced during the day, as well as while lying in bed. For instance, on each night before going to bed, participants rated on a scale from 1 (not at all) to 4 (all the time) how often they “thought about how sad you felt”, or “thought about your shortcomings, faults, and mistakes” during that particular day. In the present study, the daily RSQ achieved excellent internal consistency (α = 0.94).

Worry. Daily levels of worry were assessed using a shortened version of the PSWQ (Meyer et al., 1990), with the exception that items were modified to assess daily levels of worry. Items targeted the generality, excessiveness, and uncontrollability of reported worries. Participant rated “how true” statements, such as “I found it difficult to dismiss worrisome
thoughts” and “I did not worry about things”, were of them on each day of the study on a scale from 1 (not at all true) to 5 (very true). This version of the PSWQ possessed excellent internal consistency in the present sample (α = 0.92).

Affect. The PANAS-X was modified to assess daily levels of negative affect. Participants completed this scale before and after the experimental induction to assess the efficacy of the induction. Order of items within each scale was randomized to discourage indiscriminate responding. In the present study, these scales achieved high internal consistency (Cronbach’s α = 0.89).

Sleep Quality. A shortened version of the PSQI (Buysse et al., 1989) was used to assess nightly levels of total sleep time (TST), sleep onset latency (SOL), and subjective sleep quality (SQ). For instance, after waking each morning, participants rated the “quality of sleep last night” and reported “how many hours of sleep did you get last night” or “how long did it take you to fall asleep last night”. Participants also reported any sleep interfering behaviors in which they engaged before going to bed such as napping, smoking cigarettes, and consuming caffeinated or alcoholic beverages. Data from such nights were stricken from analysis. In the present study, this PSQI-based daily questionnaire achieved good internal consistency (α = 0.82).

EXPERIMENTAL MANIPULATION

During the distraction and mindfulness inductions, participants received a series of instructions or prompts on a computer screen for a period of 8 minutes. Participants were instructed to read each prompt slowly and quietly to themselves, while using their imagination and concentration to deliberately focus on each idea. The distraction task consisted of neutral instructions such as, “think about a ship slowly crossing the Atlantic” or “think about a freshly
painted door”. Developed by Morrow and Nolen-Hoeksema (1990), this distraction task has found repeated use in prior experimental studies (Broderick, 2005; Lyubomirsky & Nolen-Hoeksema, 1993; Vickers & Vogeltanz-Holm, 2003). Similarly, the mindfulness task was based on a meditation exercise from Kabat-Zinn’s (1990) MBSR program, and has been validated in a number of recent treatment studies (Broderick, 2005; Jain et al., 2007; Ong et al., 2008). Instructions in the mindfulness task encouraged breathing awareness and self-acceptance by asking participants to allow thoughts and feelings to “come and go” without dwelling on them. Some of the items included, “bring your attention to your breathing” and “thoughts will come to your head … simply notice those thoughts, then bring your attention back to your breathing”.

ACTIGRAPHY

All participants received an actigraph to wear on the wrist of the non-dominant hand for the duration of the study. Actigraphs are small motion detectors (acceloremeters) capable of distinguishing wakefulness from sleep based on algorithms that account for the reduced movement that characterizes the sleep state. Past research on actigraph assessment of sleep variables such as sleep onset latency and duration of sleep suggest that actigraphs are psychometrically comparable to polysomnography (PSG), the gold standard for sleep assessment (Jean-Louis, Kripke, Cole, Assmus, & Langer, 2001). Further, since actigraphs, given their small size and ergonomic design, are less intrusive than PSG techniques, they can be worn at home and elicit less participant reactivity. The actigraphs (Actiwatch-2, Mini Mitter Company Inc., OR, USA) in the present study weighed 16 grams with a standard wrist band, and were programmed to sample motion per 15-second epochs. The accompanying software program used the standard,
empirically validated *Sadeh Algorithm* to perform sleep-wake analyses (Sadeh, Sharkey, & Carskadon, 1994).

**ANALYTIC STRATEGY**

As each participant reported levels of negative affect and sleep difficulties at multiple points during the study, these data were inherently hierarchical in nature. Specifically, the present study assessed both within-person variations in the association between repetitive thought and sleep difficulties (Study 1), and whether there were any between-person differences across experimental groups (Study 2). For instance, sleep difficulties may vary within the same participant as a function of the experimental manipulation (control days vs. experimental days). In other words, Study 1 models the within-person changes in sleep difficulties as a function of daily variations in levels of rumination. On the other hand, Study 2 models the between-person effects of group membership (mindfulness vs. distraction) on sleep during days eight through fourteen.

Since ordinary least squares (OLS) regression cannot simultaneously model both within-person and between-person variations in a nested data set, hierarchical linear modeling (HLM) was used to assess the major hypotheses of the study (Bryk & Raudenbush, 1992). Accordingly, a person-period data structure was used to enter data, and a two-level model was specified with time (level-1) nested within person (level-2). Examples of such multi-level models appear below.

**Study 1: Rumination predicting sleep difficulties.**

\[
\text{Sleep}_{ij} = \pi_{0i} + \pi_{1i}(\text{Rumination}_{ij-1}) + \pi_{2i}(\text{Gender}_i) + \pi_{1i}(\text{Depression}_i) + \zeta_{0i} + \varepsilon_{ij}
\]
Study 2: Condition (Distraction vs. Mindfulness) predicting sleep difficulties.

\[
\text{Sleep}_{ij} = \pi_{0i} + \pi_{1i}(\text{Condition}_i) + \pi_{2i}(\text{Gender}_i) + \pi_{3i}(\text{Depression}_i) + \zeta_{0i} + \epsilon_{ij}
\]

where

- \( \text{Sleep}_{ij} \): Sleep difficulties for person ‘i’ at observation ‘j’
- \( \text{Rumination}_{i,j-1} \): Rumination reported by person ‘i’ at observation ‘j-1’ i.e., the night before
- \( \text{Gender}_i \): Gender of person ‘i’
- \( \text{Condition}_i \): A dummy variable representing group membership, coded as ‘0’ for the distraction group and ‘1’ for the mindfulness group
- \( \text{Depression}_i \): Baseline levels of depression for person ‘i’, based on BDI-II scores
RESULTS

PRELIMINARY ANALYSES

To avoid any “first-night” effects on validity and reliability (Selwa et al., 2008), data from the first night of the study were stricken from analyses. Further, only days on which a one-to-one correspondence between ‘before bed’ and ‘after waking’ measures could be established were included. Finally, only participants who provided at least four days of continuous data during each seven-day study were retained in the analyses. Three participants did not meet these criteria leaving a total of 39 participants, 92% of whom provided complete data. The number of days of data completion did not correlate significantly with any study variables. Univariate outliers were eliminated based on skewness and kurtosis estimates (West, Finch, & Curran, 1995), as well as a visual inspection of histograms.

Baseline levels of rumination and depression appear in Table 2. Analyses revealed no significant between-group differences between the mindfulness and distraction groups on either measure. Similarly, there were no statistically significant between-group differences between on any of the objective or subjective sleep indices in Study 1. During Study 2, a comparison of within-person changes in affect following the experimental manipulation revealed that both the distraction ($t = 3.79; p < .05$) and mindfulness exercises ($t = 3.96; p < .01$) were effective in improving affect in their respective groups.
Table 2. Objective and Subjective Sleep Measures at baseline (N = 39; Mindfulness N = 20; Distraction N = 19).

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Median</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetitive Thought</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>60.82 (15.92)</td>
<td>62.50</td>
<td>1.26</td>
<td>.190</td>
</tr>
<tr>
<td>Distraction</td>
<td>57.73 (14.56)</td>
<td>55.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-II</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>37.99 (8.75)</td>
<td>38.00</td>
<td>1.33</td>
<td>.194</td>
</tr>
<tr>
<td>Distraction</td>
<td>35.63 (10.12)</td>
<td>33.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep: Actigraphy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TST&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>436.37 (119.41)</td>
<td>431.00</td>
<td>1.89</td>
<td>.059</td>
</tr>
<tr>
<td>Distraction</td>
<td>406.09 (92.12)</td>
<td>398.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOL&lt;sup&gt;a&lt;/sup&gt;</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>25.58 (27.46)</td>
<td>18.00</td>
<td>1.04</td>
<td>.301</td>
</tr>
<tr>
<td>Distraction</td>
<td>20.66 (28.41)</td>
<td>12.00</td>
<td></td>
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</tr>
<tr>
<td>SE</td>
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<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>84.98 (8.71)</td>
<td>8.71</td>
<td>0.35</td>
<td>.727</td>
</tr>
<tr>
<td>Distraction</td>
<td>84.46 (8.39)</td>
<td>8.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep: Electronic Diary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TST&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>6.99 (1.71)</td>
<td>7.00</td>
<td>0.67</td>
<td>.500</td>
</tr>
<tr>
<td>Distraction</td>
<td>6.83 (1.76)</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQ&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>2.19 (0.80)</td>
<td>2.00</td>
<td>0.34</td>
<td>.736</td>
</tr>
<tr>
<td>Distraction</td>
<td>2.15 (0.69)</td>
<td>2.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOL&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>2.31 (1.02)</td>
<td>2.00</td>
<td>0.44</td>
<td>.662</td>
</tr>
<tr>
<td>Distraction</td>
<td>2.16 (1.05)</td>
<td>2.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. a = measured in minutes; b = measured in hours; c = self-reported on Likert-type scale from 1 through 4, with higher scores indicating worse sleep quality; d = self-reported on Likert-type scale from 1 through 6, with higher scores indicating greater sleep onset latency; t = t-test for between group differences; RSQ = Response Style Questionnaire-Rumination Scale; BDI-II = Beck Depression Inventory II
STUDY 1

The following set of analyses assessed the within-person relationship between repetitive thought and objective/subjective indices of sleep. Specifically, these analyses tested whether daily within-person changes in repetitive thought were predictive of sleep impairments during Study 1 (days 2 through 7).

*Actigraphy based sleep indices:* I first fit an unconditional means model with SOL regressed on an intercept, a level-1 residual (within-persons), and a level-2 (between-persons) residual (see Singer & Willett, 2003, p. 92). Results indicated that approximately 77% of the total variance in SOL was due to within-person fluctuations, and examination of the confidence interval (95% CI between: [346.37 – 514.34]) indicated that this variance was significantly different from zero. Similar, significant within-person variances were observed for SE and TST. Thus, the data revealed significant variations in daily levels of actigraphy-based sleep variables to justify examination of time-varying outcomes. Next, I explored whether demographic variables and time were significantly associated with these variables. Gender was significantly associated with SOL ($z = 2.86; p < .05$), with women reporting longer SOLs. Time, age, and race were not significantly associated with any of the sleep indices. Hence, gender was added as a covariate in all further analyses along with participants’ baseline levels of sleep (based on the PSQI). Similarly, given the well-established association between depression and sleep, analyses also controlled for baseline levels of depression. As can be seen in Table 3, daily rumination ($z = 2.44; p < .05$) was significantly associated with SOL, such that higher levels of rumination were
Table 3. Study 1: Repetitive thought predicting actigraphy-based SOL (N = 39)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>β</th>
<th>Z</th>
<th>p-value</th>
<th>Wald’s χ²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level - 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Intercept</td>
<td>13.83</td>
<td>2.11</td>
<td>.035*</td>
<td>15.68</td>
<td>.004**</td>
</tr>
<tr>
<td>Rumination</td>
<td>0.31</td>
<td>2.44</td>
<td>.015*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level - 2</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>6.09</td>
<td>2.21</td>
<td>.027*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-II</td>
<td>0.17</td>
<td>1.49</td>
<td>.136</td>
<td></td>
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<tr>
<td>PSQI</td>
<td>0.44</td>
<td>0.98</td>
<td>.328</td>
<td></td>
<td></td>
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<td><strong>Level - 1</strong></td>
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<td></td>
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<tr>
<td>Intercept</td>
<td>15.31</td>
<td>2.23</td>
<td>.026*</td>
<td>7.97</td>
<td>.09</td>
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<tr>
<td>Worry</td>
<td>0.08</td>
<td>0.23</td>
<td>.817</td>
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<td><strong>Level - 2</strong></td>
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<td>7.08</td>
<td>2.46</td>
<td>.014*</td>
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<tr>
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<td>0.71</td>
<td>.478</td>
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<tr>
<td>PSQI</td>
<td>.59</td>
<td>1.29</td>
<td>.196</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. SOL = Sleep onset latency; PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II

*p < .05

**p < .01

predictive of longer SOLs. Worry was not significantly related with SOL, and neither repetitive thought form was significantly associated with TST or SE.

*Electronic diary based sleep indices:* The unconditional means model indicated that approximately 54% of the total variance in SOL was due to within-person fluctuations, and examination of the confidence interval (95% CI between: [0.49 – 0.72]) indicated that this variance was significantly different from zero. Similar significant within-person variances were observed for SQ and TST. Thus, the data revealed significant variations in daily levels of diary-based sleep. Next, I explored whether demographic variables and time were significantly
Table 4. Study 1: Repetitive thought predicting diary-based SOL (N = 39)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>β</th>
<th>Z</th>
<th>p-value</th>
<th>Wald’s $\chi^2$</th>
<th>p-value</th>
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<tr>
<td>Intercept</td>
<td>0.79</td>
<td>1.88</td>
<td>.060</td>
<td>26.40</td>
<td>.000**</td>
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<tr>
<td>Rumination</td>
<td>0.04</td>
<td>3.18</td>
<td>.001**</td>
<td></td>
<td></td>
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<td><strong>Level – 2</strong></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.29</td>
<td>1.28</td>
<td>.220</td>
<td></td>
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<tr>
<td>BDI-II</td>
<td>0.01</td>
<td>0.59</td>
<td>.283</td>
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<tr>
<td>PSQI</td>
<td>0.08</td>
<td>2.23</td>
<td>.026*</td>
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<tr>
<td><strong>Level – 1</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.61</td>
<td>1.44</td>
<td>.150</td>
<td>22.17</td>
<td>.000**</td>
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<tr>
<td>Worry</td>
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<td>2.47</td>
<td>.013*</td>
<td></td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
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<td>1.64</td>
<td>.102</td>
<td></td>
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<tr>
<td>BDI-II</td>
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<td>0.93</td>
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</tr>
<tr>
<td>PSQI</td>
<td>0.07</td>
<td>1.94</td>
<td>.052</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. SOL = Sleep onset latency; PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II

* $p < .05$

** $p < .01$

associated with these variables. Neither time, nor any of the demographic variables were significantly related to SOL. However, given the well-established association between sleep and gender (Arber, Bote, & Meadows, 2009), all further analyses also controlled for gender. Daily levels of both rumination ($z = 3.18; p < .01$) and worry ($z = 2.47; p < .05$) were significantly associated with SOL, such that higher levels of repetitive thought were predictive of longer SOLs (Table 4). Similarly, with respect to SQ (see Table 5), higher levels of rumination ($z = 2.39; p < .01$) and worry ($z = 3.55; p < .01$) were associated with significantly lower perceived SQ. Neither predictor was significantly associated with TST.
Table 5. Study 1: Repetitive thought predicting diary-based SQ (N = 39)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>β</th>
<th>Z</th>
<th>p-value</th>
<th>Wald’s χ²</th>
<th>p-value</th>
</tr>
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<tbody>
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<td>Level - 1</td>
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</tr>
<tr>
<td>Intercept</td>
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<td>4.35</td>
<td>.000**</td>
<td>8.86</td>
<td>.065</td>
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<tr>
<td>Rumination</td>
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<td>2.39</td>
<td>.017*</td>
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<tr>
<td>Gender</td>
<td>0.05</td>
<td>0.31</td>
<td>.753</td>
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<tr>
<td>BDI-II</td>
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<tr>
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<td>.000**</td>
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<td>.000**</td>
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<td>2.91</td>
<td>.004**</td>
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<td>0.09</td>
<td>.929</td>
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</tbody>
</table>

Note. SOL = Sleep onset latency; PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II
* p < .05
** p < .01

STUDY 2

The next set of analyses assessed the between-group differences between mindfulness and distraction on study variables during Study 2 (days eight through fourteen). As before, I first fit an unconditional means model with actigraphy-based SE regressed on an intercept, a level-1 residual, and a level-2 residual. Results indicated that approximately 46% of the total variance in SE was due to between-person differences, and examination of the confidence interval (95% CI between: [39.25 – 152.97]) indicated that this variance was significantly different from zero.

Similar, significant between-person variances were observed for SOL and TST.Thus, the data
revealed significant variations in actigraphy-based sleep variables to justify examination of
group differences.

Once again, gender was significantly associated with SOL, with women experiencing
longer latencies ($z = 2.23; p < .05$). Similarly, the association between SE and gender
approached significance ($z = -1.78; p = .07$). Thus, all further analyses controlled for gender
(Table 6); time and other demographic variables were not significantly related to outcomes.
Group membership was significantly associated with actigraphy-based SOL ($z = -2.13; p < .05$),
such that the mindfulness group experienced shorter latencies. Group membership was not
significantly associated with actigraphy-based TST or SE. However, a significant relationship
emerged between group membership and diary-based TST ($z = 2.38; p < .05$) as well as SQ ($z =
-2.88; p < .05$), such that the mindfulness group reported longer duration and better quality than
the distraction group. Finally, with respect to repetitive thought, the mindfulness group reported
significantly lower daily levels of worry ($z = -3.32; p < .01$) than the distraction group. Group
membership was not related to rumination.

OVERALL STUDY

The final set of analyses assessed the efficacy of the distraction and MM exercises in
each respective group across the length of the study. In other words, I tested whether sleep
outcomes and negative cognitions varied significantly within each group between the baseline
week (Study 1) and the intervention week (Study 2). A dichotomous variable called
‘intervention’ was created, coded as ‘0’ for days two through seven, and coded as ‘1’ for days
eight through fourteen. In the distraction group, there were no significant associations between
Table 6. Study 2: Group membership predicting sleep outcomes and negative affect (N = 39)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>Z</th>
<th>p-value</th>
<th>Wald’s χ²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome: Actigraphy-based SOL</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Intercept</td>
<td>3.88</td>
<td>0.30</td>
<td>.765</td>
<td>12.76</td>
<td>.012*</td>
</tr>
<tr>
<td>Gender</td>
<td>15.49</td>
<td>2.26</td>
<td>.024*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-II</td>
<td>0.14</td>
<td>0.40</td>
<td>.686</td>
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<tr>
<td>PSQI</td>
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<td>0.77</td>
<td>.440</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>-13.73</td>
<td>-2.13</td>
<td>0.03*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome: Diary-based SQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.97</td>
<td>7.11</td>
<td>.000**</td>
<td>10.73</td>
<td>.030*</td>
</tr>
<tr>
<td>Gender</td>
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<td>0.99</td>
<td>.324</td>
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<td></td>
</tr>
<tr>
<td>BDI-II</td>
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<tr>
<td>PSQI</td>
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<td>0.98</td>
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</tr>
<tr>
<td>Condition</td>
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<td>-2.88</td>
<td>0.04*</td>
<td></td>
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</tr>
<tr>
<td>Outcome: Diary-based TST</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Intercept</td>
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<td>10.89</td>
<td>.000**</td>
<td>6.87</td>
<td>.14</td>
</tr>
<tr>
<td>Gender</td>
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<td>0.75</td>
<td>.451</td>
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<td></td>
</tr>
<tr>
<td>BDI-II</td>
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<td>-0.44</td>
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</tr>
<tr>
<td>PSQI</td>
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<td>-0.13</td>
<td>.898</td>
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</tr>
<tr>
<td>Condition</td>
<td>0.78</td>
<td>2.38</td>
<td>0.02*</td>
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<tr>
<td>Outcome: Daily Worry</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>11.93</td>
<td>6.26</td>
<td>.000**</td>
<td>15.46</td>
<td>.004**</td>
</tr>
<tr>
<td>Gender</td>
<td>1.21</td>
<td>1.16</td>
<td>.247</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-II</td>
<td>-0.04</td>
<td>-0.77</td>
<td>.439</td>
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<tr>
<td>PSQI</td>
<td>0.44</td>
<td>2.75</td>
<td>.006**</td>
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<td></td>
</tr>
<tr>
<td>Condition</td>
<td>-3.18</td>
<td>-3.32</td>
<td>.001**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. SQ = Sleep Quality; higher scores indicate worse quality; SOL = Sleep onset latency; SE = Sleep Efficiency; PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II

*p < .05

**p < .01
Table 7. Overall study: Mindfulness predicting within-person changes in objective and subjective sleep outcomes (N = 20)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>β</th>
<th>Z</th>
<th>p-value</th>
<th>Wald’s χ²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome: Actigraphy-based SE</td>
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<td></td>
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</tr>
<tr>
<td><strong>Level - 1</strong></td>
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</tr>
<tr>
<td>Intercept</td>
<td>86.75</td>
<td>10.98</td>
<td>.000**</td>
<td>17.46</td>
<td>.002**</td>
</tr>
<tr>
<td>Intervention</td>
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<td>3.93</td>
<td>.000**</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level – 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>- 3.55</td>
<td>- 0.86</td>
<td>.392</td>
<td></td>
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</tr>
<tr>
<td>BDI-II</td>
<td>- 0.14</td>
<td>- 0.58</td>
<td>.565</td>
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<tr>
<td>PSQI</td>
<td>- 0.21</td>
<td>- 0.36</td>
<td>.716</td>
<td></td>
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<tr>
<td>Outcome: Actigraphy-based SOL</td>
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</tr>
<tr>
<td>Intercept</td>
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<td>1.14</td>
<td>.254</td>
<td>16.56</td>
<td>.002**</td>
</tr>
<tr>
<td>Intervention</td>
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<td>- 2.30</td>
<td>.021*</td>
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<tr>
<td><strong>Level – 2</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>23.08</td>
<td>2.61</td>
<td>.009**</td>
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<td>0.79</td>
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<tr>
<td>PSQI</td>
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<td>- 0.50</td>
<td>.620</td>
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<tr>
<td>Outcome: Diary-based SQ</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level - 1</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Intercept</td>
<td>1.28</td>
<td>5.31</td>
<td>.000**</td>
<td>20.70</td>
<td>.000**</td>
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<tr>
<td>Intervention</td>
<td>- 0.21</td>
<td>- 2.22</td>
<td>.027*</td>
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<tr>
<td><strong>Level – 2</strong></td>
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<td></td>
</tr>
<tr>
<td>Gender</td>
<td>- 0.05</td>
<td>- 0.37</td>
<td>.710</td>
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</tr>
<tr>
<td>BDI-II</td>
<td>0.21</td>
<td>2.89</td>
<td>.004**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSQI</td>
<td>0.01</td>
<td>0.75</td>
<td>.451</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. SE = Sleep Efficiency; SOL = Sleep onset latency; SQ = Sleep Quality; PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory; Intervention = dichotomous variable coded as “0” for day one through seven, and as “1” on days eight through fourteen

* p < .05
** p < .01
Table 8. Overall study: Mindfulness predicting within-person changes in repetitive thought (N = 20)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>β</th>
<th>Z</th>
<th>p-value</th>
<th>Wald’s χ²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcome: Rumination</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level - 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>6.09</td>
<td>1.00</td>
<td>.317</td>
<td>21.95</td>
<td>.000**</td>
</tr>
<tr>
<td>Intervention</td>
<td>-1.82</td>
<td>-2.38</td>
<td>.018*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level – 2</strong></td>
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<td></td>
</tr>
<tr>
<td>Gender</td>
<td>3.85</td>
<td>1.22</td>
<td>.223</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-II</td>
<td>0.41</td>
<td>2.16</td>
<td>.030*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSQI</td>
<td>0.62</td>
<td>1.36</td>
<td>.175</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Outcome: Worry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level - 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>3.35</td>
<td>1.49</td>
<td>.136</td>
<td>30.85</td>
<td>.000**</td>
</tr>
<tr>
<td>Intervention</td>
<td>-0.94</td>
<td>-2.48</td>
<td>.021*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level – 2</strong></td>
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<tr>
<td>Gender</td>
<td>0.25</td>
<td>0.21</td>
<td>.831</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-II</td>
<td>0.10</td>
<td>1.46</td>
<td>.145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSQI</td>
<td>0.54</td>
<td>3.21</td>
<td>.001**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. SE = Sleep Efficiency; SOL = Sleep onset latency; SQ = Sleep Quality; PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; Intervention = dichotomous variable coded as “0” for day one through seven, and as “1” on days eight through fourteen

*p < .05

**p < .01

the distraction intervention and any of the sleep outcomes or repetitive thought variables.

A more interesting picture emerged in the mindfulness group (Table 7). Per actigraphy, participants experienced significantly shorter SOL ($z = -2.30; p < .05$) and higher SE ($z = 6.54; p < .01$) during the intervention week than during baseline. There were no significant differences in objectively or subjectively measured TST between baseline and intervention. Further, participants reported significantly better diary-based SQ ($z = -2.22, p < .05$) during the
interventions week than during the baseline week. Finally, the intervention days were also predictive of significantly lower levels of daily rumination ($z = -2.38, p < .05$) and worry ($z = -2.48, p < .05$), such that participants reported lower rumination and worry during the intervention days (Table 8).
DISCUSSION

Insomnia researchers have noted consistently since the 1980s that repetitive thought is associated with a variety of sleep impairments, including delayed sleep onset, poor sleep maintenance, and architectural disturbances (Harvey, 2005). However, cogent empirical evidence for the relationship between cognitive arousal and sleep impairment has yet to emerge owing to methodological drawbacks, such as single-night studies, cross-sectional data, and poor sleep assessment. Further, this research has focused primarily on worry as a sleep inhibiting cognitive mechanism. On the other hand, the role of rumination in sleep disturbance has not received adequate research attention. As respective cognitive pathways to anxiety and depression, worry and rumination emerged largely independently in the psychopathology literature. Researchers have only recently begun to integrate these two forms of negative repetitive thought into a unified model of cognitive arousal (Carney et al., 2010).

Secondly, the treatment implications of the association between repetitive thought and sleep disturbances beg further investigation. Mindfulness, given its theoretical and structural congruence with rumination, has shown promise in reducing the frequency and duration of rumination (Jain et al., 2007). However, only a few pilot studies have examined the efficacy of mindfulness in treating sleep disturbances, with preliminary data suggesting that mindfulness-based interventions produce significant improvements in sleep (Bootzin & Stevens, 2005; Shapiro, Bootzin, Figueredo, Lopez, & Schwartz, 2003). However, to the best of my knowledge,
no study has examined the impact of mindfulness on sleep disturbances caused by rumination and worry.

The present research represents the first attempt to examine the effects of repetitive thought on both objectively- and subjectively-measured sleep, as well as to explore whether mindfulness-based exercises can help attenuate this effect. Specifically, Study 1 followed a sample of high trait-ruminators for a period of one week during which they provided self-reported and actigraphy-based sleep data. This naturalistic study allowed for a careful examination of the covariation between repetitive thought and sleep, with adequate between-night variance to rule out participant reactivity. Next, the same participants began Study 2 during which they engaged in either a mindfulness task or a distraction exercise. The efficacy of mindfulness in attenuating both repetitive thought and related sleep disturbances could hence be reliably explored. I hypothesized that: (1) repetitive thought would be predictive of both objective and subjective sleep impairments during Study 1; (2) the mindfulness group shall experience better sleep outcomes and lower levels of repetitive thought than the distraction group during Study 2; and (3) severity of sleep disturbances and extent of repetitive thoughts shall be lower during Study 2 than Study 1 for participants in the mindfulness group.

REPETITIVE THOUGHT AND SLEEP

With respect to actigraphy-based sleep data, analyses revealed that daily levels of rumination were predictive of longer SOLs, though worry was not. To the best of my knowledge, this is the first daily study to establish an association between rumination and objective sleep
impairment. Further, since all analyses controlled for depressive symptomatology, these findings showcase the independent effect of rumination on sleep, despite the significant correlation between rumination and depression. These results are also consistent with a small, yet growing body of research which suggests that rumination, and not worry, constitutes the key ingredient in sleep-disruptive cognitive arousal (Carney et al., 2010; Takano, Iijima, & Tanno, 2012).

Similarly, rumination was also predictive of significantly longer self-reported SOLs and poor self-reported SQ.

Notably, however, while worry was not associated with any significant objective sleep impairments, it was significantly related to increased, self-reported SOL and diminished, self-reported SQ in the present study. In other words, though participants who worried did not experience objective sleep impairments, they were more likely to perceive/report them. These data further support the link between worry and sleep misperception. In addition to the well-established association between worry and cognitive distortions of objective reality (Clark, 1999), a number of studies have also validated the association between worrying and sleep-state misperception (for review, see Harvey & Tang, 2012). On the other hand, recent research suggests that sleep perception may be moderated by sensitivity thresholds and scoring criteria employed by objective assessment techniques, such as PSG and actigraphy (Pillai & Delahanty, 2012). Thus, sleep complaints in the absence of objective sleep disruption may not necessarily be equivalent to over-reporting or misperception. Given that the present study used continuous recording for a week with standardized instruments and scoring algorithms, the latter hypothesis
is unlikely. Nevertheless, these data, taken together, further highlight the need for multi-modal assessment in sleep research.

Finally, neither form of repetitive thought exerted an effect on SE or TST. These results echo the findings of the only other study on rumination and objective sleep in which rumination was associated with SOL, but not with TST or wakefulness after sleep onset (Zoccola et al., 2009). While it may be tantalizing to conclude that repetitive thought may only interfere with initial sleep onset, the fact that both the aforesaid study as well as the present study relied on a sample of healthy, college students cannot be overlooked. College students and young adults in general exhibit notoriously poor sleep hygiene (Gaultney, 2011). Sleep is often restricted due to class schedules and academic demands irrespective of quality or duration. Thus, it is possible that sleep duration among college students is more reflective of such extraneous factors. Finally, as can be seen in Table 1, average levels of sleep efficiency in the present sample were in the normal range (> 85%), permitting little room for improvement (Morin, Bastien, & Savard, 2003). Without replication studies in clinically and culturally diverse samples, the impact of repetitive thought on sleep continuity and duration cannot be reliably established.

MINDFULNESS AND SLEEP

As both groups in this study provided a week of baseline sleep data, the impact of mindfulness on sleep could be assessed in two ways: between-group differences during Study 2; and within-person changes in the mindfulness group between Study 1 (control/baseline week) and Study 2 (intervention week). During Study 2, participants in the mindfulness group exhibited
significantly lower SOL as measured via actigraphy. Similarly, they also reported significantly higher sleep quality and sleep duration than those in the distraction group. Finally, participants in the mindfulness group reported significantly better actigraphy-based SE and SOL during Study 2 than during Study 1. Similarly, they also reported significantly higher SQ during Study 2.

The present study is the first to establish a reliable association between a mindfulness-based intervention and improvements in objective sleep indices. To the best of my knowledge, the only other study (Britton, Haynes, Fridel, & Bootzin, 2012) to examine the impact of mindfulness on objectively measured sleep involved a sample of clinically depressed individuals on anti-depressant medication (ADM). In this study, individuals with depression showed significantly better PSG-based SE following an 8-week mindfulness-based CBT (MBCT) intervention. However, since this sample was medicated with ADMs including hypnotics, the impact of mindfulness cannot be extricated from the sedative effects of medication. Secondly, this study like its predecessors did not include an adherence measure. Thus, it is difficult to discern whether psycho-education about mindfulness-based exercises translated into practice. Finally, this MBCT study, like most studies on mindfulness and sleep (Ong et al., 2008; Shapiro et al., 2003) did not include a control condition. Therefore, changes in clinical outcomes cannot be reliably attributed to the intervention, begging further questions about the causal mechanism underlying sleep improvement.

The present study hypothesized that mindfulness exercises would help improve sleep by suppressing rumination and worry. This hypothesis was supported by three sets of findings. First, during Study 1, daily levels of rumination and worry were predictive of both objective and
subjective sleep impairments. Secondly, engaging in a mindfulness-based exercise prior to sleep was associated with significant overall improvements in sleep. Finally, the mindfulness exercises were associated with significant reductions in daily levels of rumination and worry. Specifically, the mindfulness group reported significantly lower levels of worry than the distraction group during Study 2, and levels of both rumination and worry dropped significantly from Study 1 to Study 2 within the mindfulness group. Further, as time (days in the study) was unrelated to any of these outcomes, within-person changes over time could be reasonably attributed to the intervention.

CLINICAL IMPLICATIONS

*Insomnia and depression:* Comorbidity studies suggest that 60 – 90% of individuals with depression experience clinically significant levels of insomnia (Kloss & Szuba, 2003). Research into such shared etiological pathways to insomnia and depression has therefore proliferated over the past decade in the psychophysiology literature. For instance, neuroendocrinological studies point to dysfunction in the body’s ‘stress-response system’ (Boyce & Ellis, 2005) as a phenomenon that characterizes both disorders. These data suggest that the mechanisms responsible for the negative-feedback inhibition of stress-response systems such as HPA axis activity are impaired in both these populations (McKay & Zakzanis, 2010; Morin, Rodrigue, & Ivers, 2003). Similarly, empirical evidence for the role of common mechanisms in the regulation of mood and sleep are also perceivable in electroencephalography (EEG) studies. A recent meta-analysis of the EEG impairments seen in depression found that rapid-eye movement (REM)
sleep abnormalities constituted a reliable biomarker of the disorder (Pillai, Kalmbach, & Ciesla, 2011). Notably, investigations of the neurochemical basis of sleep architecture suggest that corticotrophin releasing hormone systems responsible for the regulation of REM sleep (Kirby, Rice, & Valentino, 2000) are also complicit in the wake-promoting hyper-arousal observed in insomnia (Vgontzas et al., 1998). Thus, researchers have accrued cogent evidence for hormonal or neurochemical mediators of the relationship between mood and sleep disturbances.

The present study suggests that repetitive thought may represent yet another shared vulnerability to depression and insomnia. The depression literature suggests that individuals with depression are significantly more likely to engage in rumination in response to stress, and that this response style is associated with greater levels of depressive severity and relapse (Watkins, 2008). Thus, existing evidence suggests not only that rumination is elevated among individuals with depression, but also that rumination is associated with impaired sleep. However, researchers have yet to examine the impact of rumination on sleep among individuals with depression. Findings from the present study suggest that rumination may indeed constitute one of the causal factors underlying the pervasiveness of sleep disturbances among individuals with depression. Notably, both the mean and median levels (Table 1) of depressive symptomatology in the present study were in the clinically significant range (Beck et al., 1996). Thus, this study offers good, ecologically valid insight into the rumination-related sleep disturbances in this population. Further, most of the studies on sleep and rumination measure only sleep-specific cognitions such as clock-monitoring or catastrophizing the daytime consequences of insufficient sleep (e.g., Nelson & Harvey, 2003; Tang, Schmidt, & Harvey, 2007; Wicklow & Espie, 2000). These
measures may not adequately capture the key ruminative cognitions that are complicit in sleep disruption among individuals with depression.

*Cognitive Behavior Therapy for Insomnia (CBTI)*: Presently, pharmacological interventions represent the first line of treatment for sleep disturbances in medical settings (Morin, 2010). However, clinical trials show that behavioral treatments such as CBTI are as effective as pharmacological treatments in the short run, and more effective in the long run (Morin & Benca, 2012; Smith et al., 2002). Long term medication use can also lead to dependency and tolerance, and discontinuation may cause rebound insomnia (Morin & Benca, 2012). Similarly, a number of these medications, especially those with longer half-lives, can cause a variety of daytime impairments including drowsiness, dizziness, and cognitive impairments with regular use (Holbrook, Crowther, Lotter, Cheng, & King, 2000; Zammit et al., 2006). On the other hand, empirical evidence for the efficacy of CBTI has been robust, and adverse effects are minimal (Harvey & Tang, 2003).

In addition to modules devoted to behavioral strategies such as *Stimulus Control* and *Sleep Restriction*, CBTI includes a *Cognitive Restructuring* component aimed at challenging distorted beliefs about the negative consequences of insomnia, or reshaping unrealistic expectations about sleep needs. However, it is presently unclear whether this component of CBTI addresses repetitive thought forms such as rumination or worry; the efficacy of CBTI in attenuating rumination has never been investigated (Carney et al., 2010). Consistent with prior studies on MBCT for depression, the present findings suggest that mindfulness is not only effective in attenuating a ruminative response style, but also that this effect manifests in sleep
improvements. Thus, these data support recent efforts in the field of behavioral medicine to supplement CBTI with mindfulness-based interventions (Ong et al., 2008). These new forms of CBTI may be especially pertinent to comorbid forms of insomnia.

LIMITATIONS AND FUTURE DIRECTIONS

Though I believe the above findings carry a number of significant clinical implications for insomnia and depression, they must be interpreted with provisions for the limitations of the present study. First, though the present sample exhibited sufficient variance on all salient study variables, including rumination, worry, and sleep, it was composed of an ethnically and culturally homogeneous group of relatively healthy college students. Further, the proportion of women in the sample was disproportionately high. Since levels of sleep disturbances, rumination, worry, as well as depressive symptomatology are also significantly higher among women, future studies should aim to explore the reliability of these findings in male samples (Arber et al., 2009; Susan Nolen-Hoeksema, 1990). Further, as alluded to earlier, though our sample exhibited significant sleep disturbances, mean objective sleep indices were in the sub-clinical range. Thus, the present study cannot address the efficacy of mindfulness in alleviating sleep disturbances among individuals with more severe or refractory forms of insomnia. Finally, as this study focused largely on rumination and depressive symptoms, it is unclear whether null findings related to worry are a function of the relative range restriction in worry-related variables; recruitment specifically targeted high trait ruminators, and not worriers. Future
researchers should continue to explore the relative contribution of both these forms of repetitive thought to sleep disruption, especially in the context of mood and anxiety disorders.

In addition to these sample characteristics, a number of methodological shortcomings limit the scope of this study. First, the present study inferred an indirect effect of mindfulness on sleep through repetitive thought, as mindfulness was associated with significant improvements in both these outcomes. However, since levels of daily rumination and worry were measured prior to the mindfulness-based induction, these data did not lend themselves to true mediation analyses. While the manipulation check in the present study suggested that the mindfulness task was associated with reduced negative affect, future studies should seek to establish a direct temporal association between mindfulness, repetitive thought, and sleep. Finally, though actigraphy offers a sensitive objective measure of sleep and wake states, PSG remains the gold standard of sleep assessment. Some data suggest that actigraphy suffers from poor reliability in distinguishing between sleep and restful (or motionless) waking, and that it correlates poorly with PSG on certain indices such as TST (Lichstein et al., 2006; Paquet, Kawinska, & Carrier, 2007). Thus, future research will be better served by using multiple assessment strategies to fully capture the inherent heterogeneity in sleep disturbances.
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Appendix A. Glossary of sleep variables:

<table>
<thead>
<tr>
<th>Sleep Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep onset latency (SOL)</td>
<td>Delay between “lights-off” i.e., going to bed with the intention of sleeping, and the onset of sleep.</td>
</tr>
<tr>
<td>Total Sleep Time (TST)</td>
<td>Total amount of sleep obtained during the recording period.</td>
</tr>
</tbody>
</table>
| Sleep Efficiency (SE)          | Percentage of time in bed, spent asleep:  
                                 | \[
                                 | \frac{\text{Total Sleep Time}}{\text{Time in Bed}} \times 100          |
| Sleep Quality (SQ)            | Self-reported, perceived sleep quality                                     |
Appendix B. Flow diagram depicting flow of participants through the study:
Appendix C. Electronic Questionnaires:

**BEFORE BED**

Did you take any naps during the day today?
- 0. No
- 1. Yes

How many caffeinated drinks have you had in the past 4 hours?
(SCROLL BAR FROM 0 TO 24)

Did you use sleep medication to fall asleep tonight (or are you planning to)?
- 0. No
- 1. Yes

Did you use alcohol to fall asleep tonight (or are you planning to)?
- 0. No
- 1. Yes

How many standard drinks containing alcohol have you had at any point today?
(SCROLL BAR FROM 0 TO 24)

How many standard drinks containing alcohol have you had in the past 4 hours?
(SCROLL BAR FROM 0 TO 24)

How many cigarettes have you smoked at any point today?
(SCROLL BAR FROM 0 TO 24)

How many cigarettes have you smoked in the past 4 hours?
(SCROLL BAR FROM 0 TO 24)

**Rumination**

How frequently have you done each of the following today:
- 1. Not at all
- 2. Occasionally
- 3. Often
- 4. All the time

Thought, “Why do I always react this way?”
Thought, “What am I doing to deserve this?”
Thought, “Why do I have problems other people don’t have?”
Thought, “Why can’t I handle things better?”
Thought about a recent situation, and wished it had gone better.

Analyzed recent events to try to understand your feelings
Thought about why you felt the way you did
Tried to analyze what you were thinking
Analyzed your personality to try to understand why you were depressed
Spent time thinking about your feelings

Tried to understand yourself by focusing on your depressed feelings
Thought about how sad you felt
Thought about the reasons you felt sad
Thought about all your shortcomings, faults, and mistakes
Thought about how you don’t feel up to doing anything
(Worry)
How true were the following statements of you today:
1. Not at all true
2.  
3. Somewhat true
4.  
5. Very True

I found it easy to dismiss worrisome thoughts
I knew I shouldn’t worry about things, but just couldn’t help it
I didn’t worry about things
I worried all the time

(Affect)
To what extent did you feel _____ today?
1. not at all
2. a little
3. moderately
4. quite a bit
5. extremely

Sad
Blue
Downhearted
Alone
Lonely

Nervous
Afraid
Frightened
Scared

Angry
Hostile
Irritable

Happy
Joyful
Delighted
Cheerful
UPON WAKING

The following questions ask you about how you slept last night.

How long, in minutes, did it take you to fall asleep last night?
0. Less than 15
1. 15 - 30
2. 45 - 60
3. 60 - 90
4. 90 - 120
5. More than 120

How many hours of sleep did you get last night?
(SCROLL BAR FROM 0 TO 24)

How many hours did you spend in bed last night (awake or asleep)?
(SCROLL BAR FROM 0 TO 24)

How would you rate your quality of sleep last night?
1. Very good
2. Fairly good
3. Fairly bad
4. Very bad

How many times did you wake up from sleep last night?
(SCROLL BAR FROM 0 TO 24)

How rested do you feel this morning?
1. Very rested
2. Fairly rested
3. Slightly rested
4. Not at all rested
Appendix D. Experimental Inductions:

Mindfulness Meditation

Instructions:

For the next few minutes, try your best to focus your attention on each of the ideas on the following pages.

Read each item slowly and silently to yourself. As you read the items, use your imagination and concentration to focus your mind on each of the ideas. Spend a few moments visualizing and concentrating on each item.

Please continue until you receive further instructions. Repeat from the beginning if necessary.

- Sit comfortably, with your eyes closed and your spine reasonably straight.
- Bring your attention to your breathing.
- Imagine that you have a balloon in your tummy. Every time you breathe in, the balloon inflates. Each time you breathe out, the balloon deflates. Notice the sensations in your abdomen as the balloon inflates and deflates. Your abdomen rising with the in-breath, and falling with the out-breath.
- Thoughts will come into your mind, and that’s okay, because that’s just what the human mind does. Simply notice those thoughts, then bring your attention back to your breathing.
- Likewise, you can notice sounds, physical feelings, and emotions, and again, just bring your attention back to your breathing.
- You don’t have to follow those thoughts or feelings, don’t judge yourself for having them, or analyse them in any way. It’s okay for the thoughts to be there. Just notice those thoughts, and let them drift on by, bringing your attention back to your breathing.
- Whenever you notice that your attention has drifted off and is becoming caught up in thoughts or feelings, simply note that the attention has drifted, and then gently bring the attention back to your breathing.
- It’s okay and natural for thoughts to enter into your awareness, and for your attention to follow them. No matter how many times this happens, just keep bringing your attention back to your breathing.
Instructions:

For the next few minutes, try your best to focus your attention on each of the ideas on the following pages.

Read each item slowly and silently to yourself. As you read the items, use your imagination and concentration to focus your mind on each of the ideas. Spend a few moments visualizing and concentrating on each item.

Please continue until you receive further instructions. Repeat from the beginning if necessary.

Think about:

and imagine a boat slowly crossing the Atlantic
the layout of a typical classroom
the shape of a large black umbrella
the movement of an electric fan on a warm day
raindrops sliding down a windowpane
a double-decker bus driving down a street
and picture a full moon on a clear night
clouds forming in the sky
the layout of the local shopping center
and imagine a plane flying overhead
fire darting around a log in a fire-place
and concentrate on the expression on the face of the Mona Lisa
a parking lot at a drive-in
two birds sitting on a tree branch
the shadow of a stop sign
the layout of the local post office
the structure of a high-rise office building
and picture the Eiffel Tower
and imagine a truckload of watermelons
the pattern on an Oriental rug
the “man in the moon”
the shape of the continent of Africa
a band playing outside
a group of polar bears fishing in a stream
the shape of the torch on the Statue of Liberty
the shape of the state of California
the way the Grand Canyon looks at sunset
the structure of a long bridge
a train stopped at a station
a lone cactus in the desert
the shape of the country of Italy
a row of shampoo bottles on display
a gas station on the side of a highway
the fuzz on the shell of a coconut
the Presidents’ faces on Mount Rushmore
and picture the university’s clock tower
a band playing “The Star Spangled Banner”
the shape of a cello
the birthmark on Gorbachev’s head
the shape of the United States
the baggage claim area at the airport
the size of the Statue of Liberty
the shape of a baseball glove
a freshly painted door
the shiny surface of a trumpet