Exploring the relationship between mindfulness in waking and lucidity in dreams

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Robert L. Rider, M.S.

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DEDICATIONS

This work is dedicated to my family: To my father, Robert, whose lifetime of hard work gave me the opportunity to pursue my dreams and whose death was the impetus for me to explore them. To my mother, Dolores, whose love has given me the confidence and strength to believe in and love the beauty of my dreams. To my sister, Shannon, whose support has been unwavering, even when dreams turned into nightmares. To my wife, Michel, whose faith, patience, love, and support serves as a living proof that dreams can come true. Finally, to my daughter, Aislin, whose existence is nothing short of the dream of her parents' love brought to life.

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ABSTRACT

The continuity theory of dreaming proposes that waking and dreaming rely on a shared set of brain-mind processes. Research in the fields of lucid dreaming and mindfulness suggest continuity of certain neurocognitive processes. Specifically, the high levels of attention, reflection, self-awareness, volition, and control which are hypothesized to be related to lucidity are presumed here to be continuous with waking mindfulness. This study aimed to investigate relationships between: 1) Mindfulness in waking and lucidity/mindfulness in dreaming; 2) Neuropsychological functions related to mindfulness and lucidity/mindfulness in dreaming; and 3) Neuropsychological functions and subjective mindfulness in waking.

N = 44 participants completed measures of general and recent mindfulness skills and a battery of neuropsychological tests. Each morning for seven days following this initial assessment, participants rated their levels of lucidity, cognitive functioning, sensory and emotional intensity from their preceding night's dream. Relationships between waking mindfulness levels, neuropsychological functions, and dream variables were evaluated using a correlational design.

Waking mindfulness did not account for a significant amount of variance in dream lucidity, but did account for a significant amount of variance in dream mindfulness. Correlations between dream lucidity and neuropsychological measures *were not* significant. However, better performances on two neuropsychological measures (sustained attention and behavioral self-monitoring) *were* moderately correlated with dream mindfulness. Also, general mindful awareness and recent mindful acceptance were positively associated with sustained attention and behavioral self-monitoring.

Significant relationships found between waking mindfulness and dream mindfulness provide support for continuity theory. Mindfulness appears to be expressed in dreams to a degree that is consistent with recent and general levels of mindful awareness. The relationships

between neuropsychological functions and dream mindfulness suggest a shared brain bases for attention and behavioral self-monitoring across dreaming and waking. The failure to find a relationship between lucidity and any of the variables assessed in waking in this study may be due to methodological limitations. Alternatively, while high levels of attention, reflection, volition, self-awareness, and control are often observed in lucid dreams, they may not be exclusive to lucid dreams.

CHAPTER I: INTRODUCTION

In the simplest terms, lucid dreaming is a state in which the dreamer recognizes that he or she is dreaming, while dreaming (Brown, 1936). This state represents a unique blend of waking and dreaming consciousness in which an individual can be observed in a state of physiological sleep but is able to experience the vivid, internally generated reality of the dream with the awareness that it is a dream (Hearne, 1978; LaBerge, 1980b). Mainstream interest in lucid dreaming is a relatively recent development, with depictions and discussions of the topic now appearing in cinema, news media, and on countless websites.

The growing interest in lucid dreaming may lie in the potential it holds for individuals who can become adept at it to utilize their own private, sensory-realistic environment that is not subject to societal or physical limitations. While a discussion of Freud's Interpretation of Dreams (1955) is unnecessary here, it should not be overlooked that lucid dreaming likely appeals to many because it appears to offer the promise of wish fulfillment. Nonetheless, it is when the potential applications of lucid dreaming in clinical and research settings are considered that it becomes clear why this phenomenon is worthy of further investigation.

For instance, lucid dream training has been shown to be an effective treatment for recurrent nightmares (Zadra and Pihl 1997), which are often a symptom of post-traumatic stress disorder (APA, 2000). Lucid dreaming may have still more, yet unrealized, applications to psychotherapy. A novel approach to the treatment of anxiety and phobic disorders, for example, might utilize the realistic yet protected context of a lucid dream for exposure-based therapies. Lucid dreams could also aid in the alleviation of persistent negative mood symptoms in the bereaved, serving as a place for such clients to address unresolved issues with the deceased through simulated dream interactions not possible in waking. In research contexts, lucid dreamers have been able to communicate to outside observers from within their dreams to provide insights into the nature of dreaming and of consciousness itself.

Yet, in spite of evidence that lucid dreaming is a learnable skill (Laberge, 1980c), that there are now a wide variety of lucid dream induction methods available (Clerc, 1983; The Lucidity Institute, 2009; LaBerge & Dement, 1982a; Levitan, 1992; Paulsson & Parker, 2006; Price & Cohen, 1988; Price et al., 1991) and the enticing appeal for personal, clinical, and research applications, there is no evidence to suggest that lucid dreaming is any more prevalent now than it has been at any time in the past. While the potential uses for lucid dreaming in clinical or research work will hopefully be the topic of future investigations, at present, many basic questions about lucid dreaming still need to be addressed. Broadly, this study aims to address the question of whether, and to what extent, lucidity in dreams is related to psychological and neuropsychological functions in waking.

Whereas non-lucid dreams have traditionally been deemed 'cognitively deficient' compared with waking (Rechtschaffen, 1978), lucid dreams are often accompanied by a capacity for levels of cognitive and metacognitive functioning typically observed only during periods of wakefulness (Kahan & Laberge, 1994a). This can include the ability to reason clearly, control attention, maintain self- and state-reflective awareness, and act in a thoughtful and volitional manner (LaBerge, 1985a). But while anecdotal accounts suggest lucid dreams are associated with higher levels of attentional, executive, and metacognitive functioning, the particular constellation of cognitive functions associated with lucid dreaming has not been well characterized.

As has been suggested by several researchers, the state of lucid dreaming has certain unmistakable similarities to waking meditative and mindful states (Hunt, 1989; Hunt & Ogilvie, 1989; Stumbrys, 2011). Several studies have demonstrated that mindfulness meditation is associated with improvements in attentional, executive, and metacognitive functioning (Grossman, Niemann et al. 2004; Lazar, Kerr et al. 2005; Brefczynski-Lewis, Lutz et al. 2007; Ivanovski 2007; Moore and Malinowski 2009; Vestergaard-Poulsen, van Beek et al. 2009).

While it would be premature to claim that such functions are "required" for lucid dreaming, it does appear that the cognitive profile that is typically associated with mindfulness-based practices is at least shared with those proposed to be associated with lucid dreaming.

According to the continuity theory of dreaming, the brain-mind processes underlying the phenomenological experiences in waking and dreaming are shared. To date, this theory has been tested primarily with respect to the *thematic contents* of waking and dreaming (For a review, see Domhoff, 1996). With a few exceptions (Kahan et al., 1997; Kahan & LaBerge, 2011; LaBerge et al., 1995), continuity theory has not been tested with regard to the similarities and differences between *cognitive processes* in waking and dreaming. It is still unclear, for example, whether an individual's profile of cognitive strengths and weaknesses translate from their waking state into their dreams.

The ensuing review provides the theoretical framework and empirical basis for this study's overarching hypothesis that certain psychological and neuropsychological functions are, in fact, continuous across waking and dreaming and are associated with the ability of the dreamer to be aware that he or she is dreaming. The review will begin with the historical origins of the scientific investigations of mindfulness and lucid dreaming. Following this, the physiological characteristics of sleep will be discussed in order to provide the background for a description of the prevailing neuropsychological model of dreaming and a discussion of an important debate over the validity of this model. A comprehensive review of lucid dream research will then be presented, including studies which have investigated the physiological, personality, and cognitive factors associated with lucid dreams. Included in this section will be an overview of lucid dream induction methods, which should also provide some insight into the cognitive profile of lucid dreaming. In the final sections, the main theoretical bases of the present study will be presented. This will include a more detailed discussion of the continuity theory of dreams, particularly as it applies to cognitive processes, and a review of two

constructs which are presumed to be integrally related to lucid dreams – dream self-reflectiveness and dream mindfulness. The review concludes with a summary and study overview, including detailed specific aims and hypotheses.

CHAPTER II: LITERATURE REVIEW

Historical Background

In the course of characterizing and describing many of his own personal dream experiences, Dutch Psychiatrist and author, Frederik van Eeden (Van Eeden, 1913) was the first to use the term "lucid dream" in scientific publication. He wrote: "Now this is simply a question of nomenclature. I can only say that I made my observations during normal deep and healthy sleep, and that in 352 cases I had a full recollection of my day-life, and could act voluntarily, though I was so fast asleep that no bodily sensations penetrated into my perception. If anybody refuses to call that state of mind a dream, he may suggest some other name. For my part, it was just this form of dream, which I call 'lucid dreams,' which aroused my keenest interest and which I noted down most carefully."

By the mid 1950's, within the realm of psychology and psychiatry, much attention was being paid to the meaning of dream content - particularly with regard to waking psychology (Freud, 1955). Little attention was paid, however, to the level of awareness or the cognitive capacities of dreamer within the dream. The discovery of REM sleep by Eugene Aserinsky and Nathanial Kleitman in 1953 ushered in an era of dream science in which the physiology of REM sleep was believed to underlie the phenomenological experience of dreaming. However, while this era yielded important discoveries which furthered our understanding of REM physiology and the nature of dream content, it ultimately became apparent that there were several, significant problems with the assumption that REM sleep is either necessary or sufficient for dreaming (For a review, see Foulkes, 1996). Later, direct evidence that REM sleep could occur without dreaming and that dreaming could occur in the absence of REM sleep (Borbely & Wittmann, 2000; Solms, 2000a) would lead to a long and heated debate over the physiological basis of dreaming.

With the only objective method for specifying and quantifying the brain activity associated with dreaming proving to be unreliable, the scientific study of dreams was faced with a significant methodological problem.[1] By 1978, a potential solution to this problem was already available. The first laboratory studies of lucid dreaming by Hearne (1978) and later by LaBerge (1980) demonstrated that objectively verifiable physiological data could be obtained from dreams in real time. In these early studies, lucid dreamers used a previously agreed upon series of eye movements to signal to researchers that they had realized they were dreaming. [2] Lucid dreamers could also communicate about other features of the dream using these eye movement patterns.

Yet, despite its promise to bring some objectivity back into the field of dream research, the use of lucid dreaming as a research paradigm was slow to catch on. This was likely due to several limiting factors – one of which was the infrequency with which lucid dreams occur in the general population and the rarity of proficient lucid dreamers. Estimates of the prevalence of lucid dreaming in the general population have suggested that while approximately 58% of people have experienced a lucid dream at least once in their lifetime (Gackenbach, 1984), only about 21% experience lucid dreaming more than once per month (Gackenbach, 1984; LaBerge, 1985a) and just 2% are able to willfully induce lucid dreams (Gackenbach, 1984).

Another early and oddly persistent criticism of the lucid dream paradigm was the belief that lucid dreams could not even exist given what was known about REM sleep physiology.

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[1] David Foulkes' poignantly titled review, *Dream Research, 1953 – 1996*, chronicled the rise and fall of dream study since the discovery of REM sleep, and posited several explanations for the decline and near disappearance of dream laboratories (Foulkes, 1996). In his review, Foulkes attributed the ebb in research primarily to the finding that REM sleep and dreaming were not interchangeable.
[2] The approach they used to demonstrate the authenticity of lucid dreaming should be at least partly credited to Celia Green (Green, 1968). Green suggested that while most efferent motor activity is greatly attenuated during REM sleep, oculo-motor activity is its hallmark, and thus, eye movements could be used as an observable signal if the dreamer could voluntarily produce a predetermined pattern one they had realized they were dreaming (Green, 1968). The first measurable communications from a dream were sent in this way by Alan Worsley and subsequently by LaBerge in the late 1970's.

That is, prevailing models of the neurobiology of dreaming from 1953 until the late-1990's/early 2000's held that, during REM sleep when most dreams were believed to occur, the neurobiological state of the brain was not capable of such higher-level cognitive (and certainly not of metacognitive) functions. Admittedly, it is reasonable to speculate that the delayed uptake of a lucid dream research paradigm by the sleep research field can be attributed in part to the lack of a model which could account for it. Nonetheless, research had demonstrated that lucid dreaming emerged from within the context of otherwise 'normative' REM sleep processes (LaBerge, Levitan, et al., 1983) and any model of dream neurobiology needs to account for this.

Recently, there has been a resurgence of interest in lucid dreaming, with studies employing ever-more sophisticated methods to better characterize the neurophysiological correlates of lucidity. These include investigations using EEG power spectra (Holzinger et al., 2006; Voss et al., 2009) and, more recently, a breakthrough study which employed a simultaneous functional magnetic resonance imaging (fMRI) and polysomnography (Dresler et al., 2011) approach to record blood oxygen level dependent (BOLD) activation associated with motor activity during a signal verified lucid dream. This aforementioned study is likely just a preview of what is to come in lucid dream research.

As more of these sorts of studies are conducted, the reliance on content studies will likely diminish. Until such time, the exploration of dreams through subjective reports is still warranted and, ultimately, will help to guide future investigations employing more objective measures. Throughout the next several sections, a more thorough review of the scientific literature which has led to robust models of sleep physiology and dream phenomenology will be presented. This review is intended to provide the basis for one of this study's central assumptions – that dreams can support levels of cognitive functions similar to waking.

Sleep Physiology and Phenomenology

Since the introduction of Rechtschaffen and Kales' (Rechtschaffen & Kales, 1968)

standardized scoring criteria, sleep has traditionally been categorized into five stages based on characteristic polysomnographic (EEG, EOG, EMG) features. However, when the five-stage model was developed, the understanding of the processes and functions of each stage were just beginning to be understood. More recently, it has become common to see sleep studies which refer simply to non-rapid eye movement (NREM) and rapid eye movement (REM) states. NREM sleep can refer to stages one through four, which generally involve an increasing depth of sleep, culminating in slow wave sleep. REM sleep stands apart from these stages, both in terms of its electrophysiological characteristics and in its particularly strong association with vivid dreaming.

Non-REM Sleep

In terms of electrophysiology, stage-one sleep contains vertex sharp-waves and increased alpha frequency band (8 – 12 Hz) activity compared with waking. Individuals awakened from this stage report a general feeling of drowsiness and "drifting off" to sleep accompanied in some cases by hallucinatory sensations. Stage-two sleep is characterized by a decrease in the alpha activity seen during sleep onset/stage one sleep and the emergence of K-complex wave forms and spindle activity (12 – 14 Hz) in the EEG. Both K-complexes and spindles have been shown to accompany brief periods of arousal (i.e. near or full awakening), typically in response to some exogenous stimulation (De Gennaro, 2003; Yamadori, 1971). Mentation is sometimes reported from stage-two awakenings, but is often less bizarre than the hypnogogic imagery of stage one or REM-sleep dreams (Nielsen, 2000c). Stage-three sleep is marked by the increasingly frequent appearance of delta waves (0.5 – 4 Hz) in the EEG while stage-four is defined as the presence of delta waves in at least 50% of the sleep EEG (Rechtschaffen & Kales, 1968). Stages three and four are often collectively referred to as 'slow wave sleep' (SWS) or 'delta sleep' since the distinction between them appears to be somewhat arbitrary. During SWS, patterns of neural activation appear to oscillate between thalamic and

cortical networks. This oscillation is associated with the slow, periodic delta wave forms (Steriade et al., 1993) that can be observed in the EEG during these stages. This activity is believed to be generated by the intrinsic oscillating properties of certain thalamic neurons or by cortical input to inhibitory thalamic interneurons (Muzur, 2005; Steriade, 2000). Generally, awakenings from SWS yield subjective reports of phenomena that are typically easily distinguishable from reports from other stages due to their general lack of visual imagery and thought-like nature (Bosinelli & Cicogna, 2000; Hobson et al., 1998; Kahan, 2000; Purcell et al., 1986; Solms, 2000a).

REM Sleep

As alluded to above, REM sleep follows SWS in the normal temporal progression of a nighttime sleep period. The alternation of REM and NREM stages during sleep follows an ultradian (> once per day) rhythmicity of approximately 90 minutes. This alternation is thought by some to result from an interplay between inhibitory aminergic and excitatory cholinergic neurons of the mesopontine tegmentum responding to the homeostatic and circadian inputs from other parts of the CNS (Hobson & McCarley, 1977). REM sleep periods tend to be lengthier and more frequent toward the end of the sleep period due to the particular nature of the interaction of homeostatic and circadian processes (Achermann, 2004; Borbely, 1982a, 1982b; Diederich, 2007; Maquet, 1999; Maquet & Phillips, 1998) which put the brain in a more aroused state during the early morning hours.

Electrophysiologically, REM sleep is a state of low-amplitude, mixed-frequency activity that on superficial inspection appears similar to waking, leading some researchers to refer to this state as "paradoxical sleep". Within REM sleep however, there are further distinctions which may be made with regard to patterns of electrophysiological characteristics. The more physiologically active portion is referred to as phasic REM sleep, as it involves phasic bursts of muscle activity and rapid ocular saccades. The less active period, known as tonic REM,

generally involves little to no phasic muscle or oculomotor activity (Diederich, 2007; Rechtschaffen & Kales, 1968).

The unique pattern of REM sleep electrophysiology emerges from an increase in the firing rates of a distributed network of neurons across subcortical, reticular, thalamocortical and cortical levels. Activation in forebrain regions during REM sleep arises from the ascending arousal systems, including areas of the pontine brainstem, midbrain reticular activating system, hypothalamus, and basal forebrain. Phasic REM sleep potentials occur sequentially, originating in the pons and propagating along projections to the thalamic lateral geniculate body before terminating in the occipital cortex – representing the characteristic pontine-geniculate-occipital (PGO) waves seen in the REM sleep EEG. PGO waves likely account for visual phenomena of dreams. At the neuronal level, this pattern of activation is thought to be the result of simultaneous tonic disinhibition and phasic excitation of burst cells in the lateral pontomesencephalic tegmentum (Gottesmann, 2002a, 2002b, 2006, 2008). The pontine aminergic system is active in waking and inhibits the pontine cholinergic system, which is believed by some (*see* 'REM=dreaming debate' below for alternative views) to be responsible for initiating REM sleep (Hobson & McCarley, 1977). In this view, during NREM sleep aminergic inhibition begins to subside and cholinergic excitation increases until REM sleep onset, where aminergic inhibition of REM terminates and cholinergic excitability reaches its peak.

As a consequence of this proposed model of REM sleep neurobiology, there is a relatively high degree of arousal in REM sleep which is thought to be reflected in the increased vividness of dream imagery and "feeling of reality" relative to dreams of other stages. This explanation is also used to account for observations that there is a greater likelihood of awakening from REM sleep. Finally, a heightened state of arousal during REM sleep has been cited as a potential explanation for why lucid dreams tend to occur most frequently during REM periods, particularly during the early morning hours, when this state of arousal is typically at its

peak prior to awakening (LaBerge, 1985b).

Maquet and colleagues have provided some validation for the model just described using a neuroimaging approach. Using positron emission tomography, they have demonstrated that regional cerebral blood flow (rCBF) is, in fact, positively correlated with REM sleep in the pontine tegmentum. They also found relative increases in rCBF in the left thalamus, bilateral amygdaloid complexes, anterior cingulate cortex and right parietal operculum. Relative decreases in rCBF were demonstrated bilaterally in a vast area of dorsolateral prefrontal cortex (DLPFC), in the supramarginal gyrus of the parietal cortex and the precuneus during REM sleep. The authors note that the pattern of activation between the amygdala and cortical areas provides a biological basis for certain types of emotional memory processing during REM sleep (Maquet & Phillips, 1998).

Section Summary

To conclude this section on sleep physiology, empirical evidence from decades of research has largely supported the idea that REM sleep is the state most closely associated with dreaming. That said, this body of research has also demonstrated that dreams can occur during other stages of sleep as well (Bosinelli & Cicogna, 2000; Khambalia & Shapiro, 2000; Solms, 2000a). This has led to an important debate over the dissociability of REM sleep neurological processes and dream phenomenology. In the next section, one of the most popularized theories of dream neuropsychology developed by Alan Hobson and colleagues will first be reviewed. Following this review a broad overview of the debate over whether REM sleep=dreaming will be presented. The aim of these reviews will be to provide the necessary background and point of contrast for the later discussion of lucid dreaming and its physiological and phenomenological correlates.

Dream Neuropsychology

Hobson and colleagues' models of dreaming represent some of the most thorough attempts to map the 'formal features' of dreaming onto the underlying brain state of REM sleep. That is, these models have all sought to describe the gamut of characteristic phenomenological features of dreams as a function of the neurophysiology of REM sleep. This has largely been done by applying knowledge from neuropsychological studies, that is, of the phenomenological correlates of neurophysiological processes in waking, to explaining REM sleep dreams. The model described below is the most recent iteration of an ongoing attempt by Hobson and others to explain dream content by REM sleep neurobiology. Previously, the reciprocal interaction (Hobson et al., 1975; McCarley & Hobson, 1975) and activation synthesis (Hobson & McCarley, 1977) models, the current version, referred to as the Activation-Input Source -Modulation (AIM) model (Hobson & Pace-Schott, 2002; Hobson et al., 2003) is an attempt to fit the patterns of neural activity in REM sleep into a three dimensional state-space model with each dimension representing a different aspect of a brain-mind system. REM sleep falls at one extreme of the activation (A) axis (i.e. REM sleep involves a high level of activation compared with other states of consciousness), at the extreme endogeneous end of the input source (I) dimension and at the extreme cholinergic end of the modulation (M) axis (i.e. REM sleep neural activity is purported to be primarily cholinergically modulated) (Hobson & Pace-Schott, 2002).

As mentioned, the corresponding neuropsychological model of dreaming focuses on explaining the 'formal features' of dreaming: dream hallucinations, bizarreness and loosely themed narratives, a delusional belief in the reality of the dream and a lack of self-reflection, content instability, high emotionality, predominance of instinctual programs, lack of volition, and poor memory both within the dream and when attempting to recall the dream upon awakening. It is presumed then that each of these phenomenological features is relatively consistent across all dreams and the result of the particular nature of REM sleep as defined in the AIM model.

According to the specific details of the model, activation of the basal ganglia likely initiates the false sense of movement in the dream, which continues to work in concert with the cerebellum to fine tune this fictive movement while activation in the inferior parietal cortex allows for the spatial orientation of the dream body within the internally generated dream space. With noradrenergic projections to the spinal cord inhibited during REM sleep, activity in the basal ganglia, cerebellum, and parietal areas gives rise to dreamed corporeal movement without affecting PNS output (Aston-Jones, 1981). Dream hallucinations may occur in all perceptual and motor modalities during dreams. As pontine-geniculo-occipital activity is turned on in REM sleep, projections from visual areas of the occipital lobes are sent to the lateral geniculate nucleus and other thalamic nuclei involved in relaying sensory information to be interpreted by higher order visual association areas, generating dreamed visual imagery. The result is the internally formulated sensorimotor phenomena of dreaming which, in the absence of exogeneous feedback is shaped instead by these association areas, lending dreams a characteristic hyper-associative quality (Hobson & Pace-Schott, 2002).

Activation in the amygdala, anterior cingulate, parahippocampal cortex, hippocampus, and medial frontal regions during REM sleep are thought to underlie the emotionally-laden content of dreams which appears to draw on seemingly random memories which are then integrated into what becomes a loosely themed narrative based on autobiographical history. Hobson suggests that the decrease in activation in areas of the medial orbitofrontal cortex and insula during REM sleep may account for a confabulatory, normally unquestioned acceptance of the dream as "real" in spite of its bizarre, disjointed nature (Braun, 1997; Nofzinger, 1997). Deactivation of dorsolateral prefrontal areas in REM sleep likely contributes to this loss of logical reasoning as well as impaired volition and working memory in dreams (Hobson & Pace-Schott, 2002).

Though this particular model appears to be comprehensive and sufficiently and logically

ties each of the proposed 'formal features' of dreaming to underlying REM sleep processes, there are at least two features of dreaming which remain unaccounted for. While the authors explain that dreams typically involve impaired retrospective memory functions, there also appears to be impairment of prospective memory functions as well. That is, in dreams we often forget the intentions we have set forth during prior periods of waking and even from earlier within the same dream. Though this has not been demonstrated conclusively in any empirical study, the failure of prospective memory functions during REM sleep would be consistent with the neurobiology of REM sleep. It has been shown in PET and fMRI studies that there is a decrease in activity in the precuneus during REM sleep relative to wakefulness (Hobson et al., 1998; Maquet, 2000; Maquet, Peters, Aerts, Delifiore, et al., 1996; Maquet & Phillips, 1998; Maquet et al., 2005). Functional studies of the precuneus during waking suggests that it is involved in prospective remembering as the failure to recall intentions is associated with decreased activation in the precuneus compared with successful recall (Burgess et al., 2001; den Ouden, 2005). An additional feature that is poorly explained by Hobson and colleagues' model is perceptual and behavioral occurrences that are unique to dreaming, such as abnormal visual perceptual experiences and flying. Imaging studies of REM sleep have shown decreased activity in the supramarginal gyrus (Maquet, 1999; Maquet, Peters, Aerts, Delifiore, et al., 1996; Maquet & Phillips, 1998; Maquet et al., 2005) – an area believed to be involved in a number of functions including bodily representation and visual-spatial orientation (Darling, 2003). This relative deactivation may explain why dreams often involve anomalies in bodily representation and orientation.

Hobson and colleagues' AIM model provides an empirically supported foundation which begins to explain the variations in cognitive functions across the wake-sleep continuum. Though this model offers much in the way of correlating neurobiology with dream phenomenology, it has also received some warranted criticism. Aside from being slightly

incomplete, there has been an important debate over some of this model's more basic assumptions – foremost being the assumptions that dream narratives are driven by activation of subcortical limbic areas and that cholinergically modulated, pontine activation is necessarily associated with dreaming. Conflicting evidence has emerged from lesion and dream content studies which contradicts these points (Nielsen, 2004; Nielsen, 2000a; Nielsen, 2000b, 2000c; Solms, 2000a, 2000b; Solms, 1995, 2000c).

REM sleep and Dreaming

As alluded to above, Solms provided some of the first clear evidence in support of a different model of dream generation (Solms, 2000a, 2000b; Solms, 1995, 2000c). In this alternative model, the pontine brain stem is not the generator of dreaming but instead, temporal-limbic and forebrain structures. Solms also rejected the idea that dreams are simply the brain's attempt to wrap a narrative around the otherwise random firing of neuronal networks originating in the brain stem. While he shares Hobson's view that the pons may trigger the initiation of REM sleep, he contends that the there is a separate trigger for initiating the neurophysiological mechanisms underlying dreaming – mechanisms which lie in dispersed dopaminergic temporal-limbic regions. Connections between frontal and limbic regions are proposed by Solms to subserve a selection process for the activation arising from temporal-limbic areas.

In fact it had already been shown in several studies (Foulkes, 1962; Monroe et al., 1965) that about one quarter of all dreams which might be considered 'REM like' actually occur in NREM sleep (Solms, 2000a). Nielsen's review of research in this area suggested that about 50% dream mentation recall comes from NREM sleep (Nielsen, 2000c). Together, these findings cast serious doubt on any model which relates dreaming solely to the brain-stem processes of overt REM sleep, such as Hobson and colleague's neuropsychological model of dreaming (Hobson et al., 1998). On the other hand, some have suggested that there may be a 'covert' REM sleep which could potentially resolve the two models (Bosinelli & Cicogna, 2000;

Cavallero, 2000; Nielsen, 2000b, 2000c; Ogilvie et al., 2000; Pace-Schott, 2000).

NREM dreams occur in a state which bears very little electrophysiological resemblance to REM, suggesting of course that these dreams are generated by brain states other than REM sleep (Solms, 2000a). Nielsen suggested that "covert REM" processes may be present during NREM sleep stages and may be responsible for the generation NREM dreams (Nielsen, 2000c). Covert REM, Nielsen suggests, would be similar to a stage of sleep known as SP, which has been well documented in cats. SP amounts to SWS accompanied by the pontine-geniculate-occipital waves typically associated with REM sleep. As mentioned previously, these waveforms are thought to be related to dream imagery. If this process is truly occurring during human stage 2 sleep or even SWS, it seems possible that the dream reports elicited here might be difficult to distinguish from REM sleep dreams.

Whether a human analogue to SP exists has not been definitively established, but Solms' clinical studies provided evidence that individuals with pontine brainstem lesions retain the ability to dream (Solms, 2000a). In a series of studies, he identified two brain areas which might be associated with dream generation, including the prefrontal cortex and an area at the parietal-temporal-occipital (PTO) junction. In a striking refutation of one of the core assumptions of the REM = dreaming hypotheses, damage to these areas completely obliterated dreaming in his patients while leaving REM sleep intact. Thus, even attempting to explain NREM dreams by arguing for a 'covert REM' state, still fails to explain the dreams of patients with pontine lesions. In other words, it appears likely that dreaming originates from areas other than the pontine brainstem.

Based on a review of studies from lesioned patients, Solms claimed that:

"Dreaming is not an intrinsic function of REM sleep (or the brain stem mechanisms that control it). Rather, dreaming appears to be a consequence of various forms of cerebral activation during sleep. This implies a two-stage process, involving (1) cerebral activation

during sleep and (2) dreaming. The first stage can take various forms, none of which is specific to dreaming itself, since reliable dissociations can be demonstrated between dreaming and all of these states (including REM). The second stage (dreaming itself) occurs only if and when the initial activation stage engages the dopaminergic circuits of the ventromedial forebrain. It is reasonable to hypothesize on this basis that these forebrain circuits are the final common path leading from various forms of cerebral activation during sleep (both REM and NREM) to dreaming per se." (Solms, 2000a, p. 849, p. 849)

In addition to questioning the prevailing hypothesized mechanism for dream production, some researchers such as LaBerge, have taken issue with the AIM's initial oversimplification of the variety of dream experience and even its misspecification of the features of normal REM dreams within their state-space model. For instance, even while dreams are typically associated with impaired cognitive functioning, REM sleep is not associated with a low "A" value relative to waking. One of the assumptions of AIM is that information flow (I) is uniform across sensory modalities within a given state (i.e. waking, dreaming). LaBerge noted however that "it is possible for one sense to remain awake, while others fall asleep" (LaBerge, 1990b, 2000) and many are aware of the phenomenon of stimuli from the waking world becoming incorporated into dream content.   In order to capture the fact that any of the features of dreams may also be present to varying degrees in other states of consciousness such as waking and NREM sleep, the current neuropsychological model might best be broadened to explain the full variety of dreamed experience, including lucid dreaming.

Spurned by the apparent inadequacy of Hobson's neuropsychological model, Domhoff published a 'new' neurocognitive theory of dreaming, built on the above findings as well as studies of dream content in children and adults (Domhoff, 2001). He proposed that the forebrain network, believed by Solms and others to be involved in dream generation, develops gradually over the first 8 to 9 years of life and that this development is reflected in the changing

content of dreams from childhood into early adolescence. Specifically, he cites the finding that before age 9, only 20-30% of REM period awakenings lead to dream reports and that the dream content of children under age 5 is comparatively 'bland and static' by comparison. Domhoff further cites content studies which have suggested an interaction between the continuity and repetition principles, discussed in greater detail below (see Continuity Theory), which suggests that thinking during dreaming is largely figurative. To sum up his proposed theory, he states that: 1) Dreaming depends on a neural network involving limbic, paralimbic, and associational areas of the forebrain; 2) Dreaming is develops gradually over the first 8 or 9 years of life and; 3) Dream content is largely continuous with waking (Domhoff, 2001). Recently, Domhoff has expanded his neurocognitive theory of dreaming by proposing that it may be a subsystem of the 'default mode' or resting state network (Domhoff, 2011). This is an intriguing hypothesis that has been proposed by other dream researchers as well (Ioannides et al., 2009; Nir & Tononi, 2010; Pace-Schott, 2007) and which has implications for the theoretical basis of the present study. However, a discussion of these implications is more appropriately placed within the context of a later review of the continuity theory of dreams (see p. 37).

Section Summary

The prevailing model of REM sleep dreaming as proposed by Hobson and colleagues provides some guidance in understanding how the brain may produce the unique experiential qualities of dreaming in that it outlines the particular brain areas which may be involved and the nature of activation in those areas during normative REM sleep. Research in the past decade however has called some of this model's basic assumptions into question. Most importantly lesion studies which have shown REM sleep can occur in the absence of dreaming and that dreaming can occur in the absence of overt REM sleep, suggest that the mechanism of dream generation may not lie within the pontine brainstem but instead in regions of the forebrain. Nonetheless, the pattern of neurophysiological activation associated with REM sleep is most

often associated with dreaming and the possibility of covert REM processes during NREM sleep suggests that Hobson and colleagues' model remains a useful starting point for understanding why dreams take the forms and contain the types of content that they do.

As will be discussed below, lucid dreaming has been found to occur almost exclusively during REM sleep. Hobson and colleagues' neuropsychological model of REM sleep dreaming can thus serve as a starting point for understanding how lucid dreaming can emerge from the underlying brain state of REM sleep. The next section will review the research literature describing the physiological features of lucid dreams as well as the personality factors and cognitive characteristics most often associated with lucid dreaming. A review of various lucid dream induction methods will also be presented as they may also provide some insight into the brain bases for this state. The aim of these reviews is to provide the main rationale behind this study's primary hypothesis – that mindfulness in waking is related to lucidity in dreams.

Lucid Dreaming

Physiology

To investigate the neurophysiology of lucid dreaming, it is typically necessary to have, at minimum, the capability of recording physiological markers that can verify sleep and at least one participant with the capability of both inducing a lucid dream during recording and signaling to external observers that he or she has become lucid. Such signal verified lucid dreams (SVLD's) are rare, even in the most well controlled studies with some of the most adept lucid dreamers. As a result, much remains unknown about the physiological processes involved in lucid dreaming. Given that a more widespread interest in lucid dreaming is a relatively recent development and also due to the methodological difficulties in studying lucid dreams in the laboratory, there have been comparatively few studies in this area relative to sleep physiology more generally.

Nonetheless, several studies have provided some evidence which has furthered our

understanding of the physiology of lucid dreaming. By employing the SVLD paradigm, it has been demonstrated that lucid dreams (at least SVLD's, that is) most frequently occur during phasic REM sleep (LaBerge et al., 1986). SVLD's also seem to involve essentially the same patterning of electrophysiological activation as waking experiences with respect to certain behaviors carried out while the dreamer is lucid.   For instance, it appears that the right-left hemispheric lateralization observed during waking for activities like singing (greater right hemisphere activity) and counting (greater left hemispheric activity) also holds true for lucid dreaming (LaBerge & Dement, 1982b). The patterns of electrophysiological activation associated with sexual activity are also similar during both lucid dreaming and waking (LaBerge, Greenleaf, et al., 1983).

Schatzman, Fenwick, and Worsley (1988) used the SVLD method to investigate whether pre-planned actions, carried out in lucid dreams, produced corresponding changes in electrophysiological measures. These activities included kicking dream objects, writing with umbrellas, drawing triangles and snapping fingers. Results confirmed that the muscles of the body show small movements corresponding to the body's actions in the dream. Furthermore, it has been demonstrated that the eyes do track dream objects as lucid dreamers have been able to produce slow ocular saccades which are very difficult to produce in the absence of a "real" stimulus (Fenwick et al., 1984; LaBerge & Zimbardo, 2000; Schatzman, 1988). Eye movement density has also been positively correlated with lucid dream probability (LaBerge et al., 1986).

Comparisons of eye movement density, heart rate, respiratory rate, and skin potentials between epochs of lucid and non-lucid REM have demonstrated greater levels of autonomic activation overall in the thirty seconds preceding and following lucidity onset (LaBerge, Levitan, et al., 1983). Specifically, skin potentials are higher and eye movements more frequent in the thirty seconds preceding SVLDS relative to non-lucid REM periods.

One interesting though inconsistent finding is that alpha frequency band power has been

associated with 'pre-lucid' dreams (Ogilvie, 1982a; Tyson, 1984). In a "pre-lucid" state, the dreamer suspects he/she may be in a dream but has not made a distinct determination (LaBerge, 1980a; Ogilvie, 1982a; Tyson, 1984). H-reflex suppression, a characteristic of non-lucid REM sleep, has been shown to be even greater during SVLD's (LaBerge, 1990b). The direction of eye movements and rate of respiration in lucid dreams have been shown to be under voluntary control and correlate with the objective physiological measures of these variables taken during lucid dreams (LaBerge & Dement, 1982a, 1982b).

One study demonstrated increased activity in the beta-1 frequency band (13 – 19 Hz) in the parietal region during lucid as opposed to non-lucid REM periods (Holzinger et al., 2006), particularly over the left parietal lobe. This region of the brain is purported by the authors to be associated with semantic understanding and self-awareness. The authors suggest that this activity reflects the ability of the lucid dreamer to understand the meaning of the "I am dreaming" statement.

A recent study by Dresler (Dresler et al., 2011) revealed that the performance of a hand-clench motor task produced similar patterns of activation across actual waking performance, imagined performance, and dreamed performance. They used the SVLD approach along with simultaneous recording of polysomnography and fMRI to compare the degree and extent of activation across these three states. Waking demonstrated the strongest activation, followed by dreaming, then imagined hand clenching.

These studies suggest that lucid dreams emerge from a particularly active and aroused neurophysiological state, but that this state is essentially REM sleep. While it is plausible to assume that areas of the prefrontal cortex, associated with metacognitive functioning in waking, are also involved in lucid dreaming, very few studies provide support for this hypothesis. One of the few studies which does provide such support had methodological problems which reduce confidence in their results (Voss et al., 2009). Specifically, their finding that lucidity was

associated with greater theta band activity in the region of the dorsolateral prefrontal cortex was confounded by potential eye-movement artifact.

While the neurophysiological correlates of meditation will be addressed later, it should also be pointed out here that increased alpha power, of the kind seen in 'pre-lucid' states has been associated with mindfulness meditation as well (Chiesa, 2009; Ivanovski & Malhi, 2007). This would appear to support the idea that mindfulness and lucidity are related. However, the increased alpha activity often seen in frontal and parietal regions with mindfulness meditation is also an inconsistent finding and increased beta and theta frequency band power has also been associated with mindfulness meditation (Ivanovski & Malhi, 2007). The implication of these findings is, therefore, still unclear. It is entirely possible that there is no meaningful relationship between the alpha activity observed during pre-lucidity and the fact that mindfulness meditation may be associated with increases in alpha. Nonetheless, one potential explanation for these prior findings is that the neurophysiological deactivation that is typically associated with increases in alpha power is reflective of greater efficiency of processing in meditators. In dreams, this could mean a decreased demand for resources that might well allow for the additional, metacognitive capacity that would aid in lucidity onset. Alternatively, as high levels of alpha have also been associated with higher levels of dream bizarreness (Ogilvie, 1982b), it may simply be that the dreamer is more likely to notice that some aspect of his or her experience is 'dream like', thus triggering a more critical state of awareness that could lead to the onset of a lucid dream.

Examining patterns of neural activation associated with lucid dreaming using EEG is clearly difficult and potentially misleading. While a functional neuroimaging approach will likely help to clarify the neurophysiological correlates of lucid dreaming, it is still important that such investigations be guided by an empirically derived neuropsychological model of lucid dreaming as has been proposed by others (e.g. Domhoff, 2011). Such a model will aid in making

predictions about the type of activation one might expect during a lucid dream given, for instance, how lucid dreamers differ from non-lucid dreamers in terms of their waking personality characteristics and cognitive functioning.

Personality

Fortunately, compared with the number of studies investigating lucid dream physiology, there is already a relative abundance of studies which have investigated the personality characteristics of lucid dreamers. Unfortunately, it has been difficult to draw any definitive conclusions about the relationships between lucid dreaming and any demographic, sleep, or personality variables. Few studies have reliably identified any single variable or set of variables which can reliably predict lucid dreaming ability. One potential reason for this is that individuals in these studies are often arbitrarily grouped into different frequencies of lucid dream occurrence (i.e. high, medium or low) and there is rarely appreciation for the varying degrees or types of lucidity (i.e. non-lucid, pre-lucid, lucid, lucid control). In spite of these limitations, this body of research has contributed some important findings and, however inconsistent, lucid dream frequency has at times been shown to be directly or indirectly related to factors of personality, gender, and intelligence (Blagrove & Akehurst, 2000; Blagrove & Hartnell, 2000; Blagrove & Tucker, 1994; Gackenbach, 1981; Galvin, 1990; Schredl & Erlacher, 2004).

For instance, Blagrove and Hartnell (2000) found that lucid dreamers scored significantly higher than non-lucid dreamers on measures of 'need for cognition', 'creativity' and 'internal locus of control'. In other words, individuals who reported lucid dreaming were more creative, had a higher need for thought, and were more likely to attribute events in their life to factors under their own control and not to those controlled by others or to chance. The authors note that the construct 'need for cognition' was been negatively correlated with 'closed mindedness' and 'need for social desirability' and positively correlated with general intelligence in another study (Cacioppo, 1982).

Schredl and Erlacher (Schredl & Erlacher, 2004), investigated the relationship between personality and lucid dream frequency using the Neuroticism, Extraversion, Openness Personality Inventory (Ostendorf, 1994), the Tellegen and Atkinson personality inventory (Tellegen, 1974), and the Boundary Questionnaire (Hartmann, 1991). Their results showed that 82% of their sample of 444 college students had experienced a lucid dream at some point in their life. Lucid dream frequency was most closely related to dream recall but was not significantly associated with any of the personality factors they assessed. A replication of this study (Patrick & Durndell, 2004) found that both frequent and occasional lucid dreamers demonstrated a more internal locus of control and greater need for cognition measure than did nonlucid dreamers. Frequent but not occasional lucid dreamers demonstrated greater field independence than nonlucid dreamers. These personality factors - need for cognition, internal locus of control, and field independence – were all correlated with one other. The authors suggested that their results argued for continuity between 'styles' of waking and dreaming personality.

More recently, the authors of the former study attempted to better characterize lucid dream frequency in the general population (Schredl & Erlacher, 2011). Their results, with a considerably larger sample including non-students, found that about half of those asked had experienced a lucid dream at least once during their lifetime. The authors also found a high-moderate correlation, once again, between lucid dream frequency and dream recall. While women and younger individuals were found to be more likely to have lucid dreams in their sample, this finding was confounded with dream recall. None of the other demographic variables assessed in their study were related to lucid dream frequency.

In general, sex and age differences in lucid dream frequency have ranged from minimal to nonexistent. In the only study of lucid dream frequency in children, it was found that the recall of lucid dreams may decline with age, peaking at around the age of ten. In this same

study, boys recalled slightly fewer lucid dreams than girls overall (Armstrong-Kickey, 1988). Conversely, in at least one study of adult and college student samples, no sex differences were demonstrated with respect to lucid dream frequency (Gackenbach, 1985).

Overall, more frequent lucid dreaming has been consistently associated with greater field independence, an internal locus of control, and a greater need for cognition and less consistently with vestibular sensitivity, creativity, and intelligence (Blagrove & Hartnell, 2000; Blagrove & Tucker, 1994; Gackenbach, 1984; Schredl & Erlacher, 2004). It appears that perhaps the most reliable factor to be associated with lucid dream frequency however is dream recall (Brooks, 2008; Gackenbach, 1981; LaBerge, 1990b, 2000; Paulsson & Parker, 2006; Purcell et al., 1986; Schredl & Erlacher, 2011; Schredl & Erlacher, 2004). This association, perhaps due to the fact that it appears self-evident, is often glossed over or interpreted only in the most straightforward manner. That is, it is necessary to first know whether a lucid dream has occurred in order for it to be reported. If an individual has poor dream recall, they are less likely to report any dreams, let alone lucid ones. However, there may be more to the association between dream recall and lucidity than is immediately apparent.

It appears plausible that lucid dreams are more likely to be recalled than non-lucid dreams. While it would be difficult (if not impossible) to adequately test such a claim, if true, it might suggest that the *capacity* of the lucid dreamer for dream recall is, for whatever reason, greater than that of a non-lucid dreamer. Though a more thorough discussion is presented later (See 'Dream Self-Reflectiveness'), some further explanation of this idea is worth noting here.

Some have suggested the existence of a developmental continuum of 'dream ego' awareness (Kozmová & Wolman, 2006; Purcell et al., 1986; Rossi, 2000). At the low end of this continuum is the undeveloped dream ego for which dream recall is almost entirely absent. At the opposite end is a fully developed dream ego that is integrated with the waking self and for which fully controllable lucid dreaming may occur frequently (Purcell et al., 1986; Rossi, 2000).

In this view, those with greater 'dream ego' awareness would be hypothesized not only to demonstrate greater recall of prior dreams, but also greater levels of lucidity in dreams as well. There is extensive, albeit largely anecdotal, support for such a theory (Brooks, 2008), but more research is certainly needed in this area.

Questions about whether certain psychological characteristics are necessary preconditions for lucid dreaming or whether they are simply developed in parallel to lucid dream ability cannot be conclusively answered given the available evidence. Still, findings such as those described above suggest that lucid dreaming may not develop in isolation from other psychological factors. More importantly though, while these studies have shown that certain psychological characteristics may be associated with the ability to achieve lucidity they do not necessarily suggest that these functions are either necessary for nor exclusive to lucid dreams.

Cognition

Lucid dreamers often report having many of their waking cognitive faculties at their disposal during their lucid dreams. During a lucid dream, the dreamer may have the ability to remember the conditions of waking, recognize the bizarre or otherwise salient elements of the dream, make choices and willfully carry out intentions (Carskadon, 1995). Theoretically, lucid dreaming appears to be reliant upon what would traditionally be considered executive functions and, as a rule, involves a degree of metacognitive monitoring in order to maintain the awareness that one is dreaming (Kahan & Laberge, 1994a). LaBerge has described lucidity as the ability of the dreamer to "…reason clearly … and act as they wish upon reflection" though he properly qualifies this statement, noting that lucid dreamers "do not always possess these abilities to a great extent," (LaBerge, 1985a). Still, one recent study demonstrated that relative to non-lucid dreams, reports from lucid dreams contain significantly more references to choice, sustained attention, and private self-reflection (Rider et al., 2012).

Higher lucid dream frequency has been associated with better Stroop performance

(Blagrove et al., 2010) – a task which has been shown to activate the dorsolateral prefrontal and anterior cingulate cortices. Conversely, performances on the Wisconsin Card Sorting Test, a task that engages the dorsolateral prefrontal cortex were not significantly related to 'lucid dream characteristics' (Neider et al., 2011). High frequency lucid dreamers did not demonstrate any difference compared with low frequency lucid dreamers or non-lucid dreamers on a measure of change blindness (Blagrove & Wilkinson, 2010). Lucidity has also been related to performance on the Iowa Gambling Task, which has been shown to engage ventromedial prefrontal cortex (Neider et al., 2011).

Generally, cognitive functions that have traditionally been associated with dorsolateral prefrontal (i.e. reasoning and problem solving), anterior cingulate (i.e. decision making and motivated behavior), and orbitofrontal (i.e. maintenance of set, self-monitoring) cortical functioning appear to be more common in lucid versus non-lucid dreams. Despite a wealth of anecdotal reports of such high level cognition during lucid dreaming however, very few studies have investigated this claim empirically. The dearth of studies in this area may a byproduct of the tenuous nature of drawing conclusions based on self-reports on cognitive functioning, particularly cognitive functioning recalled from a previously dreamed experience. The reliance on imperfectly recalled subjective reports as indices of experiences is, however, an issue which has been grappled with and addressed in countless studies of dreaming and of psychology more broadly and one which is addressed more thoroughly below (see Limitations). Fortunately, a significant amount of research attention has been devoted to the induction of lucid dreams, which can also provide insight into the nature of cognition in both non-lucid and lucid dreaming.

Induction

Existing lucid dream induction methods use targeted attentional and mnemonic practices to attempt to increase the probability of lucid dreaming. While many of these techniques will be

reviewed below, this overview is not intended to be exhaustive (for such a review, see Gackenbach & LaBerge, 1988). The purpose of this review is to provide the background necessary to infer the underlying neuropsychological mechanisms involved in lucid dream induction and to demonstrate how mindfulness may be related to dream lucidity.

Many practices for inducing lucid dreams focus on preparation or interventions aimed at adjusting waking patterns of thought and behavior to increase the probability of lucidity in dreaming. For instance, a technique referred to as "cycle adjustment" (Levitan, 1992) take advantage of inherent circadian rhythms for alertness. The high state of physiological arousal in the early morning hours, which peaks at the time of awakening due to circadian neuromodulation from the SCN (Nielsen, 2004), is particularly conducive for lucid dreaming (Levitan, 1992; Price et al., 1991). In a pilot study by LaBerge and colleagues, participants were asked to record the times they awakened during the night or in the morning as well as whether they awakened from a dream or a lucid dream for a period of one week. Almost 60% of participants had a lucid dream during this period and 7.6% of awakenings were from lucid dreams (much higher than the estimated frequency of spontaneous lucid dreams in the general population). The overwhelming majority of lucid dreams (90%) occurred during the last 4 hours of the sleep period (Levitan, 1992).

Other wake-based lucid dream induction methods rely on intentional pre-sleep self-suggestion. German psychologist Paul Tholey pioneered the technique (Tholey, 1983a) which typically involves setting one's intention to remember to ask the question "Am I dreaming?" while dreaming. The aim is to routinize this behavior (i.e. state-testing) by posing the question as many times as can be remembered each day. This approach is often referred to as 'intention and suggestion', "reflection", or 'reflection-intention' (LaBerge, 1990a; Paulsson & Parker, 2006). The question should not be answered without some critical inspection first, perhaps by attempting to perform some action that would not be possible in waking (e.g. trying to float) or

dreaming (e.g. trying to use some man-made device like a light switch).

Since this approach relies heavily on intentional multiple cognitive processes including encoding the intention to ask the question; retrieval of the intention to carry it out; recognition of the appropriate retrieval context; faithful execution of the question; and the correct assessment of one's state, it can be said to fall under the rubric of prospective memory. Brain areas supporting these functions, particularly frontal regions and the precuneus are typically deactivated during REM sleep, compared with waking (Corsi-Cabrera et al., 2003; Maquet & Phillips, 1998; Maquet et al., 2005). It has been shown that cue-based prospective memory is more reliable than other forms of prospective memory (i.e. time-based) (Cheng, 2008) which may explain why cueing is used so frequently with this type of induction technique. For instance, Clerc suggests writing the letter 'C' on one's hand to serve as a reminder to ask the critical question (Tholey, 1983b), while LaBerge recommends pairing the state-test with approximately five to ten typically occurring events per day. Reflection/Intention procedures are among the few empirically tested lucid dream induction techniques which have been shown to be effective both for people who have had lucid dreams and those who have not (Paulsson & Parker, 2006).

Lucid awareness training is an "attempt to promote a particular attitude or state of consciousness during wakefulness," – a state of "heightened perceptual awareness" (Price et al., 1991). This approach arises from the idea that the majority of us are typically in a state of dampened awareness. The goal of lucid awareness training is to cultivate this heightened state of awareness using waking practice, akin to mindfulness, with the expectation that, through regular practice, this state will eventually become more accessible while dreaming.

Alpha-frequency brainwave entrainment has also been used in attempts to induce lucid dreams. The rationale behind using alpha entrainment were studies of meditators which observed that concentrative meditation had the effect of increasing the amount of alpha activity

in the resting EEG. Ogilvie, Hunt, and others (Ogilvie, 1982a) had a group of 10 good dream

recallers spend 2 nights in the sleep lab. The experimenters awakened the participants

periodically during the night from REM sleep, twice during their highest alpha activity period,

and twice while levels of alpha were at their lowest. In addition, half of the participants were

given alpha feedback training prior to sleep onset, both to familiarize them with the feeling

associated with alpha activity, and to train them to induce this activity. The authors

hypothesized that alpha training might thus lead to a greater awareness in dreams. Their

results indicated that arousals during high alpha periods were associated with significantly

higher lucidity ratings. However, alpha feedback training had no significant effect upon lucid

dream frequency or REM alpha levels (Ogilvie, 1982a).

In another study by Hunt and McCleod (1988), investigated the interrelation of dream

bizarreness, lucidity, and meditation practice in long-term meditators. Participants were asked

to rate their own dreams as either lucid, control/prelucid, or non-lucid and estimate their total

number of lucid, control, and prelucid dreams over the preceding year. The authors also rated

each dream collected during the study on their own seven point lucidity scale. Years of

meditation practice was found to be significantly and positively related to estimated lucid dream

frequency over the previous year.

LaBerge investigated the effects of intense concentration, practiced in the morning or

evening, on lucid dream frequency in a small sample of participants. No measures of alpha

activity were included in his study, nor were there any subjective measures of awareness. Even

with a small sample of participants, results suggested that intense concentration for fifteen

minutes in the evening was associated with a higher probability of lucid dreaming than when the

same practice was performed during the morning (Levitan, 1992).

Malamud (1979) and Sparrow (1976) both produced doctoral dissertations detailing

methods for developing lucid awareness during waking for the purposes of lucid dream

induction. Malamud's approach involved "re-dreaming" past experiences and dreams through active visualization during waking. Participants were instructed to attempt to visualize a better outcome to their dreams with the expectation that this would engender lucid awareness in future dreams. Unfortunately, her results were inconclusive with regard to whether this practice increased dream self-reflectiveness. However, she did demonstrate a measurable increase in participants' self-reflection during waking.

Lucid dream induction practices which focus on dreaming are typically concerned with the recognition of some unusual dream element that may originate from within the dream or delivered through some exogeneous means (i.e. dreamsigns). A dreamsign may be defined as "a peculiar event or object in a dream that can be used as an indicator that you are dreaming" (Levitan, 1992). In a series of early experiments published in the Lucidity Institute's newsletter, LaBerge and colleagues identified four broad categories of dreamsigns including 1) ego-related anomalies; 2) character-related anomalies; 3) object-related anomalies; and 4) setting-related anomalies. These were later refined to include dreamsigns related to inner awareness, action, form and context. Of these, frequency of inner awareness and action dreamsigns correlated significantly with lucid dream frequency, suggesting that practices aimed at enhancing inner awareness and action during waking, such as mindfulness, might facilitate the recognition of these dreamsigns, thus increasing the likelihood of lucid dreaming.

Dreamsigns can also originate from exogeneous stimuli. One example of this approach is the Nova Dreamer, developed by LaBerge and colleagues at the Lucidity Institute (Kottke, 1996). The Nova Dreamer utilizes a sleep mask with embedded ocular sensors, LED's over the eyes, and a small speaker. The detection of REMs by the ocular sensors triggers the delivery of flashing light stimulation via the embedded LED's and/or low level auditory stimulation from the internal speakers. The principle behind the Nova Dreamer is that external stimuli often become incorporated in dream content. In the example of the Nova Dreamer, the flashing LED's may

become a flashing stoplight while the sound from the speakers may become an alarm in the dream. The Lucidity Institute's website offers several accounts of how the light stimulation has been manifest in dream content (The Lucidity Institute, 2009). However, this integration of the stimuli into the dream is often not enough to trigger a lucid dream. The dreamer must still recognize the flashes or sounds as originating from the Nova Dreamer, then must also perform a reality test and accurately determine that he or she is dreaming. Thus, even with the aid of exogeneous stimulation, the dreamer's capacity for reflective awareness, volition, and logical reasoning would still appear to be necessary components for successful lucid dream induction.

The mnemonic induction of lucid dreams (MILD) is actually a set of practices aimed at the development of various abilities including dream recall, anomaly detection, prospective memory, and critical state testing. The dreamer awakens, typically in the early morning, and attempts to recall the most recent dream as completely possible. After engaging in some activity while awake, the individual returns to sleep, concentrating single-mindedly on the intention to remember to recognize that he or she is dreaming. While continuing to focus on this intention, one imagines being back in the dream and imagines recognizing that it is a dream. This process continues until the intention is firmly set or until the individual falls asleep (LaBerge, 1995).

LaBerge admits the MILD technique is "difficult to teach [to] people who have no experience with lucid dreaming" and suggests that MILD is more appropriate for individuals who wish to learn to induce lucid dreams at will (Price et al., 1991). The current evidence seems to support this position. While those without experience with lucid dreaming may not find MILD particularly effective, this approach boasts impressive rates of improvement in people with some familiarity with lucid dreaming and is the only method which has been demonstrated to allow individuals to have lucid dreams at will (LaBerge, 1990a).

Another set of techniques is aimed at the transition from waking to dreaming and are

sometimes referred to as 'Hypnogogic Techniques' (Price et al., 1991) or wake induced lucid

dream (WILD) techniques. These practices focus on developing the dreamer's capacity to

maintain self-awareness throughout the changeover from waking to dreaming consciousness.

Since REM sleep does not typically emerge until about 90 minutes into sleep, these practices

tend to be suited to the early morning hours, after an awakening, when the propensity to enter

directly into REM sleep is highest.

LaBerge argues that the maintenance of awareness through the early stages of sleep is

also a learnable skill (LaBerge, 1980). He suggests that this type of lucid dream initiation draws

on an individual's ability to engage in active self-reflection and ability to remember to recognize

that the hypnogogic imagery is part of the developing dream. However, simply attempting to

keep one's awareness sustained while falling asleep is a vague and difficult task to accomplish.

Unlike Tibetan dream yoga, wherein the dreamer has some mental imagery on which to focus,

such a "pure awareness" approach involves no special emphasis on specific thoughts or

imagery. Often, this technique is used in the context of waking up from a dream, then falling

back into sleep with conscious awareness intact. One practice which gives attention something

to focus on is a variation of the classic "counting oneself to sleep" (LaBerge, 1990a). The

variation comes with the insertion of the phrase "I'm dreaming" between each ascending

number, so that the dreamer's internal dialogue consists of something akin to "one, I'm

dreaming…two, I'm dreaming, three, etc." Presumably this counting procedure would continue

until the statement "I'm dreaming" occurred within a dream. This method appears to be less

reliant on prospective memory processes, as it has the state-testing question 'built-in'.

However, the type of passivity needed in order for the dream imagery to fully develop is almost

in conflict with the method itself, which requires active, intentional cognitive processing.

Section Summary

Based on the preceding review of lucid dream research, several conclusions may be

drawn. With respect to the neurophysiology of lucid dreaming, it can be said that lucid dreams do appear to emerge most frequently from the more physiologically active state of REM sleep (i.e. phasic REM) than from any other stage. Thus, the neuropsychological model of REM sleep dreaming as proposed by Hobson and colleagues (Hobson et al., 1998) should be modified to include the potential emergence of lucidity. Furthermore, it has been shown that many lucidly dreamed behaviors are associated with patterns of neural activation similar to their waking actual or imagined analogs. Taken together, these findings point to a potential continuity in the nature of the brain-behavior relationships between waking experience and REM sleep lucid dreams.

Overall, this broad view of the physiological, personality, and cognitive factors associated with lucid dreaming suggests that it is a relatively high-level state of consciousness compared with normative dreaming or even, perhaps, 'normative' waking states. Even more relevant to the present study, a review of the lucid dream literature reveals a striking similarity to high-level meditative and mindful states as observed during waking and suggests that certain attentional, executive, and metacognitive processes are critical to lucidity.

As discussed in the sections above on sleep physiology and dream neuropsychology, the particular set of cognitive functions that are 'available' during REM sleep and the capacity of a dreamer to employ those functions during a dream are both likely to be limited by the physiological and neurochemical state of the brain. That lucid dreaming exists at all is still poorly explained given the current models of the neurobiological basis of REM sleep – a fact which begs further explanation. The final piece of this review which is intended to serve as the basis for an expanded model of dream neuropsychology concerns the continuity theory of dreaming. This theory is critical to the assumptions of the present study and may provide some insight into how and why lucidity is possible.

Continuity Theory

Traditionally, dreaming has been viewed as phenomenological dissimilar and cognitively deficient compared to waking (Hobson et al., 2000; Rechtschaffen, 1978). Over the past 50 years however, a theory which emphasizes the similarity between waking and dreaming has challenged this view. What began with a finding which initially surprised many dream researchers, demonstrating that narrative reports of REM sleep dreams can be thematically indistinguishable from narrative reports of waking experiences (Snyder et al., 1968), has grown into a robust and empirically supported theory that has significantly altered our understanding of the relationship between waking and dreaming.

Simply stated, the continuity theory of dreams (also referred to as the continuity hypothesis) holds that dreaming and waking are reliant upon the same underlying brain-mind processes (Neider et al., 2011). Therefore, the structural and process features of both states should be, to some extent, continuous with one another. Sigmund Freud is perhaps the most prominent early advocate of this basic idea, as he theorized that dreams reflected unexpressed waking wishes and desires (Freud, 1955). As has been described above however, our understanding of dream neuropsychology has advanced significantly since Freud's *Interpretation of Dreams* and there are now clear neurobiological constraints to which any theory relating waking and dreaming phenomena must ultimately conform.

A large and growing body of empirical evidence has refined the continuity hypothesis (Collerton & Perry, 1995; Gackenbach et al., 2011; King & DeCicco, 2009; Maggiolini et al., 2010; Nielsen et al., 2004; Noreika, 2011; Pesant & Zadra, 2006; Roussy et al., 1996; Samson & Dekoninck, 1986; Schredl, 2000; Schredl & Hofmann, 2003; Schredl et al., 1998; Voss et al., 2011) and recent efforts have been made to reconcile continuity theory with the current understanding of dream neuropsychology (Domhoff, 2011). A brief, selective review of studies which have helped to clarify continuity theory is presented here with an emphasis on those

findings which are particularly relevant to the present study (For a more thorough review, see Domhoff, 1996).

The continuity hypothesis still maintains that dream content reflects waking experiences and concerns, but its modern formulation represents a significant departure from Freud's theory. The issue of whether dreams simply reflect 'daily residue' or also material from the more distant past was taken up by Nielsen and colleagues (Nielsen et al., 2004). Their results suggested maximal incorporation of waking content into subsequent dreams comes from experiences occurring on the day preceding the dream and as well as those occurring approximately one week prior (Nielsen et al., 2004). While the U-shaped curve representing the timing of incorporation is still largely unexplained, several factors appear to exert significant influence on the rate of incorporation. These include the type and emotional valence of the experience as well as the dreamer's own personality characteristics (Schredl, 2000; Schredl & Hofmann, 2003). With respect to the types of waking material which become incorporated into dream narratives, it appears that experiences of conflict are the most frequently included, particularly in nightmares (Chivers & Blagrove, 1999; Delorme et al., 2002; Levin & Nielsen, 2007). While these and other studies have provided convincing evidence that thematic content is continuous between waking and dreaming, there remains some question of whether and to what degree cognitive functioning is also continuous. Do higher or lower levels of waking cognitive function correlate with higher or lower levels of these same cognitive functions in dreams? A few studies suggest this is so.

A series of studies investigating continuity and discontinuity of cognitive process features across waking and dreaming (Kahan et al., 1997; Kahan & LaBerge, 2011) provides compelling evidence that REM dreams are far from single-minded and, in fact, are capable of supporting what are traditionally considered higher level cognitive processes. While participants' self-reports of choice, reflective awareness on one's own behavior, and reflective awareness on

one's own thoughts or feelings, were reported significantly more frequently in waking compared with dreaming – none of the above were absent from dreams. Furthermore, self-reported measures of sudden attention, focused attention, and reflective awareness on external events were not even significantly different between the two states (Kahan & LaBerge, 2011). The authors conclude that: "High-order cognition is much more common in dreams than has been assumed…" and that, "continuity theory now has evidence for not only the similarities of mental content throughout states, but also similarities at the process levels of cognition."

Earlier, reference was made to a potential link between the neurocognitive bases of dreaming and the brain's default mode network. Now that there is some evidence to support that dreaming and waking are likely continuous with respect to structural and process features, it is appropriate to revisit Domhoff's neurocognitive theory of dreaming and its implications for the relationship between mindfulness in waking and lucidity in dreams. As mentioned, Domhoff's theory draws heavily from research into the behavioral correlates of the default mode network. In fMRI studies of the brain during a resting state, individuals often report mind wandering, day-dreaming, and internal simulation of past or future autobiographical events (Hasenkamp et al., 2012). This has been associated with activity across a network of structures referred to as the default mode network. Domhoff posits that the similarity between mind-wandering and dreaming is suggestive of a similar, underlying neurobiology. In other words, the continuity observed between the contents of waking and dreaming may have its neurological basis within the default mode network (this point will be taken up once again in the section on dream mindfulness below).

Taken together, the evidence presented in these studies appears to converge in support of the continuity hypothesis, which is the primary theoretical basis of the present study. Within the constraints set by those aspects of continuity theory which have empirical support, the hypothesis that waking levels of trait mindfulness might be reflected in some aspect of dreaming

cognition appears to be theoretically sound. In the final section, consideration will be given to several possible 'dream analogues' to waking mindfulness: lucidity, dream self-reflectiveness, and dream mindfulness.

Mindfulness and Dreaming

As might be gathered from the review of lucid dream research presented earlier, the idea that there are waking correlates of dream lucidity is not new. Suspected relationships between various aspects of waking awareness and dream lucidity have been addressed in a variety of studies with mixed results. Price (1991) has argued that awareness training as a lucid dream induction practice may be most effective when a synthesis of dreaming and waking awareness occurs, an idea which was central to a theory proposed by Ernest Rossi (2000). Rossi suggests that such a synthesis is contingent on the development of 'self-reflectiveness' in waking (Rossi, 2000) which, he proposes, is manifest as increased self-reflectiveness in dreams. Given the clear relevance of Rossi's theory to the assumptions of the present study, a brief review of the basic tenets of his model and a series of studies which have attempted to test it will now be reviewed.

Dream Self-Reflectiveness

According to Rossi (2000), human psychological growth and development occurs when individuals synthesize new perspectives and experiences with old ones in a dialectical and dynamic process that is mediated by self-reflection. This process is viewed as cyclical, occurring in four interrelated stages. During each stage, an individual's degree of self-reflection is presumed to be apparent in the content and process features of both waking and dreaming experiences. At the initial stage an individual may lack self-awareness and operate primarily on habitual patterns of behavior. Dreams experienced at this stage would involve the dreamer experiencing restriction, entrapment, or limited capacity for action and their responses to the dream environment would be primarily reactive and automatic. At stage two, the individual

begins to break out of habitual action patterns but without having stabilized new patterns of action, dreams at this stage reflect conflict or bifurcation of the self as well as increased bizarreness that is frightening to the dreamer. As the resolution of this conflict approaches completion and an individual experiences a shift toward a newly stabilized pattern of more adaptive behaviors dream themes involve more "creative" elements and are laden with bizarre elements that are not viewed as frightening, but rather as humorous, strange, or simply illogical. Additionally, dream awareness may become more detached or divided, with the dreamer capable of witnessing and participating in the dream simultaneously. Rossi describes stage four as one in which a newly stabilized self seeks to continue the process which has brought it into existence. Dream content at this stage would reflect a dreamer who directs his or her dream toward some desired outcome, solving dream dramas in constructive ways, or even having more frequent lucid dreams. The achievement of psychosynthesis then would be presumably related to the development of the highest form of dream self-reflectiveness - lucid control dreams.

Purcell and colleagues adapted Rossi's model of dream self-reflectiveness into a nine-category hierarchical scale referred to as the 'Dream Self-reflectiveness Scale' (Purcell et al., 1986). Lower level categories were designed to reflect the types of dreams associated with the earlier stages of Rossi's model while higher level categories were to reflect more advanced stages. When the authors applied this scale to the content of dreams from different stages of sleep, they found that the greatest degree of self-reflectiveness occurred during dreams from REM sleep. Purcell and colleagues (Purcell, 1987; Purcell et al., 1986) also investigated the effects on dream self-reflectiveness of various types of 'attention to dreams' training protocols including training in dream reporting, training in dream reporting as well as a manualized program to enhance dream self-reflectiveness, training in dream reporting, dream self-reflectiveness, and mnemonic techniques for inducing lucid dreams, and hypnosis with the

suggestion to participants to become lucid in their dreams. Of all the techniques administered to the experimental groups, the mnemonic technique was the most effective for increasing lucid dream frequency and was associated with greater dream self-reflectiveness compared with any other group. Dream self-reflectiveness training was not significantly better at raising scores on the dream self-reflectiveness scale than any other method, though several participants who underwent this training did have lucid dreams during the study.

While these studies do not directly test Rossi's model of psychosynthesis, they do conceptualize dream awareness as a continuum which was a novel approach at that time. This approach has not been widely used due, in part to the fact that lucidity lends itself to dichotomization (i.e. a dream is either lucid or it is not). Nonetheless, the present study also conceptualizes dream lucidity as a continuum, with non-lucid, pre-lucid, and lucid dreams representing possibilities for dream awareness which fall at different points along the continuum. In addition to operationalizing lucidity as a continuous variable, a novel experimental construct termed 'Dream Mindfulness' was also used and will now be discussed in detail.

Dream Mindfulness

It has been demonstrated that mindfulness meditation training can lead to improvements in cognitive flexibility, visuo-spatial processing, working memory, executive functioning, and metacognitive functioning (Hargus et al., 2010; Moore & Malinowski, 2009; Zeidan et al., 2010) – all of which appear to be important for lucid dreaming. Several studies have demonstrated that, compared with non-meditators, individuals who practice meditation have significantly more frequent lucid dreams (Gackenbach et al., 1986; Hunt & Ogilvie, 1989; Hunt & Ogilvie, 1988). Furthermore, as Hunt (1989) has stated, lucid dreaming is actually a meditative state which is sought in certain meditative practices. Advanced practitioners of transcendental meditation for example, claim to maintain awareness through a large proportion of their sleep – a state often referred to as 'dream witnessing' (Travis, 1994).

While awareness training and meditation training may induce or increase the frequency of lucid dreams, the relationship between mindfulness in waking and lucidity in dreams has still not been clearly characterized. Purcell and colleagues used the construct of dream self-reflectiveness to refer to the set of cognitive and metacognitive processes that, when fully developed, would give rise to lucid dreaming. The term 'dream mindfulness' may be more appropriate term for capturing the particular constellation of cognitive functions most often associated with lucidity.

In waking, 'mindfulness' implies a continual, moment-to-moment presence of mind within which an individual is capable of either passively observing or actively engaging with the environment in a nonreactive, nonjudgmental (i.e. accepting) manner. Mindfulness practice has been shown to have a profound impact on the function of the default mode network (Brewer et al., 2011; Farb et al., 2007; Holzel et al., 2011; Holzel et al., 2007; Taylor et al., 2011). One recent study demonstrated that different types of meditation practice can differentially impact the functional connectivity of brain regions as imaged during resting state. Specifically, an anti-correlation between extrinsic and intrinsic brain systems was stronger during a form of focused attentional meditation and weaker during a non-dual awareness style of meditation when both were compared to a fixation condition (i.e. without mediation). The authors conclude that 'the anti-correlation found between extrinsic and intrinsic systems is not an immutable property of brain organization and that practicing different forms of meditation can modulate this gross functional organization in profoundly different ways' (Josipovic et al., 2012).

Domhoff proposes that the parallel between mind wandering and dreaming is supported by the finding that neural recruitment during resting state is strongest when subjects were unaware of their own mind wandering (Christoff et al., 2009). He suggests that mind wandering may be:

"…more pronounced when it lacks meta-awareness. A lack of ''meta-awareness'' is

reminiscent of the ''single-mindedness'' of dreams, with dreamers rarely aware that they are dreaming (Rechtschaffen, 1978, 1997). The parallels between the lack of meta-awareness during dreaming and the failure to encode external events during mind wandering may provide an opening to a cognitive explanation, in terms of a lack of focused attention when the mind is involved in simulation, for why both dreams and drifting waking thoughts are usually soon forgotten"

One logical hypothesis given what is known about the relationship between mindfulness meditation and this default mode network (Berkovich-Ohana et al., 2012; Hasenkamp et al., 2012; Josipovic et al., 2012) is that a mindful brain would be more aware of its wandering during waking. To extend this to dreaming, individuals who are more mindful in waking would likely demonstrate more coherent dreams with concurrently higher levels of attentional control, self-awareness, and more thoughtful, volitional (i.e. non-reactive) self actions.

Thus, higher levels of dream mindfulness are conceptualized in this study as a concurrently greater capacity of the dreamer to: 1) Control attention by sustaining it and/or shifting it willfully; 2) Think/reflect on the events of the dream while dreaming; 4) Have awareness of his or her own thoughts, behaviors, sensations, and emotions; 5) Engage in volitional behavior (i.e. be aware of choices, make decisions, and act on those decisions) and; 6) Control or manipulate elements of the dream (self, objects, characters, environment). It is important to state here that, while 'dream mindfulness' is hypothesized to be related to lucidity, it is likely that even non-lucid dreams involve some degree of these functions. Based on the current understanding of the factors affecting incorporation of thematic content from waking into dreaming, it also seems likely that temporal fluctuations in levels of waking mindfulness will impact the degree to which dreams are more or less mindful. Dreams following a day of focused mindfulness practices, for example, would presumably be more mindful and possibly lucid depending on the nature of the practice whereas subsequent dreams (e.g. two or more

days after such practice) would be relatively less mindful and less likely to be lucid. As emotional valence has been shown to be an important factor in determining the degree of waking-dreaming continuity, the acceptance component of mindfulness practice would likely impact the rate of incorporation of daily emotional concerns into dreams as well. According to the current model of continuity theory, if a higher level of acceptance is associated with lower emotional valence in waking, it should also be associated with lower emotional valence (i.e. intensity), fewer conflicts, and generally a more positive emotional tone to in dreams. It might also be reasoned that a more accepting attitude toward emotional experiences in waking would be associated with less frequent nightmares.

Within the context of continuity theory, it is also reasonable to predict a relationship between waking levels mindfulness, particularly the attentional component of mindfulness, and sensory experiences in dreaming. Specifically, an individual who is keenly attentive to sensory phenomena in waking may be both more attuned to their dreamed sensory experience and perhaps more likely to dream more vividly. It could be further hypothesized that the modalities most frequently or intensely attended to in waking would be the same modalities which would be more vividly experienced in dreams. For example, a mindfulness practitioner who regularly attends to their sense of movement through space in waking might report more intense vestibular or proprioceptive sensations in dreams.

Extending continuity theory to account for a presumed relationship between the neuropsychological functions associated with mindfulness practice is, for several reasons, not as straightforward. The neurophysiological state of the brain during the dream could vary depending on the stage of sleep during which the dream occurs, introducing a variable set of biological constraints on any continuity of neuropsychological functioning. Nonetheless, presuming there is continuity of function, it might still be predicted that an individual's particular neuropsychological profile would be consistent between waking and dreaming. That is, the

idiosyncratic pattern of cognitive strengths and weaknesses that can be observed on formal testing should be consistent across waking and dreaming states, mediated by the availability of neural resources, if dreaming and waking are reliant upon a shared underlying brain basis. A direct test of this hypothesis would be difficult however, since sleeping individuals would not likely perform to the best of their ability on tests of neuropsychological functioning and in-dream administration is not yet a possibility.[3]

Section Summary

Continuity theory has become one of the prevailing explanations for how dreams take on their unique forms. Support for this theory has come from studies of dream content, dream cognition, and dream neuropsychology. Though the balance of research in this area has focused on continuity of the thematic contents of waking into dreaming, it has been suggested that at least some cognitive processes are also continuous across the two states. The overarching aim of this study is to investigate whether the waking levels of mindfulness are also related to dream content. Specifically, this study will explore the dreaming correlates of waking levels of general and recent mindful awareness and acceptance, neuropsychological functions in waking, and a variety of dream cognitive, emotional, and sensory experiences. As argued briefly above and discussed in more detail below, it is predicted that self-reported levels of dream mindfulness and lucidity will both be positively correlated with self-reported waking levels of general and recent mindful awareness and acceptance and also with a set of neuropsychological functions that are presumed here to be related to mindfulness including sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set-shifting . It also stands to reason that there will be a positive relationship between

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[3] This point may appear to be made in jest but, in fact, it has already been shown that while dreaming lucidly individuals can carry out pre-determined activities akin to waking tests of motor function (Dresler et al., 2011; Erlacher & Schredl, 2004; Erlacher & Schredl, 2008). It has also been shown that lucid dreamers can both perceive and respond to external stimulation (Kottke, 1996). Perhaps future research could carry out basic tests of response time to prompts delivered through visual or tactile modalities.

dream mindfulness and dream lucidity. Supporting, ancillary hypotheses are also made with regard to sensory and emotional experiences in dreams as detailed below and for the presumed relationships between waking mindfulness and neuropsychological functioning.

Chapter Summary and Study Overview

The continuity theory of dreaming proposes that the phenomenological experience of waking and dreaming rely on a shared set of underlying brain-mind processes. Continuity theory has gained increasing empirical support in recent years, with studies demonstrating significant relationships between individuals' experiences during waking and the content of their subsequent dreams. While the bodies of research concerning lucid dreaming and mindfulness suggest that these two states may rely on a similar set of cognitive processes, no study has addressed the question of whether waking mindfulness skills are related to 'dream mindfulness' or dream lucidity. The term dream mindfulness is used here to refer to dream content with concurrently higher levels of attention, reflection (i.e. thoughts about the dream), self-awareness, volition, and dream control. Dream mindfulness is presumed to be related to dream lucidity, or the awareness that one is dreaming.

Specific Aims and Hypotheses

This study aimed to investigate whether higher levels of mindfulness skills in waking are related to higher levels of dream lucidity and dream mindfulness and whether dream lucidity is, itself, related to dream mindfulness (***Specific Aim 1***). There were four primary hypotheses related to this aim. First, higher levels of self-reported waking mindfulness skills were expected to predict higher ratings of dream lucidity (***Hypothesis 1a***), and second, to higher ratings of dream mindfulness (***Hypothesis 1b***) (i.e. self-reported attention, reflection, self-awareness, volition, and control). Furthermore, higher ratings of lucidity were predicted to be correlated with higher levels of dream mindfulness (***Hypothesis 1c***). Higher ratings of dream attention,

reflection, self-awareness, volition, and control were hypothesized to be positively associated with higher levels of general waking mindfulness and recent mindful awareness and acceptance scores (***Hypothesis 1d***).

Two ancillary hypotheses were also proposed. Measures of general and recent waking mindfulness were predicted to be related to ratings of emotional intensity in dreams (***Hypothesis 1e***). Specifically, lower levels of recent mindful acceptance were predicted to be associated with a greater intensity of negative emotion and a lower intensity of positive emotion. Measures of general and recent waking mindfulness were predicted to be related to ratings of emotional intensity in dreams (***Hypothesis 1f***).

This study also aimed to determine whether neuropsychological measures of sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set shifting in waking are related to dream lucidity and measures of dream mindfulness (i.e. the dream mindfulness scale and its subcomponents: self-rated attention, reflection, self-awareness, volition, and control) (***Specific Aim 2).***

Finally, this study sought to determine whether better performance on measures sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set shifting are related to higher levels of self-reported waking mindfulness skills (***Specific Aim 3***). It was expected that higher levels of self-reported waking mindfulness skills would be associated with better performances on these same neuropsychological measures (***Hypothesis 3)***.

CHAPTER III: METHOD

Participants

Participants were recruited from introductory psychology courses at Drexel University through the Drexel SONA system and via printed and in-person solicitations at local meditation centers in the Philadelphia region in an attempt to attain a sample reflecting a range of waking mindfulness skills. A total of N=47 healthy participants were enrolled in the study. Of this sample, n=44 (17 male, 25 female; 39 right-hand, 3 left-hand dominant) completed all aspects of the study. Due to non-compliance with part 2 of the protocol, data from 3 participants were not included in the final analysis, bringing the total with complete data for analysis of the primary hypothesis to N=41(17 male, 24 female). Age of this sample ranged from 18 to 41 years (*M*=21.2y, *SD*=4.6y). Participants' self-identified race was as follows: 29 White/Caucasian/European descents, 6 Asian/Asian American, 4 Indian/Indian American, 1 African American, and 1 participant of Middle Eastern descent. The highest level of education was 2 years post-graduate, with 86% of participants reporting completion of more than 1 but less than 4 years of college and 14% having some graduate level education. All individuals who completed the study were entered into a drawing for $200. Students were awarded extra credit for their participation. The study was reviewed and approved by Drexel University's Office of Regulatory Research Compliance.

Measures

Demographics Questionnaire

Participants first completed a demographics questionnaire (Appendix A), which was created and administered by the experimenter to determine eligibility for the study and characterize important demographic factors with either known or suspected relationships to the study measures. These included items inquiring about typical sleep and wake habits, dream

recall, dream journaling, prior knowledge of or experience with lucid dreaming, nightmare frequency, video game and caffeine use, and meditation practice.

Dream Journal

The dream journal is a common measure of dreaming. In a meta-analysis of studies investigating dream recall, Schredl and Reinhart (2008) found that the use of a dream diary has sufficient reliability for measuring dream recall with good internal consistency (Schredl and Fulda, 2005). The dream journal, in its open ended format, has also been shown to have good test-retest reliability (Bernstein and Belicki, 1995, 1996). The use of the dream journal in the current study was intended primarily to provide data for scoring by independent raters for future exploratory analyses. These data were also used as both an ongoing quality control measure and to improve compliance with the DES-2 during part 2 of the protocol.

Participants submitted their dream reports either in person or online at Surveymonkey.com. Participants were asked to report bed time and wake time as well as the total number of dreams recalled from the prior night's sleep. They were then asked to describe one of their dreams from the previous night (whichever one they recalled the best) in a narrative format. It was requested that reports be written in the first-person and in present tense in order to facilitate future content analyses. All identifying information was to be removed at the time of entry for confidentiality purposes. The instructions given at the end of their part 1 session were to begin the dream journal the morning after baseline testing was completed to ensure maximal temporal proximity to the time of neuropsychological and mindfulness measurements. The instructions were to write as much detail as could be confidently recalled as soon as possible after awakening. Participants were asked not to embellish upon the actual dream content or include extraneous information unless necessary to provide relevant context such as the relationship between the dreamer and another character in the dream (e.g. family member, friend, coworker).

Dream Experiences Survey v. 2

The Dream Experiences Survey is an experimental tool which was first developed by the study's author for a prior study of the relationships between sleep and dream habits and neuropsychological performance (Rider et al., 2008). The items have been adapted and expanded for use in the current study. This survey was administered after the dream narrative was submitted each morning during part 2. The Dream Experiences Survey v. 2 (DES-2) was designed specifically to use subjective ratings of dream content variables in order to avoid sole reliance on the scoring of dream narratives, post-hoc, to evaluate this study's hypotheses.[4]

Participants were first asked to report how much of the dream they could recall (from 'almost none of it' to 'all of it') and whether the dream was a nightmare. Participants then rated their dream on 13, Likert-type items with a range of 1 to 5. Response options for the overall intensity of the dream ranged from 'not intense at all' to 'the most intense dream I've had'. Next, ratings of lucidity, based on 'how close' participants were to realizing they were dreaming, ranged from 'not at all' to 'I realized I was dreaming'. If participants had a lucid dream during the study, they were asked to answer all subsequent items with regard only to the lucid portion of their dream. The remaining scales assessed specific dream content or process characteristics. The intensity of sensory (visual, auditory, tactile, olfactory/gustatory, vestibular) and emotional experiences (anger, apprehension, sadness, confusion, happiness, other) were assessed on scales ranging from 'not at all' intense' to 'most intense'. Coherence of the dream narrative, attentional control, awareness and action on choices (i.e. volition), control of dream elements, participation, self-awareness, and bizarreness were also assessed using 5-point Likert scales with examples provided at each level of the scale (for more details see Appendix B). Three subscales were derived from the DES-2 to summarize ratings of sensory intensity

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[4] The findings of this study will be based solely on subjective report, which is discussed further in the limitations section of Chapter V. However, it is noteworthy here that future analyses are planned in order to further evaluate this study's results with respect to blinded objective ratings as well.

(sum of scores on the visual, auditory, tactile, gustatory/olfactory, and vestibular scales), negative emotional intensity (average of sadness, anger, and fear/apprehension scales), and dream mindfulness (sum of attention, reflection, volition, control, self-awareness scales).

Mindful Awareness and Attention Scale

The Mindful Attention and Awareness Scale (MAAS; Brown & Ryan, 2003) is a self-report scale containing 15 items rated on 6-point Likert type scales (1 = almost always; 6 = almost never). The MAAS yields a single factor of self-report mindfulness. Specifically, participants rated the degree to which they function with or without awareness of present experience in cognitive, emotional, interpersonal, and physical domains and generally throughout their daily life (Brown & Ryan, 2003). An example of the type of items on the MAAS includes, "I could be experiencing some emotion, and not be conscious of it until sometime later." The MAAS reliably discriminates between practitioners and non-practitioners of mindfulness, and has predictive value in assessing well-being outcomes, with good convergent validity with other measures of well-being for adult populations (Brown & Ryan, 2003). Previous studies have demonstrated that the MAAS has good test–retest reliability and internal consistency, with alpha coefficients ranging from 0.82 to 0.87. Scores range from 15 to 90, with higher total scores indicating greater mindfulness (Schmertz, 2006). Normative samples exist for adults in the general community (N=436; M=4.20; SD=.69) and college students (N=2277; M=3.83, SD=.70) (Brown & Ryan, 2003).   Total score on the MAAS was used in the current study as a measure of self-reported mindfulness. Descriptive statistics for the MAAS are summarized in Table 1.

The Philadelphia Mindfulness Scale

The Philadelphia Mindfulness Scale (PHLMS) is a 20-item self-report measure which assesses both the awareness (i.e. attending) and accepting (i.e. non-judging) components of mindfulness. Individuals are asked to rate the frequency with which they experience certain

events such as "I am aware of what thoughts are passing through my mind" on the awareness subscale and "I try to distract myself when I feel unpleasant emotions" on the acceptance subscale. Frequency is rated from 1 ("Never") to 5 ("Very Often"). Scores for each subscale are calculated by taking the sum of item scores. Total scores range from 20 to 100. Higher scores on the awareness subscale are purported to reflect better attentional ability while lower scores on the acceptance subscale are indicative of a less accepting, more judgmental attitude.

The test was developed by Cardaciotto and colleagues (2005) at Drexel University and has good internal consistency, and good construct and criterion validity (both convergent and predictive). The PHLMS has an internal consistency of 0.66, which, by some standards, is considered low. However, this is likely due to the fact that higher scores on the awareness subscale are indicative of higher levels of attention while higher scores on the acceptance subscale are indicative of lower levels of non-judging acceptance. Because the scales are intended to measure both the awareness and acceptance components of mindfulness, it is more informative to focus on the alpha levels of the individual subscales. These are acceptable for both the awareness (alpha=.75), and acceptance subscales (alpha=.75). Correlations between scores on the PHLMS and the MAAS were found to be significant, but relatively low (r=.43) (Cardaciotto, 2005). PHLMS total score and awareness and acceptance subscales were assessed in the present study. Descriptive statistics for the present study are summarized in Table 1.

PEBL Neuropsychological Test Battery

The Psychology Experiment Building Language (PEBL) v. 0.12 was developed by Shane Mueller, Ph.D. and is a freely available, open-source programming tool and experiment launcher. Each participant was administered a neuropsychological test battery running under the PEBL launcher in the order listed below. Unless otherwise indicated all tests were administered with default settings. With the exception of the Subliminally-cued Flicker Paradigm

Test, all tests were created and made freely available by Shane Meuller and licensed under the General Public License (GPL).

PEBL Trail Making Test

The Trail Making Test (Reitan, 1955) is a commonly used neuropsychological measure consisting of two parts (A and B). It is typically given in clinical settings to characterize visual attention and sequencing, processing speed, graphomotor speed, and cognitive set shifting speed (part B only). A practice trial is typically administered prior to both parts of the test. In part A, the examinee is presented with a sheet of paper with encircled numbers (1 to 25) arranged non-sequentially across the page. They are then asked to draw a line connecting the encircled numbers in their correct numerical order as quickly as possible. In Part B, the encircled items are both numbers (1 to 13) and letters (A through L) and instructions are to sequence them in alternating order (i.e. 1-A-2-B-3-C) as quickly and as accurately as possible. Other administration criteria vary in clinical settings, such as whether or not the examinee can lift his or her pencil once they have started or how quickly the administrator should correct errors if they occur. Time to completion and errors are typically recorded.

The PEBL version of the Trail Making Test (pTMT) uses an automated algorithm to generate each item. The specific layout of items in the Halstead–Reitan version of Trails A and B are included by default among 5 trials of each type. A standardized set of instructions is displayed prior to testing. Importantly, participants in this study were told they could view the arrangement of items as long as they wished prior to commencing the test, but once they clicked on the number 1, the timer would start and they should proceed through the remainder of the test as quickly as possible.

The pTMT contained ten trails, alternating between A and B-type trials. Each part A trial had a corresponding B trial (an isomorphic arrangement of items) with an equal distance to connect all the items. The test yielded several measures, including the total time to complete

each part, total clicks per trial, accuracy (number of clicks required to complete the trial/total clicks), and distance covered. One previous study demonstrated that, in a large sample, completion times and accuracy scores on Parts A and B were all strongly correlated. Thus, for the purposes of this study the average time to complete the A and B trial types were considered sufficient to characterize processing speed (pTMT A average completion time) and cognitive set shifting speed (pTMT B average completion time). More information about the PEBL version of the Trail Making Test, including additional test characteristics and comparisons with traditional versions of the test, are available elsewhere (See Piper et al., 2011).

PEBL Corsi Block Test

The Corsi Block-Tapping Test (Corsi, 1972), is a measure of visuospatial working memory originally described by Corsi as an indicator of medial temporal lobe function. It has been used widely in clinical and research settings and has been included in more than one standardized battery of neuropsychological tests. Recently, Kessels and colleagues (2000) described a standardized version of the test, including instructions, apparatus configuration, specific trials, scoring, measures, and normative values. The design of the PEBL version (pCBT) adheres to Kessels' standardized parameters.

In the current study, participants were given a standardized set of instructions presented on-screen prior to the test. Once they began the test, blue-colored blocks were displayed on a black background, arranged in a static spatial array on the screen. Blocks were illuminated (i.e. changed color from blue to yellow) in a predetermined sequence and participants were instructed to reproduce the sequence by clicking on the blocks in the same order they were illuminated. The span of the sequence began with 3 target blocks being illuminated with an inter-stimulus interval of 1000ms. There was a 1000ms interval between trials during which participants saw the word "Ready?" in white text centered on a black background. Two trials of each span-length were administered regardless of accuracy on the first trial. Span lengths

ranged from 3 to 9 targets per trial and trials increased by one item as long as the participant correctly reproduced one of the two prior trials. When two trials of a span length were failed, the test was discontinued. The test produced several measures including block span (longest block span accurately reproduced at least once), total items correct, and total score, which was computed as product of the total number of correct trials and the highest block span correctly reproduced at least once. Since it had the highest variability, pCBT total score was used for further analysis as a measure of visual working memory span.

PEBL Victoria Stroop Color-Word Test

The Stroop Color-Word Test measures an effect described first by Jaensch (1929), which takes advantage of a bottleneck in attention. When information from the same lexical category is presented simultaneously in different modalities (color and print), competition for attention creates interference with performance. There are several standardized versions of the Stroop Test widely used in clinical neuropsychological settings (For reviews and descriptions of various forms of the Stroop test, see: Algom, 2004; Cox et al., 2006; Jensen & Rohwer, 1966; Stroop, 1935; Troyer et al., 2006b). Recent research has suggested that individuals who reported frequent lucid dreaming were significantly faster on the incongruent condition of the Stroop task than were self-reported occasional lucid dreamers or non-lucid dreamers (Blagrove et al., 2010). However, the authors' findings are considered tentative until they can be replicated since observed power was not reported and each group in their study had a sample size of only n=15. Should there be sufficient data to test the hypothesis that frequent lucid dreamers perform significantly faster on the incongruent Stroop trial than occasional or non-lucid dreamers, this analysis will be performed as part of the exploratory analyses of the current study (Exploratory Hypothesis 2).

In the PEBL version of the Victoria Stroop test (pSTRP), participants used the number keys (1, 2, 3, and 4), mapped to the different colors (red, green, yellow, blue) to name each

item. The color-to-key mapping was displayed at the bottom of the screen throughout all trials and was randomized across participants (i.e. 1, 2, 3, and 4 were randomly associated with 'red', 'blue', 'yellow' or 'green'). Color to key mapping was consistent, however, within testing sessions. A standardized set of written instructions was displayed prior to the test followed by a practice screen designed to familiarize participants with the color-to-key mapping. The practice screen consisted of a black box in the center of the screen and the color-key presented below. The black box changed color according to the participant's key press. No score was recorded during the practice trial. Learning was assessed qualitatively by having participants look away from the screen as they were instructed to press the key for each color. The practice was repeated until the participant could successfully key in each color without looking at the color-key.

Once participants felt they had adequately learned the mapping, they began the test. There were 3 trials presented in the same order to all participants ('D', 'W', and 'C'). In Trial D, participants identified the colors of dots (red, green, yellow, blue). Trial W involved naming the colors of a list of non-color words ("hard", "when", "over", "and"). In Trial C, color words ("red", "green", "blue") were presented in color that was different from the printed word (e.g. the word "red" may have been presented in green font). On all trials, items were presented in a 6 x 4 rectangular array and evenly distributed spatially. Participants were asked to key in their responses, working sequentially from left to right, as quickly as possible while being careful not to make any errors. The item to be named was enclosed in a gray box which advanced to the next item only once it was correctly named (by key press). If the item was incorrectly named, the box flashed, indicating an incorrect response had occurred, and the participant had to try again until they made the correct response. No other feedback was given during test administration.

The test yielded multiple measures including completion time, errors, and total key

presses per trial. Trial C had three additional measures including intrusion scores (trials for which the color word was name instead of the word color) and two efficiency scores (Trial C time/Trial D time and Trial C time/Trial W time).

<u>PEBL Subliminally Cued Flicker-Paradigm Test</u>

The Subliminally Cued Flicker-Paradigm Test v. 0.55 (pCFPT) was designed by Harris (2007) for testing the effects of subliminal cues on change blindness. A series of 45 scenes are presented on the screen successively. Each scene is comprised of two images of the same scene (e.g. a busy street) which differ with respect to one element. Images are presented in an alternating fashion every 1 second which creates a flickering effect. The participant is instructed to locate the element which differs between the two, otherwise identical images and press the space bar on when they have done so. An 8 x 6 grid is then presented overlaying the image with each coordinate numbered sequentially from left to right, top to bottom. Participants were instructed to type in the number of the coordinate which most closely approximated the location of the changing element. Correct and incorrect responses were recorded as well as response latencies. Trials were either uncued, subliminally cued with the correct location (i.e. a black star appeared for <300 ms prior to the image in the location where the change was to occur) or subliminally cued in the same way but with the incorrect location. The test yielded multiple measures including total accuracy, response latency per trial, and accuracy on each type of cued trial (correctly-cued, falsely-cued, and un-cued).

Using a less complex form of the cued flicker test, Blagrove and Wilkinson (2010) did not find a significant association between ability to spot changes in the images and frequency of lucid dreams. However, the authors admitted that their negative finding may have been due to several factors, including the manner by which they characterized lucid dream frequency, the coarseness of their measures (i.e. dichotomous scoring on accuracy with scores ranging from 0-6) or the short length of the test (20s per item, 6 items). As with their investigation of Stroop

task performance and lucid dream frequency, the authors did not report power and had a small group sample sizes. Given their negative findings and the fact that part of our screening questions included an item about lucid dream frequency, it seemed worthwhile to conduct analyses using this variable to further test Blagrove and Wilkinson's hypothesis (Exploratory Analysis 1).

The current study used a much longer administration (20s per item, 45 items) with the addition of a subliminal cueing factor which will allow us to test whether dream lucidity, prior lucid dream frequency, or any other self-report dream measure is associated with change blindness. As part of the exploratory analyses of the current study, the relationship between change blindness and lucid dream frequency will be re-evaluated. Overall accuracy (total number of items correct) will be used as the primary measure of change blindness. Additional measures used will include average response latency, and both accuracy and response latency on each type of trial (correctly-cued, incorrectly-cued, un-cued).

PEBL Psychomotor Vigilance Task

The PEBL version of the Psychomotor Vigilance Task (pPVT) is a simple, high-signal-load, reaction time test designed to evaluate participants' ability to sustain attention. The pPVT yields an index of sustained attention (frequency of omissions/lapses), average response time, and response time given various inter-stimulus intervals (binned into 1000 ms intervals ranging from 1000 to 9000 ms). The PVT has been used extensively in sleep research and has little to no learning curve. While the PEBL psychomotor vigilance task has not been used extensively in research, it is based on has similar administration and timing parameters to the original PVT (Dinges & Powell, 1985). For the current study, average response time on the pPVT was used as a measure of sustained attention and false-starts were used as a measure of behavioral inhibition.

Procedures

Participants were recruited via print, internet, and in-person solicitation in the local community, through the Drexel SONA system which provides extra credit to undergraduate students at Drexel University, and from area establishments which offer classes in mindfulness meditation (Dhyana Yoga, Studio 34 Yoga, The Zen Center of Philadelphia, and the Philadelphia Tibetan Buddhist Center). Interested participants were screened by phone.

In order to be eligible for the study, participants were required to be fluent in English, aged 18 to 45 years with a stable and normally timed sleep period. Selection was not contingent on race, ethnicity, socioeconomic status, religious beliefs. Individuals with a history of alcohol or drug abuse, psychiatric illness, neurological insult or syndrome, or any acute or chronic, debilitating medical conditions or current medications affecting sleep were excluded from the study.

The study protocol was divided into assessment and dream-reporting phases. A general overview of the study procedure is presented in Figure 1. Part 1 involved the administration of the neuropsychological and mindfulness measures (detailed below). Part 2 was a week-long period during which participants were asked to report their dreams on a daily basis (Part 2) and to fill out the DES-2 for each dream they reported. Dream reports and responses to the DES-2 were submitted via SurveyMonkey.com. This study was reviewed and approved by Drexel University's Office of Regulatory Research Compliance.

Part 1: Neuropsychological and Mindfulness Assessment

Participants completed the neuropsychological and mindfulness assessments at the Department of Psychology's PSA building at Drexel University. The neuropsychological test battery was administered via PEBL on a laptop PC running Windows 7 (64 bit). Each test was preceded by a standard set of written instructions as detailed above and the experimenter was present to ensure adequate understanding of and adherence to the protocol.

Part 2: Dream Journaling and DES-2

After completing the baseline assessment, participants commenced a seven-day dream journaling part. Participants were asked to submit a unique dream report from each night and, in order to complete the study, they were required to submit at least one dream reports from four separate nights during the 7-day period. Individuals unable to recall at least four dreams were given the option of taking another week to complete the study or were disempanelled if they felt they could not complete any more reports. In addition to the daily dream reporting procedure, participants were asked to complete the DES-2 for each dream reported. Throughout the protocol, reminders were sent by the investigator via email to request that participants fill out their dream diaries and to ensure there were no problems with adhering to the general procedures.

Statistical Analyses

All analyses were performed using SPSS 19.0© (SPSS Inc., Chicago, IL, 2010). Alpha levels of .05 and .01 were used depending upon the number of variables and type of statistical test used (as described below). Data normality was inspected both visually and by statistical analysis (i.e. normality curve, box and whiskers analysis, measures of skewness and kurtosis) to identify outliers. Genuine outliers (z > 2.0 SD) were excluded from the analysis and, along with missing data points, were interpolated using the participant or group mean for the data point in question, where appropriate. All variables were assessed to ensure that none violated the specific assumptions of each planned statistical test. If such a violation occurred, it is reported within the results section.

Sample size

No prior study has investigated relationships between mindfulness or neuropsychological functioning and subjective ratings of dream content. Thus, an a priori power

analyses was performed using G*Power 3.0 (Faul, 2008) using an estimated medium effect size for all statistical tests. Hypothesized relationships between the independent and dependent variables in this study were expected to be unidirectional. Given an alpha of .05, desired power of .80, and assuming a medium effect size of .15, a sample size of N = 44 was calculated for regression analyses, which was used to test the primary hypotheses of this study.

Independent Variables

Variables derived from self-report mindfulness and neuropsychological testing served as the independent (predictor) variables used to test this study's primary hypotheses. Total scores on the MAAS were considered a measure of general mindfulness. The PHLMS awareness and acceptance subscales were considered to measure recent mindful awareness and acceptance. Neuropsychological functions were measured by the PEBL test battery. Sustained attention was determined by average response times on the pPVT. Total score on the pCBT was used to measure visual attention span. The primary measure of change blindness was the total score on the pCFPT. Cognitive set-shifting was measured as the average completion time for pTMT B. There were two measures of behavioral self-monitoring including pSTRP part C completion time and total number of false starts on the pPVT.

Dependent Variables

Dependent measures were derived from the DES-2. All DES-2 ratings were evaluated for relationships to the independent variables. Dream lucidity, attention, reflection, self-awareness, volition, and dream control were measured by their corresponding rating scales on the DES-2. Dream mindfulness was measured as the sum of the attention, reflection, self-awareness, volition, and control scores. Since the number of dreams reported during part 2 of the study varied between participants, ranging from 4-7 total dreams, average item and subscale scores from across all dreams were used to produce one score on each item/subscale for each participant.

CHAPTER IV: RESULTS

The results of this study are presented in the next several sections. Descriptive statistics are presented first. Following this is a summary of the demographic characteristics of this study's sample along with preliminary analyses evaluating the relationships between these demographics, as well as variables collected at screening, and the study's primary measures. The results of each of the study hypotheses are then grouped within their respective aims.

Descriptives

Mindfulness measures

N=47 participants completed the PHLMS and MAAS. Scores on the MAAS ranged from 38 to 80, with a mean of 61.57 (*SD*=8.99). This was similar to the normative samples for community adults or college students (Brown & Ryan, 2003). PHLMS total and subscale scores were similar to the normative sample (Cardaciotto, 2005) with total scores ranging from 37 to 90, with a mean of 67.65 (*SD*=8.04). The awareness subscale scores ranged from 23 to 48, with a mean of 38.32 (*SD*=4.90) and acceptance subscale scores ranged from 14 to 47 with a mean of 29.34 (*SD*=6.57). Awareness and acceptance subscales on the PHLMS were not significantly correlated (*p*>.05), but total score on the PHLMS demonstrated a high-moderate, positive correlation with the awareness subscale, $r(46)=.57$, $p<0.1$ and a high correlation with the acceptance subscale $r(46)=.79$, $p<.01$. There was a low, positive, but significant correlation between scores on the MAAS and the awareness subscale of the PHLMS, $r(46)=.24$, $p=.05$. The correlation between MAAS scores and PHLMS acceptance subscale scores was not significant (*p*>.05).

Neuropsychological measures

N=47 participants completed the neuropsychological test battery. Descriptive statistics are summarized in Tables 2-6. Noteworthy statistics and test characteristics are described

below.

For the PEBL Trail Making Test, average completion times across all 5 part A and part B trials were normally distributed, with no significant outliers. Results on both tasks were consistent with a large sample study of healthy young adults (Piper et al., 2011). A paired samples t-test revealed that the difference between average completion times on parts A and B was significant, $t(46)=10.30$, $p<.001$.

On the PEBL Corsi Block Test, memory and block span scores were normally distributed and consistent with scores of the standardization sample (Wilde et al., 2004). Data were missing on this task for one participant due to a technical error. There was one significant outlier whose total score, which was the outcome measures used to represent visual attention span, was significantly higher than the mean ($SD>3.0$). This result was not due to any known methodological error, but rather represented an unusually strong performance by this participant. Thus, to be faithful to these observations, this outlier was not removed for hypothesis testing.

Performances on the PEBL Victoria Stroop task were in line with available normative values for traditional administration of the Victoria Stroop test for color and word naming conditions (Bayard et al., 2011; Charchat-Fichman & Oliveira, 2009; Troyer et al., 2006a) but much shorter than has been found with the traditional administration for the incongruent trial of this task. It should be noted that participants in the present study were not required to verbalize their responses, which is likely to have contributed to this finding (see Limitations). Still, scores on this task were normally distributed, with no significant outliers.

No published statistics were available for the PEBL version of the Subliminally Cued Flicker Paradigm test and since the testing parameters for similar tasks vary widely in the literature, it is difficult to determine whether the present sample's performances are consistent with what would be expected in the general population. Nonetheless, scores on this task were

normally distributed with the exception of accuracy on un-cued trials, which was slightly positively skewed. There were no significant outliers.

Average response times on the PEBL Psychomotor Vigilance Task were normally distributed, with no significant outliers. This variable was used to represent sustained attention ability in the hypothesis tests described below. False starts (i.e. responding when no stimulus was presented) were slightly negatively skewed with two statistical outliers that appeared to be due to a failure to instruct these participants to attempt to avoid such errors during the test. Thus, these scores were replaced with the group mean (M=4.2) for the purposes of hypothesis testing. Since two variables from this measure were used to represent two presumably orthogonal neuropsychological functions, Pearson correlation was used to confirm that they were not correlated. However, results of this analysis demonstrated a low-moderate, positive correlation between these variables $r(44)$=.35, p<.01. In other words, more frequent false starts were associated with longer average response times. This did not appear to be due to any particular feature of the pPVT or to any systematic error in the administration parameters used in this study. Therefore these variables were still considered separately, as planned, in the hypothesis tests.

Dream Experiences Survey

N=44 participants completed the DES-2 on at least 4/7 days, as required by the protocol, which provided an initial sample of 203 dreams. Data from two participants were deemed invalid due to missing item responses (n=1) or dream narratives (n=2). The resulting sample consisted of n=42 participants and a total of 191 dreams for which the DES-2 was fully completed. Descriptive statistics for each item and subscale on the DES-2 are summarized in Table 7. Subscale scores (i.e. Sensory Intensity Subscale, Negative Emotional Intensity Subscale, Dream Mindfulness Subscale) were computed for each dream. Participant's daily ratings were averaged to produce a single score for each item and subscale to be used for

testing hypotheses related to specific aims 1 and 2. Unless otherwise indicated, all items were normally distributed.

Reliability analyses (Chronbach's alpha coefficient, inter-item correlations, corrected item-to-total correlations) were conducted for the DES-2 and the three (sensory intensity, negative emotion, and dream mindfulness) subscales. Overall internal consistency for the DES-2 was excellent (Chronbach's alpha = .93) and internal consistency of all three subscales were very good (Dream mindfulness subscale, Chronbach's alpha=.87; Sensory intensity and negative emotion subscales, Chronbach's alpha=.83). Power was insufficient to meet the assumption of non-additivity for these analyses however, so confidence in Chronbach's alpha is low. Inter-item correlations among the items and subscales comprising the DES-2 ranged from .40 to .90. Of note, dream recall was moderately and positively related to dream mindfulness subscale scores, $r(42)=.62$, p<.01 and ratings of dream attention, $r(42)=.61$, $p<.01$ and self-awareness, $r(42)=.62$, $p<.01$. Overall intensity ratings were also moderately and positively related to intensity ratings of anger, $r(42)=.62$, $p<.01$, and fear, $r(42)=.61$, $p<.01$. Auditory intensity was moderately and positively correlated with sadness, $r(42)=.62$, $p<.01$, anger, $r(42)=.61$, $p<.01$, and confusion, $r(42)=.61$, $p<.01$. Item to total correlation coefficients ranged from .59 to .86 for the sensory intensity subscale, from .83 to .89 for the negative emotion subscale, and from .70 to .85 for the dream mindfulness subscale. Item-to-total correlations (item ratings to total DES-2 score) were not computed since the DES-2 total score was not used in any of the analyses.

<u>Lucid Dreams</u>

Across the 7-day dream-reporting phase of the study, n=209 reports answered the question "How close were you to realizing you were dreaming during this dream?" A total of16 reports (7.6%) from 11 participants (n=5 female) contained rating of '5' on this item, indicating the participant had realized he or she was dreaming during the dream (i.e. lucid dreams).

These dreams were selected for further analyses. On closer inspection of these narratives, it was revealed that only 3 (1.4%) made any mention of the dreamer being aware that he or she was dreaming during the dream.

Demographics

Demographic variables relevant to the measures used in this study were collected for N=47 participants. Average typical bed time (prior to the study) was 2145h (*SD*=3.9h) and average typical wake time was 0730h (*SD*=2.5h). Typical number of dreams per night prior to the study ranged from 0 to 4 (*M*=1.46, *SD*=.70). Typical amount of dream detail recalled from dreams was scored on a 5-point Likert scale ranging from 'none' to 'all or nearly all the detail'. Of the full sample 25.6% said they could recall that they had dreamt, but could not recall the details of their dream;10.6% said they could recall 'bits and pieces' from their dreams, 21.3% reported being able to recall 'some of the detail', 31.9% reported being able to recall 'most of the detail', and 10.6% reported being able to recall 'nearly all of the detail' from their dreams. Prior knowledge of lucid dreaming was reported by 36.2% of participants. Frequency of lucid dreaming ranged from 'never' to 'more than once per month'. The breakdown of lucid dream frequency prior to the study was 42.6% 'never', 31.9% 'at least once', 8.5% 'at least once per month', and 2.1% 'more than once per month'. Nightmare frequency was assessed by a 5-point Likert scale ranging from 'never' to 'all the time'. It was found that 21.3% of participants reported experiencing nightmares 'rarely' or 'never', 40.4% reported having nightmares 'sometimes', 17% reported frequent nightmares, and 6.4% reported having nightmares 'all the time'. Regular video game use (>1h per week) was reported by 25.5% of participants, of which only one participant played immersive, first-person games for >1h per week. Daily caffeine use was reported by 51.1% of participants.[5] Current or recent meditation practice was scored on a

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[5] If individuals reported regular caffeine use, they were asked not to use caffeine in the evenings during phase 2 of the study.

yes/no basis. 55.3% of participants reporting no regular meditation practice and 19.1%

reporting at least moderate practice (< once per week).

Preliminary analyses were conducted to evaluate relationships among all variables

assessed at screening and the primary variables of interest in this study. Relationships

between demographic variables and all other study measures were evaluated using Pearson

correlations and an alpha of .05 (one-tailed). Age was moderately and positively correlated with

pTMT A performance, with younger participants demonstrating faster average completion times,

$r(45)=.43$, $p<.01$. A significant positive correlation was found between pTMT B and age as well.

Younger participants demonstrated faster minimum completion times $r(45)=.33$, $p=.03$. On the

pSTRP task, color naming speed demonstrated a low-moderate and positively correlation with

age $r(45)=.29$, $p<.05$, with younger participants demonstrating faster completion times. Word

reading speed was also positively correlated with age $r(45)=.33$, $p=.03$ in the low-moderate

range with younger ages again demonstrating faster completion times. Age was negatively

correlated with pPVT average reaction time $r(37)=.33$, $p<.05$, false starts, $r(44)=-.30$, $p<.05$, and

lapses, $r(46)=-.31$, $p=.04$, all in the low-moderate range, with older participants performing

comparatively worse on these measures. For the pCFPT, a significant, low-moderate, positive

correlation was found between age and accuracy on correctly cued trials $r(45)=.30$, $p=.04$, such

that older participants performed better than younger participants.

Differences in performance based on sex were evaluated using student's t-tests and

alpha levels were set at .05 (two-tailed). Males had a significantly greater number of correct

trials on the pCBT ($M=9.10$, $SD=1.89$) compared to females ($M=8.00$, $SD=1.52$), $t(43)=2.16$,

$p=.04$. This difference was also significant with respect to block span, with males demonstrating

longer spans ($M=6.50$, $SD=1.43$) than females ($M=5.65$, $SD=1.16$), $t(36.12)=2.15$, $p=.04$.

Females had a significantly more correct trials ($M=12.85$, $SD=1.54$) relative to males ($M=11.15$,

$SD=2.20$) on un-cued trials of the pCFPT, $t(45)=-3.12$, $p<.01$. Females also had significantly

faster response times (*M*=13.72s, *SD*=4.54s) relative to males (*M*=16.54s, *SD*=3.44s), *t*(45)=-3.01, *p*<.01 on falsely-cued trials of the pCFPT. Males had faster average reaction times (*M*=294.72ms, *SD*=31.69ms) compared to females (*M*=327.05ms, *SD*=40.24ms) on the pPVT, *t*(37)=-2.63, *p*=.01.

Participants with visual problems were significantly slower on the pTMT A (*M*=16.43s, *SD*=4.60s) compared to those without known visual problems (*M*=13.16s, *SD*=3.77s), *t*(40)=-2.45, *p*=.02.[6] Those who reported using caffeine had significantly slower average completion times on pTMT A (*M*=20.51s, *SD*=3.41s) compared with those who did not (*M*=17.92s, *SD*=2.88s), *t*(32)=-2.54, *p*=.02. Caffeine users also had slower minimum completion times on the pTMT B (*M*=21.90s, *SD*=5.10s) relative to those who did not regularly use caffeine (*M*=18.07s, *SD*=3.46s), *t*(39)=-2.68, *p*=.01.

Typical nightmare frequency was low-moderately correlated with scores on the PHLMS awareness subscale, *r*(40)=.36, *p*=.02, with higher nightmare frequency associated with higher PHLMS awareness scores. It is important to note that the PHLMS acceptance subscale was not correlated with typical nightmare frequency, but was weakly correlated with the number of nightmares had during the study, *r*(42)=.27, *p*=.04. No other significant correlations were found between scores on the MAAS or PHLMS and any other demographic variables (all *p*>0.05).

Results of Hypothesis Testing

Specific Aim 1

Primary Hypotheses

Specific Aim 1 was to investigate whether higher levels of mindfulness skills in waking were related to higher levels of dream lucidity and dream mindfulness. Linear regression was used to test the hypothesis that higher levels of waking mindfulness would account for a

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[6] All participants who reported visual acuity problems wore either glasses or contact lenses during the administration of the neuropsychological measures.

significant amount of the variance in ratings of dream lucidity (**Hypotheses 1a**) and dream

mindfulness (**Hypothesis 1b**). All mindfulness measures were entered into the regression

model for both analyses.

Results indicated that the three waking mindfulness measures *did not* explain a

significant amount of the variance in dream lucidity ratings, R^2=.08, F(3,41)=.09, p=.97. The

three waking mindfulness measures *did*, however, explain a significant amount of the variance

(20%) in average dream mindfulness, R^2=.20, F(3,41)=3.10, p=.04, with recent mindful

awareness (PHLMS awareness subscale) demonstrating a moderate and positive correlation

with dream mindfulness, β=.40, t(41)=2.72, p=.01 (See Figure 1).

Pearson correlation was used to assess the relationship between dream lucidity and

dream mindfulness. Results revealed a weak, marginally significant, but positive correlation

between dream lucidity and dream mindfulness, r(41)=.22, p=.08 (**Hypothesis 1c**).

To further investigate whether waking mindfulness was associated with the components

of the dream mindfulness subscale, Pearson correlations were used to test the direction and

degree of association between waking mindfulness measures and average ratings of dream

attention, reflection, self-awareness, volition, and control (**Hypothesis 1d**). Results are

summarized in Table 8. Of note, general mindfulness was weakly and positively associated

with dream attention, r(41)=.29, p=.03, but not with dream reflection, self-awareness, volition, or

control (all p>.05). There were low-moderate to moderate positive correlations between recent

mindful awareness and dream attention, r(41)=.39, p<.01, reflection r(41)=.39, p<.01, self-

awareness, r(41)=.32, p=.02, and volition, r(41)=.37, p<.01. The correlation between recent

mindful awareness and dream control was only marginally significant, but in the predicted

direction r(41)=.24, p=.07. The correlation between recent mindful acceptance and dream

attention was also marginally significant, again in the predicted direction r(41)=-.23, p=.08.

Recent mindful acceptance was not significantly correlated with dream reflection, self-

awareness, volition, or control (all $p>.05$).

<u>Ancillary Hypotheses</u>

It was hypothesized that levels of recent mindful acceptance would be associated with negative emotional intensity in dreams (**Hypothesis 1e**). This hypothesis was also tested using Pearson correlation. It should be noted here that higher levels of recent mindful acceptance are indicated by lower scores on the PHLMS acceptance subscale. Higher levels of recent mindful acceptance were moderately correlated with lower ratings of negative emotional intensity in dreams, $r(37)=.41$, $p<.01$ as well as lower ratings of specific negative emotions including anger, $r(37)=.36$, $p=.01$, fear $r(37)=.35$, $p=.01$, and sadness, $r(37)=.33$, $p=.02$. Recent mindful acceptance was not significantly correlated with ratings of dream happiness ($p>.05$) and, while recent mindful acceptance was not correlated with typical nightmare frequency, it was weakly and positively correlated with the number of nightmares had during the study, $r(42)=.27$, $p=.04$.

General mindfulness and recent mindful awareness were predicted to be positively associated with sensory intensity in dreams (**Hypothesis 1f**). Relationships between waking mindfulness measures and ratings of dream sensory intensity were evaluated using Pearson correlations. Recent mindful awareness was weakly and positively associated with ratings of tactile intensity $r(42)=.26$, $p=.05$ and marginally, but positively correlated with ratings of gustatory/olfactory intensity $r(42)=.24$, $p=.06$, vestibular intensity, $r(42)=.21$, $p=.09$, and overall sensory intensity $r(42)=.22$, $p=.08$. All other relationships between general mindfulness and recent mindful awareness and ratings of sensory intensity in dreams were non-significant ($p>.05$).

Recent mindful acceptance was weakly and positively associated with sensory intensity in dreams, $r(42)=.27$, $p=.04$. Recent mindful acceptance demonstrated a high-moderate association with ratings of auditory intensity in dreams, $r(42)=.57$, $p<.01$. All other relationships between recent mindful acceptance and dream sensory intensity ratings were non-significant

(p>.05).

Summary

Overall, there was mixed support for **Hypotheses 1a-1d**. Higher levels of waking mindfulness *did not* account for a significant amount of the variance in dream lucidity and tests for relationships between waking mindfulness and dream lucidity were not statistically significant. However, recent mindful awareness *did* account for a significant amount of the variance in dream mindfulness. A weak, positive correlation was found between general mindfulness and dream attention. Positive correlations ranging from low-moderate to moderate were found between recent mindful awareness and dream attention, reflection, self-awareness, and volition. Recent mindful awareness also demonstrated a marginally significant but positive correlation with dream control.   Recent mindful acceptance showed marginal but positive correlation with dream attention. The relationship between dream mindfulness and dream lucidity was marginally significant in the predicted direction.

The hypothesis that levels of self-reported waking mindfulness would explain a significant amount of the variance in self-ratings of dream lucidity (**Hypothesis 1a**) was not supported. As predicted however, higher levels of waking mindfulness skills did explain a significant amount of variance in ratings of dream mindfulness (**Hypothesis 1b**), with recent mindful awareness demonstrating a significant correlation with dream mindfulness. Consistent with **Hypothesis 1c**, higher ratings of lucidity were marginally and positively associated with higher levels of dream mindfulness. With regard to **Hypothesis 1d**, there was a positive association between general levels of mindfulness and dream attention as predicted, but not dream reflection, self-awareness, volition, or control.

The present results fully support **Hypotheses 1e**, with recent mindful acceptance moderately correlated with negative emotional intensity in dreams, as well as with specific negative emotions including anger, fear, and sadness, all in the predicted direction. Happiness

was not associated with acceptance.

Higher levels of general and recent mindful awareness were predicted to be significantly associated with higher levels sensory intensity (**Hypothesis 1f**). Contrary to this hypothesis, higher levels of recent mindful acceptance, but not recent mindful awareness, were significantly associated with higher levels sensory intensity. The strongest association between waking acceptance and any of the dream variables was auditory intensity.

Specific Aim 2

Specific Aim 2 was to investigate whether neuropsychological measures of sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set shifting were related to dream lucidity, dream mindfulness, or the components of the dream mindfulness subscale (attention, reflection, self-awareness, volition, or control). All relationships were evaluated using Pearson correlation with the exception of a partial correlation, controlling for sex, which was used to evaluate the relationship between visual attention span and dream ratings. All tests were one-tailed (alpha=.05).

None of the neuropsychological variables demonstrated statistically significant associations with dream lucidity or dream mindfulness (all p>.05). There was a statistical trend for better performance on a measure of behavioral self-monitoring (fewer false starts on the pPVT) to be associated with higher levels of dream mindfulness, $r(40)$=.26, p=.05. Sustained attention was moderately and negatively correlated with ratings of dream self-awareness, $r(40)$=-.40, p<.01, in the predicted direction such that faster average response times were related to higher ratings of dream self-awareness. Sustained attention was also marginally correlated with ratings of dream volition, $r(40)$=-.25, p=.07 and attention, $r(40)$=-.25, p=.08. Both were also in the predicted direction. Visual attention span was not associated any of the dream ratings when controlling for sex (all p>.05). Correlations between change detection and dream attention, reflection, self-awareness, volition, and dream control were not statistically significant

(all $p>.05$). Behavioral self-monitoring (false starts on the pPVT) was moderately and negatively correlated with dream reflection $r(40)=-.43$, $p<.01$ and weakly and negatively associated with ratings of dream self-awareness, $r(40)=-.25$, $p=.05$. The correlation between behavioral self-monitoring (false starts on the pPVT) and ratings of dream attention was marginally significant in the predicted direction $r(40)=-.23$, $p=.07$. In other words, higher numbers of false starts were related to lower ratings of these dream variables. There was also a marginally significant, positive correlation between cognitive set shifting and ratings of dream control, $r(41)=.24$, $p=.07$.

Overall, there was mixed support for **Hypotheses 2.** The hypothesis that better performance on measures of a range of neuropsychological functions would be associated with greater dream lucidity was not fully supported. However, better performances on measures of sustained attention and behavioral self-monitoring were moderately associated with higher ratings of dream self-awareness. Sustained attention also demonstrated marginally significant correlations with ratings of volition and attention. Behavioral self-monitoring (pPVT false starts) demonstrated was moderately associated with dream reflection and weakly associated with dream mindfulness, self-awareness, and attention. There was also a non-significant trend for better performance on a measure of cognitive set shifting to be related to higher ratings of dream control.

Summary

It was hypothesized that better performance on a variety of neuropsychological measures tapping sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set shifting would correlate with higher participant ratings of dream lucidity and dream mindfulness (**Hypothesis 2)**. Contrary to this hypothesis, waking neuropsychological performances were not significantly correlated with lucidity or dream mindfulness.

When measures of sustained attention, visual attention span, behavioral self-monitoring,

change detection, and cognitive set shifting were evaluated with respect to dream cognitive functions though, several relationships were revealed. Sustained attention was moderately associated with higher ratings of dream self-awareness, while behavioral self-monitoring (pPVT false starts) was moderately associated with dream reflection and weakly associated with dream mindfulness, dream self-awareness and dream attention. There were also statistical trends for relationships between better performance on a measure of sustained attention and higher ratings of volition and attention and for better performance on a measure of cognitive set shifting and higher ratings of dream control.

Specific Aim 3

Specific Aim 3 was to investigate whether better performance on neuropsychological measures sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set shifting are related to higher levels of self-reported waking mindfulness. Relationships between self-reported waking mindfulness skills and sustained attention, change detection, behavioral self-monitoring, and cognitive set shifting were assessed using Pearson correlation. Partial correlation, controlling for sex, was used to evaluate the relationship between mindfulness skills and visual attention span. All relationships were analyzed using one–tailed tests and an alpha of .05.

Levels of general mindfulness were moderately and negatively associated with average response times on a measure of sustained attention, $r(38)=-.30$, $p=.03$ and moderately and negatively associated with behavioral self-monitoring as well, $r(38)=-.38$, $p<.01$. Recent mindful awareness demonstrated a low-moderate, negative correlation with response latencies on a measure of change detection, $r(40)=-.31$, $p=.03$. Levels of recent mindful acceptance were weakly and positively associated with a measure of sustained attention, $r(38)=.27$, $p=.05$ and moderately and positively correlated with behavioral self-monitoring $r(44)=.41.$, $p<.01$. Recent mindful acceptance scores were also weakly and negatively correlated with efficiency scores on

the Stroop task, r(45)=-.26, p=.04.. There were no other significant correlations between neuropsychological measures and self-reported levels of general mindfulness or recent mindful awareness or acceptance.

<u>Summary</u>

There was mixed support for **Hypothesis 3**. Higher levels of general mindfulness skills and recent mindful acceptance were associated with better performance on measures of sustained attention and behavioral monitoring. Levels of recent mindful acceptance were also weakly associated with efficiency on the pSTRP task. It was expected that higher levels of self-reported waking mindfulness skills would be associated with better performances on these same neuropsychological measures. As expected, better MAAS performance was related to better performance on a measure of sustained attention. However, recent mindfulness awareness was not associated with sustained attention. Higher levels of recent mindful acceptance were also associated with better performances on measures of sustained attention, behavioral self-monitoring, and better efficiency on the Stroop C task. There were no other significant correlations between neuropsychological measures and self-reported waking mindfulness skills. Contrary to predictions, none of the self-report mindfulness measures were significantly correlated with cognitive set shifting or visual attention span.

Chapter Summary

To summarize, self-reported general self-reported waking mindfulness skills (MAAS), mindful awareness and acceptance (PHLMS) skills, and neuropsychological measures of sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set shifting were not significantly associated with ratings of dream lucidity (DES-2). Greater waking mindful awareness (PHLMS awareness) was, however, associated with higher average dream mindfulness, and attention, reflection, volition and self-awareness. Better performance on measures of sustained attention and behavioral self-monitoring were correlated

with higher average ratings of dream self-awareness. There were also statistical trends for better performances on sustained attention to be related to higher ratings of volition and attention as well. Finally, there was a non-significant trend for better performance on a measure of cognitive set shifting to be related to higher ratings of dream control. Finally, higher levels of general mindfulness skills and recent mindful acceptance were associated with better performances on measures of sustained attention and behavioral monitoring.

CHAPTER V: DISCUSSION

In the next several sections, the theoretical implications of the results will be addressed with regard to both the specific aims and hypotheses as set forth in the introduction and existing theoretical models of dreaming and mindfulness. A separate section is dedicated to a discussion of the degree to which the present results support continuity theory and a proposal is made for the expansion of this theory to account for the findings that waking cognitive and psychological processes may be continuous between waking and dreaming. Following this discussion, the limitations of the present study will be reviewed followed by a brief conclusion.

The overarching aim of this study was to investigate whether mindfulness in waking was related to lucidity in dreams. To address this aim, a correlational design was used – assessing the relationships between levels of waking mindfulness, performances on measures of neuropsychological functions with presumed relationships to mindfulness, and self-ratings of dream lucidity as well as dream sensory, emotional, and cognitive variables. The specific aims were to investigate the degree of association between: 1) Levels of self-reported mindfulness in waking and levels of dream lucidity, dream cognitive function, and dream sensory and emotional intensity; 2) Performance on neuropsychological measures (sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set shifting) and the aforementioned dream variables; and 3) Performance on these aforementioned neuropsychological measures and self-reported mindfulness in waking.

Theoretical Implications

Relationships between waking mindfulness and dreaming

This study did not find support for the hypothesis that waking mindfulness is related to dream lucidity (**Hypothesis 1a**), and thus the null hypothesis cannot be rejected given the present results. While it is possible that mindfulness and lucidity are truly unrelated, an

alternative interpretation is that there were not enough lucid dreams in this study to adequately characterize the relationship between mindfulness and lucidity (i.e. a type II error).

Yet another interpretation is that lucidity is not best characterized as a continuum. While lucid and non-lucid dreams clearly differ on several cognitive and psychological variables (Kahan & LaBerge, 2011; Rider et al., 2012), characterizing lucidity on a continuum (or as anything other than an awareness of the fact that one is dreaming), raises the very difficult problem of identifying and operationalizing aspects of lucid dream consciousness which are *necessarily* associated with it.

The difficulty with identifying the appropriate terminology to operationalize lucidity has been encountered and addressed extensively in the literature (Barrett, 1992; Kahan, 1994; Kahan et al., 1997; Kahan & Laberge, 1994b; Kahan & LaBerge, 2011; LaBerge et al., 1995; Purcell et al., 1986; Voss et al., 2009). Barrett (1992), for example, described four "corollaries" of lucidity including: 1) knowledge that one is dreaming; 2) knowledge that objects will disappear after waking; 3) knowledge that physical laws are not applicable; and 4) memory of the waking world is intact. However, in the 50 individuals whose dreams she examined, less than a quarter of those which were deemed "lucid" by the dreamer contained evidence of all four of these corollaries. Other researchers have experimented with different terms to describe awareness in lucid dreams, classifying them as a "hybrid state" of consciousness (Voss et al., 2009) or referring to the lucidity as the high-end of a continuum of "dream self-reflectiveness" (Kahan, 1994; Moffit, 1991; Purcell, 1987; Purcell et al., 1986). Still others have applied modifiers such as 'lucid control dreams' (Gackenbach, 2009) and 'high lucidity' (Ogilvie et al., 1983) to differentiate the realization of dreaming from the nature of the dreamer's awareness and volitional faculty during the ensuing dreamed experience. Even after many decades of dream research, the problem of characterizing consciousness in dreams, and even more so in lucid dreams, is far from resolved. In fact, in a recent article by Kahan and LaBerge (2011), the

authors present a list of over 15 constructs that have been used to describe the nature of conscious awareness in lucid dreams.

In an attempt to address the incompatibility of the term 'lucidity' with the aspects of consciousness often associated with lucidity in the literature, an alternative construct referred to as 'dream mindfulness' was derived. Dream mindfulness was operationalized as concurrently high ratings of dream attention, reflection, self-awareness, volition, and control. The rationale for using this term, as opposed to 'lucidity' was that, while lucidity may often include high levels of these cognitive functions, they may not *necessarily* be present in all lucid dreams and, conversely, may be present in some non-lucid dreams.

As is implied by the term, dream mindfulness was purported here to be more akin to waking mindfulness than lucidity. It was therefore hypothesized that higher levels of waking mindfulness skills would explain a significant amount of variance in ratings of dream mindfulness. Indeed, the three waking mindfulness measures together explained a significant amount of the variance in dream mindfulness and recent levels of mindful awareness were moderately and positively correlated with levels of dream mindfulness. That this pattern of relationships was largely consistent with the pattern expected of the lucidity scale supports the notion that, while higher levels of cognitive function may be associated with lucid dreaming, they are not necessarily exclusive to lucid dreams.

The trend for higher ratings of lucidity to be associated with higher levels of dream mindfulness, though tenuous, does provide some additional support for the claim that higher levels of cognitive function, while associated with lucid dreaming, are not necessarily exclusive to lucid dreaming. It seems appropriate at this point to acknowledge the large body of research which has already demonstrated that dream cognition is not as different from waking cognition as is typically thought (See, for example: Cartwright, 1981; Gackenbach & LaBerge, 1988; Hunt & Ogilvie, 1989; Kahan et al., 1997; Kahan & Laberge, 1994b; Kahan & LaBerge, 2011;

LaBerge et al., 1995; Maggiolini et al., 2010; Schredl, 1998). It has been demonstrated that even non-lucid dreams contain some degree of attentional control, reflection on the events of the dream, awareness of one's own thoughts, feelings, appearance, and behavior, intentional/volitional activity and choice (Kahan et al., 1997; Kahan & LaBerge, 2011). Consistent with anecdotal reports, recent research has shown that lucid dreams do, in fact, contain more frequent incidence of these functions (Rider et al., 2012).

The MAAS, used to measure "*general mindfulness*", which was only associated with dream attention, assesses the present-moment attention and awareness component of mindfulness. The authors of the measure explicitly state that items containing attitudinal components, such as acceptance, were excluded (Brown & Ryan, 2003). *Recent mindful awareness*, as measured by the PHLMS awareness subscale, which attempts to measure awareness of thoughts, feelings, and perceptions, was associated with dream mindfulness and nearly all of its subcomponents. The PHLMS awareness subscale thus appeared to better capture the type of waking mindfulness skills that are continuous with dream mindfulness as conceptualized in the present study.

However, that dream attention, reflection, self-awareness, volition, and control might be collectively considered as a construct separate from lucidity (i.e. dream mindfulness) and that this construct is correlated with waking mindfulness is a novel finding which has implications for the continuity theory of dreams (discussed in detail below). The correlation between recent mindful acceptance and dream attention was marginally significant, a finding which is less straightforward to interpret. While psychological acceptance may not be directly related to attentional control in dreams, it seems possible that it could moderate the relationship between recent waking mindful awareness and dream attentional control.

Participants who tended to be less accepting and more labeling and judgmental of their waking experiences also tended to report more intense feelings of anger, fear, and sadness in

their dreams. This set of results is novel, but consistent with a large number of studies which investigated the relationship between waking and dreaming emotions in a different manner. Specifically, previous studies have demonstrated that psychological stress and/or negative mood in waking is typically associated with more negative emotions in dreams and a higher incidence of nightmares (For a review, see Levin & Nielsen, 2007). This has been purported by some to be related to the "replay" of important emotional experiences for the purposes of psychological growth (Hobson & Schredl, 2011), to the processing of emotional memories (Bednar, 2000; Cartwright et al., 1998; Dolcos et al., 2004, 2005; Walker & van der Helm, 2009), or to a role for REM sleep in brain plasticity (Fosse et al., 2001; Hobson & Schredl, 2011).

Of course, the finding that higher levels of waking mindful acceptance were related to lower intensity of negative emotions in dreams may simply reflect the nonjudgmental nature of individuals with higher levels of acceptance. That is, perhaps participants with higher levels of psychological acceptance were simply judging their emotional experiences in both waking and dreaming as being less intense.

A more speculative interpretation is also worthy of mention given the large body of evidence which now strongly suggests that REM sleep plays an important role in emotional memory processing (Bednar, 2000; Cartwright et al., 1998; Dolcos et al., 2004, 2005; Walker & van der Helm, 2009). Based on the results of this study, it appears plausible that the relationship between waking mindful acceptance and negative emotional intensity in dreams may reflect a socially beneficial, adaptive function of dreaming. Possibly, negative emotional experiences which are not processed in a psychologically accepting manner during waking are more intensely expressed in dream content in order to reduce their valence and allow for the consolidation of the informational component of the memory which, when retrieved, will not also activate its initially associated emotional response. The proposed mechanism for such a process would involve a decoupling of the declarative, emotionally neutral aspects of some

memory representation from the emotionally salient aspects.

Another interpretation is that these results demonstrate continuity between the mode of emotional processing across waking and dreaming. This is consistent with work by Schredl and colleagues in the past decade which has demonstrated that emotional salience is an important factor affecting the incorporation of waking experiences into dream content (Schredl, 2000), but implies that psychological acceptance is another important factor which might affect the rate of incorporation of waking emotional concerns.

Contrary to the hypothesis that higher levels of waking mindfulness would be related to higher levels of sensory intensity in dreams, only recent mindful acceptance, but not recent mindful awareness, was significantly associated with higher levels sensory intensity in dreams. Interestingly, waking acceptance demonstrated the strongest association auditory intensity. While this was not expected, it appears that the most likely interpretation of these results is that the PHLMS does, in fact, tap perceptual awareness and that the capacity for this sort of perceptual awareness in dreams is proportional to that in waking – particularly with respect to auditory awareness. A different and more speculative interpretation, when considered in light of the relationships between waking acceptance and negative emotional intensity, there may be an interaction between negative dream content, auditory content, and waking levels of emotional acceptance. Finally, recalling the relationships between the default mode network and mindfulness practice stated above, it appears plausible that the auditory intensity item reflects, to some degree, dialogue in dreams. This relationship could then represent a continuation of waking self-talk.

Relationships between neuropsychological functioning and dreaming

The finding that sustained attention performance was only marginally associated with dream attention is somewhat inconsistent with the result demonstrating a significant relationship between recent mindful awareness and dream attention. This may be the result of two aspects

of REM sleep neuropsychological functioning. The first factor is the reduced capability of the brain to activate regions important for sustained attention during REM sleep. Due to the particular balance of the neurochemical milieu in REM sleep, that is, a prevalence of acetylcholine coupled with a reduction of noradrenaline and serotonin relative to waking, there is a relative deactivation in the dorsolateral prefrontal cortex, posterior cingulate gyrus, precuneus, and inferior parietal cortex (Braun et al., 1997; Maquet, 2000; Maquet & Phillips, 1998; Maquet et al., 2005; Maquet, Peters, Aerts, Delfiore, et al., 1996; Nofzinger et al., 1997). The second factor is that the PHLMS intends to tap perceptual awareness, which may not necessarily be diminished during dreaming as has been postulated by Hobson and colleagues (Hobson & Pace-Schott, 2002).

The pattern of correlations between false starts on the pPVT and dream variables suggests that those with better performance on this measure demonstrated slightly higher levels of mindfulness, self-awareness, and attention and moderately higher levels of reflection. One explanation for these findings which appears plausible within the continuity theory of dreaming is that those who committed a greater number of false start errors on the pPVT may have done so in an attempt to correct for inattentiveness, as suggested by the finding that false-starts and average response times were moderately and positively correlated. Possibly, such inattentiveness may have been related to mind-wandering/daydreaming. This finding might then be consistent with Domhoff's proposal that continuity between waking and dreaming is neurologically based in the default mode network. That is, if a greater number of false starts on this measure indicate more mind-wandering, this might be reflected in dream content as a less mindful dreamer who is particularly less likely to engage in reflection on the events of his or her dreams, less capable of controlling his or her attention in dreams, and less self-aware during dreaming. However, this hypothesis is admittedly speculative and could not be adequately tested with the design of this study. As such, further research is necessary to clarify these

results

Relationships between self-reported mindfulness and neuropsychological functioning

This study employed two measures of mindfulness, one which tapped general levels of mindful attention and awareness (MAAS) and another which intended to measure recent (within the week preceding the study) levels of mindful awareness and acceptance (PHLMS). Thus, it was possible to investigate the relationship between general levels of mindful attention, recent levels of mindful awareness and acceptance, and performance on neuropsychlogical measures of sustained attention, visual attention span, behavioral self-monitoring, change detection, and cognitive set shifting.

It appears likely that the differences in the manner by which each the MAAS and PHLMS measured 'awareness' best explains the particular pattern of observed results. Specifically, the awareness subscale of the PHLMS includes a variety of questions that focus on awareness of thoughts, emotions, and perceptions (Cardaciotto, 2005). The MAAS, on the other hand, contains a large number of items which appear to tap into problems of attention/inattentiveness, such as frequency of attentional lapses, problems focusing or concentrating, and forgetfulness in everyday life (Brown & Ryan, 2003). This interpretation is further supported by this study's finding that higher levels of recent mindful awareness (PHLMS awareness subscale) were associated with faster response times on a measure of change detection – a test which is particularly sensitive to visual perceptual function – while general mindfulness (MAAS) was associated only with performance on a measure of sustained attention.

Interestingly, higher levels of recent mindful acceptance were also associated with better performance on measures of sustained attention and behavioral self-monitoring (both pPVT false starts and pSTRP efficiency). This, again, appears somewhat contradictory given the lack of a significant relationship between these measures and recent mindful awareness. It has been suggested that individuals with high levels of arousal do not necessarily perform better on

tasks requiring attentional control, particularly in cases of anxiety (Eysenck et al., 2007).

Though the correlational design can only allow us to conclude the direction and strength of this

relationship, it seems reasonable to hypothesize that acceptance could moderate the effect of

attentional variability on attentional performance by reducing distractibility (see 'Future

Directions').

Implications for the Continuity Theory of Dreams

A significant amount of work suggests that recent waking experiences are frequently

incorporated into the content of dreams. Several factors have been shown to influence the rate

of incorporation including emotional valence, personality, type of experience, and temporal

proximity to the dream in question (Schredl, 2000; Schredl & Hofmann, 2003). While there is

ample evidence to support continuity theory with respect to thematic content (Collerton & Perry,

1995; Gackenbach et al., 2011; King & DeCicco, 2009; Maggiolini et al., 2010; Nielsen et al.,

2004; Noreika, 2011; Pesant & Zadra, 2006; Roussy et al., 1996; Samson & Dekoninck, 1986;

Schredl, 2000; Schredl & Hofmann, 2003; Schredl et al., 1998), several researchers have

recently called into question the completeness of the theory (Hobson & Schredl, 2011). The

important difference between these prior studies and the finding that mindful awareness and

dream mindfulness are related is that the former focus on the structural features of dreams (i.e.

thematic content) while this study looked for relationships between psychological and cognitive

processes across the two states.

Continuity in cognitive processes has not been widely reported across sleep and wake,

though it has been hypothesized based on the continuity of thematic content and personality

variables. To date, only a small number of studies have investigated relationships between

waking and dreaming perceptual (DeKoninck et al., 1996) and cognitive processes (Blagrove et

al., 2010; Blagrove & Wilkinson, 2010; Kahan et al., 1997; Kahan & LaBerge, 2011). Thus, a

central issue in the present study is the question of whether, in addition to the incorporation of

content, waking levels of perceptual and cognitive functions are continuous with dream perceptual and cognitive function. It was this study's aim to explore the relationships between waking mindfulness and related neuropsychological functions, and ratings of dream cognitive, emotional, and sensory experiences. As such, the findings of this study are uniquely suited to addressing, and possibly expanding, the continuity theory of dreaming.

The results of this study suggest that dream lucidity was not related to any waking mindfulness or neuropsychological variables. That lucidity was not related to waking mindfulness is surprising, especially given the similarity of the two constructs (Stumbrys, 2011). However, if the null hypothesis is correct, then would seem that these two constructs are not continuous. This study's failure to find a relationship between lucidity and mindfulness may be because the cognitive functions necessary for dream lucidity are different from those which are associated with mindfulness.

An alternative explanation pertains to the manner in which dream lucidity and waking mindfulness were measured in the present study. Unfortunately, this study did not measure the conceptual equivalent of lucidity in waking. That is, participants were not asked how close they were to realizing they were awake during wakefulness, nor were they asked about how frequently during waking they performed reality tests of the sort which might be associated with lucid dream induction. Thus it was not possible to make a direct comparison of dreaming and waking ratings of lucidity. This difference in waking and dreaming constructs was intended, as the primary constructs of interest were waking mindfulness and dream lucidity, not reality testing.

Some have suggested that lucidity is better conceptualized as a continuum of awareness (Moss, 1986; Stumbrys, 2011). However, a "lucidity" continuum may confound what is a set of cognitive processes associated with lucidity and the testing of reality or even the spontaneous realization that that one is dreaming. Whether the realization that one is dreaming

comes about due to the recognition that the dream contains some bizarre element which would be impossible in waking (LaBerge, 1990b; LaBerge & Dement, 1982a; Levitan, 1992) or due to a particularly metacognitive state of awareness, such as that achieved by long-term meditators (Gackenbach et al., 1986; Hunt, 2000; Hunt & Ogilvie, 1989) – the realization must come in order for the dream to be "lucid" in the traditional sense.

The results of this study demonstrated that waking mindfulness explained a significant amount of the variance in levels of dream mindfulness. Importantly, recent mindful awareness, but not general levels of mindfulness were significantly and moderately related to dream mindfulness. Recent mindful awareness was also related to dream attention, reflection, volition, and self-awareness separately with a trend for higher dream control. These results may be the most consistent of this study's findings with respect to continuity theory. They appear to match the model for temporal incorporation of waking experience into dreaming (i.e. more recent experiences have a higher rate of incorporation into dream content) and are conceptually as well as statistically related.

Additional results from this study also lend support to the continuity theory of dreams. Specifically, Performance on neuropsychological measures of sustained attention, behavioral self-monitoring, change detection, and cognitive set shifting were also found to be related to dream cognitive function. Without rehashing the specific pattern of these relationships, it appeared that there was some degree of consistency between performance on these measures and similar aspects of dream cognition.

It was also found that lower levels of recent mindful acceptance were related to higher scores on the negative emotional intensity subscale of the DES-2. This suggests that individuals who are more labeling and judgmental of their emotional experience tend to experience a greater intensity of negative emotions in their dreams. The findings that nightmare frequency during the study, but not typical nightmare frequency prior to the study, was

correlated with recent levels of psychological acceptance also appear to support the idea that emotional concerns are continuous across waking and dreaming. These findings are consistent with prior studies which have consistently demonstrated that emotional salience is an important factor affecting the incorporation of waking experience into dreams, with recent emotional concerns in waking being arguably the most reliable type of experience to be incorporated into dream content (Chivers & Blagrove, 1999; Delorme et al., 2002; Levin & Nielsen, 2007; Nielsen et al., 2004; Schredl, 2000).

Limitations

Specific Aim 1

In an attempt to capture a range of lucidity, defined as "awareness in the dream state that one is dreaming," (LaBerge, 1985a; Van Eeden, 1913), participants in this study were asked to rate "how close" they were to realizing they were dreaming during the dream on a '1' to '5' scale. It was explained to participants that a rating of '1' would indicate the participant had no awareness that he or she was dreaming. A rating of '2' or '3' would indicate that the participant had at least some fleeting recognition that the experience was dream-like (with higher ratings meaning a greater degree of recognition). A rating of '4' was reserved for "pre-lucid" dreams in which the dreamer had a clear suspicion but not a full realization that he or she was dreaming, Ratings of '5' were reserved exclusively for dreams in which the participant had full awareness that he or she was dreaming.

There are several problems with the manner in which lucidity was assessed in this study. First, it is important to point out here that the concept of lucidity was novel to the majority of the participants in this study (only 36% had previously heard of lucid dreaming). Also, the difference between a rating of '1','2', or '3' is particularly ambiguous. These issues probably reduced the sensitivity of the lucidity scale and, with it, the ability of the correlational analyses to detect a relationship between lucidity and mindfulness even if one exists. Unfortunately, when

the scale was dichotomized by combining ratings of '1' through '4' into 'non-lucid' and ratings of '5' into 'lucid', the power of the correlation analysis was significantly reduced due to a shortage of 'lucid' ratings. Furthermore, since participants' ratings of "how close they were to realizing they were dreaming" was used as the primary measure of lucidity, it may be that the construct of 'awareness of dreaming while dreaming' was not appropriately specified.

Whether due to problems with the operational definition of lucidity or to the small number of lucid dreams in this study, this construct was not related to mindfulness in waking. Nonetheless, the null hypothesis that there is not a relationship between mindfulness skills in waking and lucidity in dreams cannot be rejected based on the results of this study and more research is needed to address this question.

Specific Aim 2

In addition to the problem with the measurement of lucidity discussed above, problems with the measurement of the Stroop effect may have reduced the ability of the present study design to accurately assess the relationships between performances on this task and ratings of dream lucidity. The Stroop task used by Blagrove and colleagues (2010) required participants to correctly verbalize the color of the word in the incongruent condition, which is more consistent with the traditional administration of this task. The authors also employed a computerized version of the task, but used a set of 40 stimuli compared with just 24 in the present study. The range of completion times for the incongruent trial in the present study was 12.96s to 69.58s with a mean of 28.58s (*SD*=10.98). While Blagrove did not report this information for his sample, estimation of the average time to complete the incongruent trial is approximately 45s with an estimated standard deviation of 6s. The difference in range of completion times could not be estimated however, but it can be speculated with reasonable confidence that it was more narrow than that of the present sample. Given these factors, it appears that the PEBL version of the Victoria Stroop, administered in the manner described in the methods, was not sufficiently

sensitive to capture the Stroop effect. Behavioral observations during testing also lend some support to this explanation, as it appeared that some participants had learned the key mappings better than others prior to beginning the task – likely introducing unwanted variance in scores.

Specific Aim 3

Problems with measurement of neuropsychological functions as described above may also have prevented the detection of relationships between performances on these measures and self-report mindfulness. This is particularly true for the computerized versions of traditional neuropsychological measures of visual attention span (PEBL Corsi Block Test), behavioral self-monitoring (PEBL Victoria Stroop Task), and cognitive set shifting (PEBL Trail Making Test part B). This may be due to differences in the parameters of the computerized versus traditional administration.

The failure to find any significant relationships between neuropsychological measures of visual attention span and any of the self-report mindfulness measures appears more likely to have been due to insufficient power as the result of the small sample size, a small effect size, or both. Alternatively, it may be that the test did not adequately measure the construct in question, perhaps leading to a Type II error. Since the precise reason for the negative finding cannot readily be determined, the null hypothesis cannot be rejected and further investigation is necessary (see 'Future Directions'). Also, though the MAAS has previously been shown to be marginally correlated with Trails B performance (Ballantyne et al., 2010), the administration parameters for the Trails B trials in the present study were not comparable to this previous study, which may account for the discrepancy in results across the two studies.

Summary and Conclusions

This study sought to contribute to the research literature spanning the fields of psychological mindfulness, neuropsychology, sleep and dreaming. The overarching aim was to investigate relationships between mindfulness in waking and lucidity in dreams. Based on prevailing models of dream neuropsychology, most importantly the continuity hypothesis, the specific aims of this study were to investigate relationships between factors associated with mindfulness in waking and factors believed to be associated with lucidity in dreams. Using a correlational design to test the hypotheses associated with each specific aim, a sample of N=44 healthy participants were asked to complete tests of neuropsychological functioning and self-report measures of mindfulness and dreaming.

The results of this study suggest did not support the prediction that the constructs of waking mindfulness and dream lucidity would be related. Several factors may have contributed to this negative finding including a restricted range of lucidity in the sample and possible misspecification of lucidity. The null hypothesis, that waking mindfulness and dream lucidity are not related cannot be discounted. However, the pattern of relationships demonstrated between other waking and dreaming variables suggests that the former explanation is more likely and that additional research is necessary to better clarify the precise waking correlates of lucidity.

This study can provide some direction to future studies, suggesting that future studies on this topic should assess two components of mindfulness, acceptance and awareness. It would also be advisable to investigate the potential relationships between other neuropsychological functions and lucidity, particularly executive and meta-cognitive functions such as prospective memory, planning, and inhibition. Lucidity may be better characterized in a more direct manner as well.

Despite the limitations of the study's primary aim, a number of significant relationships between waking measures of mindfulness, associated neuropsychological functions, and dream

content were demonstrated and can also provide direction for future research. Perhaps most notably, the three waking mindfulness measures used in this study accounted for a significant amount of the variance in dream mindfulness, the construct designed to capture a set of cognitive functions often associated with lucidity. As subjective levels of mindful awareness in the week preceding the study were moderately associated with levels of dream mindfulness during the study, it appears plausible that this relationship represents continuity of the type and level of awareness between waking and dreaming. It also seems reasonable to presume then, that mindfulness-based practices in waking may foster mindfulness in dreaming – a potential question for future research.

It is worth mentioning that the relationship between dream mindfulness and dream lucidity was marginally significant and in the predicted direction. Though further research with a larger sample of lucid dreams would be needed to better evaluate this relationship, it is interesting to note that within the summary measure of dream mindfulness, several 'cognitive' dream variables were significantly associated with lucidity ratings including dream attention and control. Given these findings and prior research demonstrating that lucidity can arise by simply triggering a habitual state-test during REM sleep (e.g. NovaDreamer), it stands to reason that while dream mindfulness, dream attention, and dream control may be associated with lucidity, they are neither necessary for lucidity nor exclusively associated with lucid dreams. In other words, it appears that one does not have to be a 'mindful dreamer' in order to be a lucid dreamer. That said, it would be interesting to examine the similarities and differences between the content of lucid dreams which have been induced by externally triggered state-tests versus those which occur spontaneously or through some practice or combination of practices aimed at enhancing awareness in both waking and dreaming.

Overall, the results appear to provide additional support for the hypothesis that the underlying brain-mind processes associated with waking and dreaming phenomena are shared,

at least with respect to many cognitive, emotional, and sensory functions. Levels of mindfulness in waking, specifically recent levels of the awareness component of mindfulness, appear to be moderately continuous with the construct of dream mindfulness. These findings in particular suggest that further investigation into the relationships between mindfulness in waking and its correlates in dreams is warranted.

REFERENCES

Achermann, P. (2004). The two-process model of sleep regulation revisited. *Aviation Space and Environmental Medicine, 75*(3,suppl.), A34 - 43.

Algom, D., Chajut, E., Lev, S. (2004). A rational look at the emotional stroop phenomenon: A generic slowdown, not a stroop effect. *Journal of Experimental Psychology-General, 133*(3), 323 - 328.

Armstrong-Kickey, D. (1988). A validation of lucid dreaming in school age children. *Lucidity Letter, 7*(2). www.spiritwatch.ca/Issue7_2/LL7_2_Hickey.htm.

American Psychiatric Association (2000). *Diagnostic andStatistical Manual of Mental Disorders: DSM-IV-TR.* Washington, DC.

Aston-Jones, G., Bloom, F. (1981). Nonrepinephrine-containing locus coeruleus neurons in behaving rats exhibit pronounced responses to non-noxious environmental stimuli. *The Journal Neuroscience, 1*, 887-900.

Ballantyne, E. C., Maucieri, L., Francis, T. J., Chaplin, A., & Beitel, M. (2010). The neuropsychology of mindfulness: Attentional aspects. *Clinical Neuropsychologist, 24*(4), 561-562.

Barrett, D. (1992). Just how lucid are lucid dreams? *Journal of the Association for the Study of Dreams, 2*(4), 221-228.

Bayard, S., Erkes, J., Moroni, C., du Languedoc, R. (2011). Victoria stroop test: Normative data in a sample group of older people and the study of their clinical applications in the assessment of inhibition in alzheimer's disease. *Archive of Clinical Neuropsychology, 26*(7), 653-661.

Bednar, J. (2000). Internally-generated activity, non-episodic memory, and emotional salience in sleep. *Behavioral and Brain Sciences, 23*(06), 908-909.

Berkovich-Ohana, A., Glicksohn, J., Goldstein, A. (2012). Mindfulness-induced changes in gamma band activity - implications for the default mode network, self-reference and attention. *Clinical Neurophysiology, 123*(4), 700-710.

Blagrove, M., Akehurst, L. (2000). Personality and dream recall frequency: Further negative findings. *Dreaming, 10*(3), 139-148.

Blagrove, M., Bell, E., Wilkinson, A. (2010). Association of lucid dreaming frequency with stroop task performance. *Dreaming, 20*(4), 280-287.

Blagrove, M., Hartnell, S. (2000). Lucid dreaming: Associations with internal locus of control, need for cognition and creativity. *Personality and Individual Differences, 28*(1), 41-47.

Blagrove, M., Tucker, M. (1994). Individual-differences in locus of control and the reporting of lucid dreaming. *Personality and Individual Differences, 16*(6), 981-984.

Blagrove, M., Wilkinson, A. (2010). Lucid dreaming frequency and change blindness performance. *Dreaming, 20*(2), 130-135.

Borbely, A., Wittmann, L. (2000). Sleep, not rem sleep, is the royal road to dreams. *Behavioral and Brain Sciences, 23*(06), 911-912.

Borbely, A. (1982a). Sleep regulation: Introduction. *Human Neurobiology, 1*(3), 161-162.

Borbely, A. (1982b). A two process model of sleep regulation. *Hum Neurobiol, 1*(3), 195-204.

Bosinelli, M., & Cicogna, P. (2000). REM and NREM mentation: Nielsen's model once again supports the supremacy of rem. *Behavioral and Brain Sciences, 23*(6), 913-+.

Braun, A. (1997). Regional cerebral blood flow throughout the sleep-wake cycle. *Brain, 120*, 1173-1197.

Braun, A., Balkin, T., Wesensten, N., Carson, R., Varga, M., Baldwin, P., Herscovitch, P. (1997). Regional cerebral blood flow throughout the sleep-wake cycle - an (h2o)-o-15 pet study. *Brain, 120*, 1173-1197.

Brewer, J. A., Worhunsky, P. D., Gray, J. R., Tang, Y. Y., Weber, J., & Kober, H. (2011). Meditation experience is associated with differences in default mode network activity and connectivity. *Proceedings of the National Academy of Sciences of the United States of America, 108*(50), 20254-20259.

Brooks, J, Vogelsong, J. (2008). *Exploring dream consciousness: Experiments in lucidity*

Brown, A.E. (1936). Dreams in which the dreamer knows he is asleep. *Journal of Abnormal and Social Psychology, 31*, 59-66.

Brown, K, & Ryan, R. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822-848.

Burgess, P, Quayle, A, & Frith, C. (2001). Brain regions involved in prospective memory as determined by positron emission tomography. *Neuropsychologia, 39*(6), 545-555.

Cacioppo, J.; Petty, R. (1982). The need for cognition. *Journal of Personality and Social Psychology, 42*, 116 - 131.

Cardaciotto, L. (2005). *Assessing mindfulness: The development of a bi-dimensional measure of awareness and acceptance.* (Doctoral Dissertation Dissertation), Drexel University, Philadelphia. Retrieved from http://hdl.handle.net/1860/547

Carskadon, M.A. (1995) *Encyclopedia of Sleep and Dreaming*. New York: Simon & Schuster MacMillan.

Cartwright, R. (1981). The contribution of research on memory and dreaming to a 24-hour model of cognitive behavior. In W. Fishbein (Ed.), *Sleep, dreams, and memory* (pp. 239-247). New York: Scientific Books.

Cartwright, R., Luten, A., Young, M., Mercer, P., Bears, M. (1998). Role of rem sleep and dream affect in overnight mood regulation: A study of normal volunteers. *Psychiatry Research, 81*, 1-8.

Cavallero, C. (2000). Rem sieep = dreaming: The never-ending story. *Behavioral and Brain Sciences, 23*(06), 916-917.

Charchat-Fichman, H., & Oliveira, R. M. (2009). Performance of 119 brazilian children on stroop paradigm-victoria version. *Arq Neuropsiquiatr, 67*(2B), 445-449.

Cheng, H., Wang, K., Xi, C., Niu, C., Fu, X. (2008). Prefrontal cortex involvement in the event-based prospective memory: Evidence from patients with lesions in the prefrontal cortex. *Brain Injury, 22*(9), 697 - 704.

Chiesa, A. (2009). Zen meditation: An integration of current evidence. *Journal of Alternative and Complementary Medicine, 15*(5), 585-592.

Chivers, L., Blagrove, M. (1999). Nightmare frequency, personality and acute psychopathology. *Personality and Individual Differences, 27*, 843-851.

Christoff, K., Gordon, A., Smallwood, J., Smith, R., Schooler, J. (2009). Experience sampling during fmri reveals default network and executive system contributions to mind wandering. *Proc Natl Acad Sci, 106*(21), 8719-8724.

Clerc, O. (1983). Natural induction of lucid dreams. *Lucidity Letter, 2*(1), 4-5.

Collerton, D., Perry, E. (1995). Dreaming and hallucinations - continuity or discontinuity? Perspectives from dementia with lewy bodies. *Consciousness and Cognition, 20*(4), 1016-1020.

Corsi-Cabrera, M., Miro, E., del-Rio-Portilla, Y., Perez-Garci, E., Villanueva, Y., Guevara, M. (2003). Rapid eye movement sleep dreaming is characterized by uncoupled eeg activity between frontal and perceptual cortical regions. *Brain and Cognition, 51*(3), 337-345.

Corsi, P. (1972). Human memory and the medial temporal region of the brain. *Dissertation Abstracts International, 34*, 819B.

Cox, W., Fadardi, J., Pothos, E. (2006). The addiction-stroop test: Theoretical considerations and procedural recommendations. *Psychological Bulletin, 132*, 443-476.

Darling, W., Pizzimenti, M., Rizzo, M. (2003). Unilateral posterior parietal lobe lesions affect representation of visual space. *Vision Research, 43*(15), 1675 - 1688.

De Gennaro, L., Ferrara, M. (2003). Sleep spindles: An overview. *Sleep Medicine Reviews, 7*, 423-440.

DeKoninck, J., Prevost, F., & LortieLussier, M. (1996). Vertical inversion of the visual field and REM sleep mentation. *Journal of Sleep Research, 5*(1), 16-20.

Delorme, M, Monique, L, & Kormick, J De. (2002). Stress and coping in the waking and dreaming states during an examination period. *Dreaming, 12*(4), 171-183.

den Ouden, H. E., Frith, U., Frith, C., Blakemore, S. J. (2005). Thinking about intentions. *NeuroImage, 28*(4), 787 - 796.

Diederich, N. (2007). The neurology of rem sleep. A synoptic tour de force. *Nervenarzt, 78*(4), 406-+

Dinges, D, & Powell, J. (1985). Microcomputer analyses of performance on a portable, simple visual rt task during sustained operations. *Behavior Research Methods, Instruments, & Computers, 17*, 652 - 655.

Dolcos, F., LaBar, K., Cabeza, R. (2004). Interaction between the amygdala and the medial temporal lobe memory system predicts better memory for emotional events. *Neuron, 42*(5), 855-863.

Dolcos, F., LaBar, K., Cabeza, R. (2005). Remembering one year later: Role of the amygdala and the medial temporal lobe memory system in retrieving emotional memories. *Proceedings of the National Academy of Sciences of the United States of America, 102*(7), 2626-2631.

Domhoff, G. (2001). A new neurocognitive theory of dreams. *Dreaming, 11*(1), 13-33.

Domhoff, G. (1996). *Finding meaning in dreams: A quantitative approach.* New York: Plenum Press

Domhoff, G. (2011). The neural substrate for dreaming: Is it a subsystem of the default network? *Consciousness and Cognition, 20*, 1163-1174.

Dresler, M., Koch, S., Wehrle, R., Spoormaker, V., Holsboer, F., Steiger, A, Czisch, M. (2011). Dreamed movement elicits activation in the sensorimotor cortex. *Current Biology, 21*(21), 1833-1837.

Erlacher, D., & Schredl, M. (2004). Time required for motor activity in lucid dreams. *Perceptual and Motor Skills, 99*(3), 1239-1242.

Erlacher, D., Schredl, M. (2008). Cardiovascular responses to dreamed physical exercise during rem lucid dreaming. *Dreaming, 18*(2), 112-121.

Eysenck, M., Derakshan, N., Santos, R., Calvo, M. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*(2), 336-353.

Farb, N., Segal, Z., Mayberg, H., Bean, J., McKeon, D., Fatima, Z., Anderson, A. (2007). Attending to the present: Mindfulness meditation reveals distinct neural modes of self-reference. *Social Cognitive and Affective Neuroscience, 2*(4), 313-322.

Faul, F. (2008). G*power version 3.0.10. Universitat Kiel, Germany.

Fenwick, P., Schatzman, M., Worsley, A., Adams, J., Stone, S., Baker, A. (1984). Lucid dreaming - correspondence between dreamed and actual events in one subject during rem-sleep. *Biological Psychology, 18*(4), 243-252.

Fosse, R., Stickgold, R., Hobson, J. (2001). The mind in REM sleep: Reports of emotional experience. *Sleep, 24*(8), 947-955.

Foulkes, D. (1996). Dream research: 1953-1993. *Sleep, 19*(8), 609-624.

Foulkes, W. (1962). Dream reports from different stages of sleep. *Journal of Abnormal Psychology, 65*(1), 14-&.

Freud, S. (1955). *The interpretation of dreams. Newly translated by james strachey. For the first time in english, the complete and definitive text.* New York: Basic Books.

Gackenbach, J. (1981). Lucid dreaming: Individual differences in personal characteristics. *Sleep Research, 10*.

Gackenbach, J. (1984). An estimate of lucid dreaming incidence. *Lucidity Letter, 3*(1), 81-82.

Gackenbach, J. (1985). Sex differences in lucid dreaming self-reported frequency: A second look. *Lucidity Letter, 4*(1). www.spiritwatch.ca/Past_issues/SEX_DIFFERENCES_II_LUCID_DREAMING_SELF.htm

Gackenbach, J. (2009). Electronic media and lucid-control dreams: Morning after reports. *Dreaming, 19*(1), 1 - 6.

Gackenbach, J, Cranson, R, Alexander, O. (1986). Lucid dreaming, witnessing dreaming, and the transcendental meditation technique: A developmental relationship. *Lucidity Letter, 5*(2), 1-13.

Gackenbach, J., LaBerge, S. (Eds.) (1988). *Conscious mind, sleeping brain: Perspectives on lucid dreaming*. New York: Plenum Press.

Gackenbach, J., Rosie, M., Bown, J., Sample, T. (2011). Dream incorporation of video-game play as a function of interactivity and fidelity. *Dreaming, 21*(1), 32-50.

Galvin, F. (1990). The boundary characteristics of lucid dreamers. *Psychiatric Journal of the University of Ottawa-Revue De Psychiatrie De L Universite D Ottawa, 15*(2), 73-78.

Gottesmann, C. (2002a). Mental imagery during sleep. *Behavioral and Brain Sciences, 25*(2), 193-+.

Gottesmann, C. (2002b). The neurochemistry of waking and sleeping mental activity: The disinhibition-dopamine hypothesis. *Psychiatry and Clinical Neurosciences, 56*(4), 345-354.

Gottesmann, C. (2006). Dreaming and schizophrenia: A common neurobiological background? *M S-Medicine Sciences, 22*(2), 201-205.

Gottesmann, C. (2008). Noradrenaline involvement in basic and higher integrated rem sleep processes. *Progress in Neurobiology, 85*(3), 237-272.

Green, C. (1968). *Lucid dreams*. London: Hamish Hamilton.

Hargus, E., Crane, C., Barnhofer, T., Williams, J. (2010). Effects of mindfulness on meta-awareness and specificity of describing prodromal symptoms in suicidal depression. *Emotion, 10*(1), 34-42.

Hartmann, E. (1991). *Boundaries in the mind*. New York: Basic Books.

Hasenkamp, W., Wilson-Mendenhall, C., Duncan, E., Barsalou, L. (2012). Mind wandering and attention during focused meditation: A fine-grained temporal analysis of fluctuating cognitive states. *NeuroImage, 59*(1), 750-760.

Hearne, K. (1978). *Lucid dreams: An electrophysiological approach and psychological study.* (Ph.D. Doctoral Dissertation), University of Liverpool.

Hobson, J, Schredl, M. (2011). The continuity and discontinuity between waking and dreaming: A dialogue between michael schredl and allan hobson concerning the adequacy and completeness of these notions. *International Journal of Dream Research, 4*(1), 3-7.

Hobson, J., McCarley, R, Wyzinski, P. (1975). Sleep cycle oscillation - reciprocal discharge by 2 brain-stem neuronal groups. *Science, 189*(4196), 55-58.

Hobson, J., McCarley, R. (1977). The brain as a dream state generator: An activation-synthesis hypothesis of the dream process. *Am J Psychiatry, 134*(12), 1335-1348.

Hobson, J., Pace-Schott, E. (2002). The cognitive neuroscience of sleep: Neuronal systems, consciousness and learning. *Nature Reviews Neuroscience, 3*(9), 679-693.

Hobson, J., Pace-Schott, E., Stickgold, R. (2000). Dreaming and the brain: Toward a cognitive neuroscience of conscious states. *Behavioral and Brain Sciences Special Issue: Sleep and Dreaming, 23*(6), 793-842, 904-1018, 1083-1121.

Hobson, J., Pace-Schott, E., Stickgold, R. (Eds.). (2003). *Dreaming and the brain: Toward a cognitive neuroscience of conscious states*. Cambridge, MA: Cambridge University Press.

Hobson, J., Stickgold, R, Pace-Schott, E. (1998). The neuropsychology of rem sleep dreaming. *Neuroreport, 9*(3), R1-R14.

Holzel, B., Lazar, S., Gard, T., Schuman-Olivier, Z., Vago, D. R., Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science, 6*(6), 537-559.

Holzel, B., Ott, U., Hempel, H., Hackl, A., Wolf, K., Stark, R., Vaitl, D. (2007). Differential engagement of anterior cingulate and adjacent medial frontal cortex in adept meditators and non-meditators. *Neuroscience Letters, 421*(1), 16-21.

Holzinger, B., LaBerge, S., Levitan, L. (2006). Psychophysiological correlates of lucid dreaming. *Dreaming, 16*(2), 88-95.

Hunt, H. (1989). *The multiplicity of dreams: Memory, imagination, and consciousness*. New Haven: Yale University Press.

Hunt, H. (2000). New multiplicities of dreaming and reming. *Behavioral and Brain Sciences, 23*(06), 953-955.

Hunt, H., Ogilvie, R. (1989). Lucid dreams in their natural series: Phenomenological and psychological findings in relation to meditative states. In J. Gackenbach & S. LaBerge (Eds.), *Conscious mind, sleeping brain: Perspectives on lucid dreaming* (pp. 389-417). New York: Plenum Press.

Hunt, H., Ogilvie, R. (1988). Lucid dreams in their natural series. In J. Gackenbach & S. LaBerge (Eds.), *Conscious mind, sleeping brain: Perspectives on lucid dreaming* (pp. 389 - 417). New York, NY: Plenum Press.

The Lucidity Institute (2009). Http://www.Lucidity.Com/novadreamer.Html. Retrieved February 9, 2009

Ioannides, A., Kostopoulos, G., Liu, L., Fenwick, P. (2009). Meg identifies dorsal medial brain activations during sleep. *NeuroImage, 44*(2), 455-468.

Ivanovski, B., Malhi, G. S. (2007). The psychological and neurophysiological concomitants of mindfulness forms of meditation. *Acta Neuropsychiatrica, 19*(2), 76-91.

Jensen, J., Rohwer. (1966). The stroop color-word test: A review. *Acta Psychologica, 25*, 36-93.

Josipovic, Z., Dinstein, I., Weber, J., & Heeger, D. J. (2012). Influence of meditation on anti-correlated networks in the brain. *Frontiers in Human Neuroscience, 5*.

Kahan, T. (1994). Measuring dream self-reflectiveness - a comparison of two approaches. *Dreaming, 4*(3), 177-193.

Kahan, T. (2000). The "problem" of dreaming in nrem sleep continues to challenge reductionist (two generator) models of dream generation. *Behavioral and Brain Sciences, 23*(6), 956-+.

Kahan, T., Laberge, S. (1994a). Lucid dreaming as metacognition: Implications for cognitive science. *Consciousness and Cognition, 3*(2), 246-264.

Kahan, T, LaBerge, S, Levitan, L, & Zimbardo, P. (1997). Similarities and differences between dreaming and waking cognition: An exploratory study. *Consciousness and Cognition, 6*(1), 132-147.

Kahan, T., Laberge, S. (1994b). Lucid dreaming as metacognition - implications for cognitive science. *Consciousness and Cognition, 3*(2), 246-264.

Kahan, T., LaBerge, S. (2011). Dreaming and waking: Similarities and differences revisited. *Consciousness and Cognition, 20*(3), 494-514.

Kessels, R., van Zandvoort, M., Postma, A., Kappelle, L., de Haan, E. (2000). The corsi block-tapping task: Standardization and normative data. *Applied Neuropsychology, 7*(4), 252-258.

Khambalia, A., Shapiro, C. (2000). A new approach for explaining dreaming and rem sleep mechanisms. *Behavioral and Brain Sciences, 23*(6), 958-+.

King, D., DeCicco, T. (2009). Dream relevance and the continuity hypothesis: Believe it or not? *Dreaming, 19*(4), 207-217.

Kottke, D., Wright, D., Laberge, S., Rich, R. (1996). U.S. Patent: US5507716-A.

Kozmová, M., Wolman, R. (2006). Self-awareness in dreaming. *Dreaming, 16*(3), 196-214.

LaBerge, S. (1980a). Lucid dreaming as a learnable skill: A case study. *Perceptual and Motor Skills, 51*, 1039-1042.

LaBerge, S. (1980b). *Lucid dreaming: An exploratory study of consciousness during sleep.* (Ph.D. Ph.D. Dissertation), Stanford University.

LaBerge, S. (1985a). *Lucid dreaming.* New York: Ballantine Books.

LaBerge, S. (1985b). The psychophysiology of lucid dreaming: The temporal distribution of lucid dreams within and between rem periods. *Psychophysiology, 22*(5), 599-599.

LaBerge, S. (1990a). *Exploring the world of lucid dreaming.* New York, NY: Ballantine Books.

LaBerge, S. (1990b). Lucid dreaming: Psychophysiological studies of consciousness during rem sleep. In J. F. K. Richard R. Bootzin, and Daniel L. Schacter (Ed.), *Sleep and cognition.* Arlington, VA: APA.

LaBerge, S. (1995). *A course in lucid dreaming.* Palo Alto, CA: The Lucidity Institute.

LaBerge, S. (2000). Lucid dreaming: Evidence and methodology. *Behavioral and Brain Sciences, 23*(6), 962-+.

LaBerge, S., Dement, W. (1982a). Induction of lucid dreams. *Sleep Research, 9*, 138.

LaBerge, S., Dement, W. (1982b). Voluntary control of respiration during REM sleep. *Sleep Research, 11*, 107.

LaBerge, S., Greenleaf, W., Kedzierski, B. (1983). Physiological responses to dreamed sexual activity during lucid rem sleep. *Psychophysiology, 20*(4), 454-455.

LaBerge, S., Kahan, T., Levitan, L. (1995). Cognition in dreaming and waking. *Sleep Research, 24A*.

LaBerge, S., Levitan, L., Dement, W. (1986). Lucid dreaming: Physiological correlates of consciousness during rem sleep. *Journal of Mind and Behavior, 7*, 251-258.

LaBerge, S., Levitan, L., Gordon, M., Dement, W. (1983). The psychophysiology of lucid dream initiation. *Psychophysiology, 20*(4), 455-455.

LaBerge, S., Zimbardo, P. (2000, April 10). *Smooth tracking eye-movements discriminate both dreaming and perception from imagination.* Paper presented at the Toward a Science of Consciousness Conference IV, Tucson, AZ.

Laberge, S. (1980c). Lucid dreaming as a learnable skill - a case-study. *Perceptual and Motor Skills, 51*(3), 1039-1042.

Levin, R., Nielsen, T. (2007). Disturbed dreaming, posttraumatic stress disorder, and affect distress: A review and neurocognitive model. *Psychological Bulletin, 133*(3), 482-528.

Levitan, L. (1992). A thousand and one nights of exploring lucid dreaming. *Nightlight, 4*(2).

Maggiolini, A., Cagnin, C., Crippa, F., Persico, A., Rizzi, P. (2010). Content analysis of dreams and waking narratives. *Dreaming, 20*(1), 60-76.

Malamud, J. (1979). *The development of a training method for the cultivation of "lucid" awareness in fantasy, dreams, and waking life.* (doctoral dissertation). University of Michigan. Ann Arbor, Michigan. Retrieved from http://sawka.com/spiritwatch/training_for_lucid_awareness.htm

Maquet, P. (1999). Brain mechanisms of sleep: Contribution of neuroimaging techniques. *Journal of Psychopharmacology, 13*(4), S25-S28.

Maquet, P. (2000). Functional neuroimaging of normal human sleep by positron emission tomography. *Journal of Sleep Research, 9*(3), 207-231.

Maquet, P., Peters, J., Aerts, J., Delifiore, G., Degueldre, C., Luxen, A., Franck, G. (1996). Functional neuroanatomy of human rapid eye movement sleep and dreaming. *Nature, 383*(12), 163 - 166.

Maquet, P, & Phillips, C. (1998). Functional brain imaging of human sleep. *Journal of Sleep Research, 7*, 42-47.

Maquet, P., Ruby, P., Maudoux, A., Albouy, G., Sterpenich, V., Dang-Vu, T., Laureys, S. (2005). Human cognition during rem sleep and the activity profile within frontal and parietal cortices: A reappraisal of functional neuroimaging data. In S. Laureys (Ed.), *Boundaries of consciousness: Neurobiology and neuropathology* (Vol. 150, pp. 219-227).

Maquet, P., Peters, J., Aerts, J., Delfiore, G., Degueldre, C., Luxen, A., Franck, G. (1996). Functional neuroanatomy of human rapid-eye-movement sleep and dreaming. *Nature, 383*(6596), 163-166.

McCarley, R., Hobson, J. (1975). Neuronal excitability modulation over sleep cycle - structural and mathematical-model. *Science, 189*(4196), 58-60.

Moffit, A., Purcell, S., Hoffman, R., Wells, R., Pigeau, R. (1991). Single-mindedness and self-reflectiveness: Laboratory studies. *Lucidity Letter, 10th Anniversary Issue*.

Monroe, L., Rechtschaffen, A., Foulkes, D., Jensen, J. (1965). Discriminability of rem and nrem reports. *Journal of Personality and Social Psychology, 2*(3), 456-460.

Moore, A., Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*(1), 176-186.

Moss, K. (1986). The dream lucidity continuum. *Lucidity Letter, 5*(2), 25-28.

Muzur, A. (2005). Toward an integrative theory of sleep and dreaming. *Journal of Theoretical Biology, 233*(1), 103-118.

Neider, M., Pace-Schott, E. F., Forselius, E., Pittman, B., & Morgan, P. T. (2011). Lucid dreaming and ventromedial versus dorsolateral prefrontal task performance. *Consciousness and Cognition, 20*(2), 234-244.

Nielsen, T, Kuiken, D, Alain, G, Stenstrom, P, & Powell, R. (2004). Immediate and delayed incorporations of events into dreams: Further replication and implications for dream function. *Journal of Sleep Research, 13*, 327-336.

Nielsen, T. (2004). Chronobiological features of dream production. *Sleep Medicine Reviews, 8*(5), 403-424.

Nielsen, T. (2000a). A review of mentation in rem and nrem sleep: Covert REM sleep as a possible reconciliation of two opposing models. *Behavioral and Brain Sciences, 23*, 793 - 809.

Nielsen, T. (2000b). Covert rem sleep effects on rem mentation: Further methodological considerations and supporting evidence. *Behavioral and Brain Sciences, 23*(06), 1040-1057.

Nielsen, T. (2000c). A review of mentation in rem and nrem sleep: Covert rem sleep as a possible reconciliation of two opposing models. *Behavioral and Brain Sciences, 23*(06), 851-866.

Nir, Y., Tononi, G. (2010). Dreaming and the brain: From phenomenology to neurophysiology. *Trends in Cognitive Sciences, 14*(2), 88-100.

Nofzinger, E. A., Mintun, M. A., Wiseman, M., Kupfer, D. J., & Moore, R. Y. (1997). Forebrain activation in rem sleep: An fdg pet study. *Brain Research, 770*(1-2), 192-201.

Nofzinger, E.; Mintun, M.; Wiseman, M.; Kupfer, D.; Moore, R. (1997). Forebrain activation in rem sleep: An fdg pet study. *Brain Research, 770*, 192-201.

Noreika, V. (2011). Dreaming and waking experiences in schizophrenia: How should the (dis)continuity hypotheses be approached empirically? *Consciousness and Cognition, 20*(2), 349-352.

Ogilvie, R, Hunt, H, Kushniruk, A, Newman, J. (1983). Lucid dreams and the arousal continuum. *Lucidity Letter, 2*(2), 49.

Ogilvie, R, Takeuchi, T, & Murphy, T. (2000). Expanding nielsen's covert rem model, questioning solms's approach to dreaming and rem sleep, and reinterpreting the vertes & eastman view of rem sleep and memory. *Behavioral and Brain Sciences, 23*(06), 981-983.

Ogilvie, R., Hunt H., Tyson P., Lucescu M., Jeakins D. (1982a). Lucid dreaming and alpha activity: A preliminary report. *Perceptual and Motor Skills, 3*(1), 797 - 808.

Ogilvie, R., Hunt, H., Tyson, P., Lucescu, M., Jeakins, D. (1982b). Lucid dream-ing and alpha activity: A preliminary report. *Perceptual and Motor Skills, 55*, 795 - 808.

Ostendorf, F., Angleitner, A. (1994). A comparison of different instruments proposed to measure the big five. *European Review of Applied Psychology, 44*, 45 - 53.

Pace-Schott, E. (2000). Nielsen's concept of covert rem sleep is a path toward a more realistic view of sleep psychophysiology. *Behavioral and Brain Sciences, 23*(6), 983-+.

Pace-Schott, E. (2007). The frontal lobes in dreaming. In D. Barrett & P. McNamara (Eds.), *The new science of dreaming: Biological aspects* (Vol. 1, pp. 115-154). Westport, CT: Praeger/Greenwood.

Patrick, A., Durndell, A. (2004). Lucid dreaming and personality: A replication. *Dreaming, 14*(4), 234-239.

Paulsson, T., Parker, A. (2006). The effects of a two-week reflection-intention training program on lucid dream recall. *Dreaming, 16*(1), 22-35.

Pesant, N., Zadra, A. (2006). Dream content and psychological well-being: A longitudinal study of the continuity hypothesis. *Journal of Clinical Psychology, 62*(1), 111-121.

Piper, J., Li, V., Eiwaz, M., Kobel, Y., Benice, T., Chu, A., Meuller, S. (2011). Executive function on the psychology experiment building language tests. *Behavioral Research Methods*.

Price, R., Cohen, D. (1988). Lucid dream induction: An empirical evaluation. In J. Gackenbach & S. LaBerge (Eds.), *Conscious mind, sleeping brain: Perspectives on lucid dreaming* (pp. 105 - 132). New York: Plenum Press.

Price, R., LaBerge, S., Bouchet, C., Ripert, R., Dane, J. (1991). The problem of induction: A panel discussion. *Lucidity Letter, 10th Anniversary Issue*.

Purcell, S. (1987). *The education of attention to dreaming in high and low frequency dream recallers: The effects of dream self-reflectiveness, lucidity and control.* (Ph.D. Dissertation), Carleton University.

Purcell, S., Mullington, J., Moffitt, A., Hoffmann, R., Pigeau, R. (1986). Dream self-reflectiveness as a learned cognitive skill. *Sleep, 9*(3), 423-437.

Rechtschaffen, A. (1978). The single-mindedness and isolation of dreams. *Sleep, 1*(1), 97-109.

Rechtschaffen, A, Kales, A. (1968). *A manual of standardized terminology, techniques, and scoring system for sleep stages of human subjects.*: US Department of Health, Education, and Welfare Public Health Service - NIH/NIND.

Reitan, R. (1955). The relation of the trail making test to organic brain damage. *Journal of Consulting Psychology, 19*, 393-394.

Rider, R., Pallais, W., LaMarca, K., LaBerge, S. (2012). *Differences in the cognitive and psychological content of lucid and non-lucid dreams*. Paper presented at the SLEEP 2012, Boston, MA.

Rider, R., Shenoy, P., Mandel, S., Swirsky-Sacchetti, T. (2008). The relationship between sleep and neuropsychological functioning. *Clinical Neuropsychologist, 22*(3), 425-425.

Rossi, E. (2000). *Dreams, consciousness, spirit: The quantum experience of self-reflection and co-creation* (3 ed.). Malibu, CA: Palisades Gateway Publishing.

Roussy, F., Camirand, C., Foulkes, D., DeKoninck, J., Loftis, M., Kerr, N. H. (1996). Does early-night rem dream content reliably reflect presleep state of mind? *Dreaming, 6*(2), 121-130.

Samson, H., Dekoninck, J. (1986). Continuity or compensation between waking and dreaming - an exploration using the eysenck personality-inventory. *Psychological Reports, 58*(3), 871-874.

Schatzman, M.; Worsley, A.; Fenwick, P. (1988). Correspondence during lucid dreams between dreamed and actual events. In J. Gackenbach, ; LaBerge, S. (Ed.), *Conscious mind sleeping brain: Perspectives in lucid dreaming.* New York: Plenum Press.

Schmertz, S. (2006). *The relation between self-report mindfulness and performance on tasks of attention.* (M.A.), Georgia State University.

Schredl, M., Erlacher, D. (2011). Frequency of lucid dreaming in a representative german sample. *Perceptual and Motor Skills, 112*(1), 104-108.

Schredl, M. (1998). Stability and variability of dream content. *Perceptual and Motor Skills, 86*(2), 733-734.

Schredl, M. (2000). Continuity between waking life and dreaming: Are all waking activities reflected equally often in dreams? *Perceptual and Motor Skills, 90*(3), 844-846.

Schredl, M., & Erlacher, D. (2004). Lucid dreaming frequency and personality. *Personality and Individual Differences, 37*(7), 1463-1473.

Schredl, M., & Hofmann, F. (2003). Continuity between waking activities and dream activities. *Consciousness and Cognition, 12*(2), 298-308.

Schredl, M., Sahin, V., & Schafer, G. (1998). Gender differences in dreams: Do they reflect gender differences in waking life? *Personality and Individual Differences, 25*(3), 433-442.

Snyder, F., Karacan, I., Tharp Jr, V.K., & Scott, J. (1968). Phenomenology of rems dreaming. *Psychophysiology, 4*, 375.

Solms, M. (2000a). Dreaming and rem sleep are controlled by different brain mechanisms. *Behavioral and Brain Sciences, 23*(6), 843-+.

Solms, M. (2000b). The mechanism of the rem state is more than a sum of its parts. *Behavioral and Brain Sciences, 23*(06), 1008-1009.

Solms, M. (1995). New findings on the neurological organization of dreaming - implications for psychoanalysis. *Psychoanalytic Quarterly, 64*(1), 43-67.

Solms, M. (2000c). Forebrain mechanisms of dreaming are activated from a variety of sources. *Behavioral and Brain Sciences, 23*(6), 1035-+.

Sparrow, S. (1976). *Lucid dreaming: Dawning of the clear light.* Virginia Beach, VA: A. R. E. Press.

Steriade, M. (2000). Corticothalamic resonance, states of vigilance and mentation. *Neuroscience, 101*(2), 243-276.

Steriade, M., Dossi, R., Contreras, D. (1993). Electrophysiological properties of intralaminar thalamocortical cells discharging rhythmic (approximate-to 40 hz) spike-bursts at approximate-to 1000 hz during waking and rapid eye-movement sleep. *Neuroscience, 56*(1), 1-9.

Stroop, J. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*(6), 643-662.

Stumbrys, T. (2011). Lucid dreaming: Discontinuity or continuity in consciousness? *International Journal of Dream Research, 4*(2), 93-97.

Taylor, V., Grant, J., Daneault, V., Scavone, G., Breton, E., Roffe-Vidal, S., Beauregard, M. (2011). Impact of mindfulness on the neural responses to emotional pictures in experienced and beginner meditators. *NeuroImage, 57*(4), 1524-1533.

Tellegen, A.; Atkinson, G. (1974). Openness to absorbing and self-altering experiences: A trait related to hypnotic susceptibility. *Journal of Abnormal Psychology, 83*, 268 - 277.

Tholey, P. (1983). Techniques for inducing and maintianing lucid dreams. *Perceptual and Motor Skills, 57*, 79 - 90.

Travis, F. (1994). The junction point model: A field model of waking sleeping and dreaming, relating dream witnessing, the waking/sleeping transition, and transcendental meditation in terms of a common psychophysiologic state. *Dreaming, 4*(2), 91 - 104.

Troyer, A., Leach, L., Strauss, E. (2006b). Aging and response inhibition: Normative data for the victoria stroop test. *Aging Neuropsychology and Cognition, 13*(1), 20-35.

Tyson, P., Ogilvie, R., Hunt, H. (1984). Lucid, prelucid, and nonlucid dreams related to the amount of eeg alpha activity during rem sleep. *Psychophysiology, 21*(442 - 451).

Van Eeden, F. (1913). A study of dreams. *Proceedings of the Society for Psychical Research, 26*, 481-461.

Voss, U, Holzmann, R, Tuin, I, & Hobson, J. (2009). Lucid dreaming: A state of consciousness with features of both waking and non-lucid dreaming. *Sleep, 32*(9), 1191 - 1200.

Voss, U., Tuin, I., Schermelleh-Engel, K., & Hobson, A. (2011). Waking and dreaming: Related but structurally independent. Dream reports of congenitally paraplegic and deaf-mute persons. *Consciousness and Cognition, 20*(3), 673-687.

Walker, M., van der Helm, E. (2009). Overnight therapy? The role of sleep in emotional brain processing. *Psychological Bulletin, 135*(5), 731-748.

Wilde, N., Strauss, E., Tulsky, D. (2004). Memory span on the wechsler scales. *Journal of Clinical and Experimental Neuropsychology, 26*(4), 539-549.

Yamadori, A. (1971). The role of the spindles in the onset of sleep. *Kobe Journal of Medical Science, 17*, 97-111.

Zeidan, F., Johnson, S., Diamond, B., David, Z., Goolkasian, P. (2010). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition, 19*(2), 597-605.

TABLES AND FIGURES

Table 1: Descriptive Statistics for the PHLMS and MAAS

	PHLMS Awareness	PHLMS Acceptance	PHLMS Total	MAAS Total
Mean	38.32	29.34	67.66	61.57
SD	4.91	6.57	8.04	8.99
Min	23.00	14.00	37.00	38.00
Max	48.00	47.00	90.00	80.00

Note: Depicted are the descriptive statistical values for the two self-report measures of mindfulness administered to all N=47 participants who completed part 1 of the study. PHLMS awareness and acceptance scores were used as measures of 'recent mindful awareness' and 'recent mindful acceptance', respectively. Total score on the MAAS were used as a measure of 'general mindful awareness'.

Table 2: Descriptive Statistics for the PEBL Trail Making Test (pTMT)

pTMT Measure	N	Mean	SD	Min	Max
Trails A (Average Time)	46	19536.29	3298.55	13027.20	29823.60
Trails B (Average Time)	47	24197.97	4951.42	15662.80	37630.80
Trails A (Fastest Time)	47	17353.87	2670.65	11281.00	26026.00
Trails B (Fastest Time)	47	20462.74	4681.24	11665.00	34455.00

Note: Depicted are the descriptive statistical values for the PEBL Trail Making Test parts A and B. This test was administered to all N=47 participants who completed phase 1 of the study. Average completion times across all five trials of each part (Trails A Time and Trails B Time, above) and fastest completion times are shown in milliseconds. One data point was missing for the Trail Making Test Part A average completion time, due to a technical malfunction the values for this participant were not recorded. Average completion time for Trails B was used as the measure of 'cognitive set shifting'.

Table 3: Descriptive Statistics for the PEBL Corsi Block Test (pCBT)

pCBT Measure	N	Mean	SD	Min	Max
Block Span	46	6.02	1.34	4	9
Total Score	45	52.96	22.74	20	126
Total Correct	45	8.49	1.77	5	14

Note: Depicted are the descriptive statistical values for the PEBL Corsi Block Test. This test was administered to all N=47 participants who completed part 1 of the study. Due to a technical error, data from two participants were not recorded for the total score and total items correct and from one participant for block span. Total score on this test was used as a measure of 'visual attention span'.

Table 4: Descriptive Statistics for the PEBL Victoria Stroop Test (pSTRP)

pSTRP Measure	N	Mean	SD	Min	Max
Color Naming Time	47	26.50	7.18	17.27	51.35
Word Reading Time	47	22.46	5.72	14.49	37.56
Interference Trial Time	47	28.58	10.98	12.96	69.58
Interference Trial Intrusions	47	0.79	1.21	.00	6.00
Efficiency (Interference/Color Naming)	47	1.08	0.24	.58	1.66
Stroop Efficiency (Interference/Word Reading)	47	1.26	0.27	.73	1.88

Note: Depicted are the descriptive statistical values for the PEBL Victoria Stroop Test. This test was administered to all N=47 participants who completed part 1 of the study. Interference trial time was used as a measure of 'behavioral self-monitoring'.

Table 5: Descriptive Statistics for the PEBL Cued Flicker Paradigm Test (pCFPT)

pCFPT Measure	N	Mean	SD	Min	Max
Average RT (Un-Cued Trials)	47	14938.21	4413.32	5498.44	26204.17
Average RT (Correctly-Cued Trials)	47	13290.03	4694.00	1638.77	24293.63
Average RT (Falsely-Cued Trials)	47	15342.62	3440.91	8626.38	26367.82
Correct Responses (Un-Cued Trials)	47	12.13	2.02	6.00	15.00
Correct Responses (Correctly-Cued Trials)	47	11.74	1.85	7.00	14.00
Correct Responses (Falsely-Cued Trials)	47	11.68	1.64	6.00	15.00
Average RT	47	22944.21	4047.35	16698.76	31605.51
Total Correct	47	35.55	4.19	19.00	41.00

Note: Depicted are the descriptive statistical values for the PEBL Subliminally-Cued Flicker Paradigm Test. This test was administered to all N=47 participants who completed part 1 of the study. Average response times (RT) across all trial types are shown in milliseconds. The total number of correct responses was used as a measure of 'change detection'.

Table 6: Descriptive Statistics for the PEBL Psychomotor Vigilance Task (pPVT)

pPVT Measure	N	Mean	SD	Min	Max
Response Latency 1000ms ISI	47	393.21	74.51	267.00	664.31
2000ms ISI	47	348.61	70.43	243.56	606.54
3000ms ISI	47	322.71	58.31	245.13	533.10
4000ms ISI	47	315.43	52.48	228.12	509.75
5000ms ISI	47	310.20	52.20	232.55	468.56
6000ms ISI	47	307.62	48.68	223.90	437.75
7000ms ISI	47	307.26	49.67	232.07	420.50
8000ms ISI	47	312.71	63.20	227.46	595.56
9000ms ISI	47	301.37	52.74	231.63	512.75
Mean Response Latency (all ISI bins)	47	314.62	40.05	240.04	392.66
SD of Response Latency (all ISI bins)	47	70.05	29.98	30.85	205.54
False Starts	47	4.33	3.75	.00	15.00
Lapses	47	5.47	6.12	.00	28.00

Note: Depicted are the descriptive statistical values for the PEBL Psychomotor Vigilance Task. This test was administered to all N=47 participants who completed part 1 of the study. Response latencies across all inter-stimulus interval (ISI) bins are shown in milliseconds.

Table 7: Descriptive Statistics for the Dream Experiences Survey v. 2

Rating Scale		Night 1	Night 2	Night 3	Night 4	Night 5	Night 6	Night 7
Recall	Mean	3.54	3.46	3.27	3.36	3.15	3.13	3.22
	SD	1.00	1.12	1.20	0.96	1.04	0.89	1.48
Overall Intensity	Mean	2.46	2.37	2.37	2.67	2.30	2.25	2.56
	SD	0.90	1.07	1.22	1.24	1.03	1.06	1.13
Lucidity	Mean	2.61	2.46	2.39	2.54	2.40	1.88	2.33
	SD	1.26	1.19	1.12	1.31	1.43	0.89	1.22
Visual Intensity	Mean	3.73	3.63	3.29	3.41	3.80	3.31	3.22
	SD	0.95	1.16	1.42	1.23	1.11	1.20	1.56
Auditory Intensity	Mean	2.85	2.95	2.70	2.79	2.70	2.69	2.44
	SD	1.28	1.30	1.47	1.36	1.34	1.14	1.33
Tactile Intensity	Mean	2.37	2.46	2.49	2.51	2.70	2.13	2.67
	SD	1.30	1.40	1.53	1.27	1.45	1.36	1.66
Taste/Smell Intensity	Mean	1.37	1.68	1.75	1.72	1.55	1.50	1.11
	SD	0.86	0.99	1.26	0.89	1.00	0.73	0.33
Vestibular Intensity	Mean	2.76	2.59	2.46	2.92	2.90	2.81	2.56
	SD	1.26	1.32	1.38	1.36	1.59	1.22	1.42
Happiness	Mean	1.98	2.76	2.10	2.31	2.25	2.06	1.89
	SD	1.11	1.41	1.37	1.30	1.33	1.34	1.54
Sadness	Mean	2.46	2.10	1.98	2.08	2.25	2.44	1.44
	SD	1.27	1.34	1.42	1.29	1.59	1.41	1.33
Anger	Mean	2.27	2.07	1.73	2.36	2.00	2.44	1.44
	SD	1.38	1.37	1.28	1.33	1.52	1.31	1.33
Fear	Mean	2.93	2.20	2.13	2.44	2.80	2.56	2.22
	SD	1.37	1.42	1.51	1.45	1.58	1.41	1.64
Confusion	Mean	2.85	2.32	2.37	2.56	2.40	2.25	2.00
	SD	1.39	1.27	1.44	1.35	1.27	1.13	1.41
Coherence	Mean	3.10	3.15	2.80	2.69	2.90	3.19	2.44
	SD	1.20	1.24	1.40	1.06	0.91	1.22	1.24
Attention	Mean	2.95	2.85	2.63	2.67	2.65	2.94	2.78
	SD	1.12	1.35	1.22	0.98	1.42	1.06	1.30
Volition	Mean	2.80	2.68	2.34	2.59	2.65	2.81	2.67
	SD	1.12	1.31	1.41	1.07	1.50	1.38	1.58
Control	Mean	2.29	2.44	2.02	2.38	2.05	2.19	2.11
	SD	0.78	1.07	1.13	0.88	0.89	1.11	1.05
Self-Awareness	Mean	3.27	2.88	2.51	2.92	3.00	2.69	2.89
	SD	0.92	1.08	1.08	1.01	1.08	0.87	1.17
Participation	Mean	4.15	3.90	3.61	3.92	4.10	4.06	3.00
	SD	0.96	1.41	1.63	1.01	1.21	0.93	1.41
Bizarreness	Mean	2.63	2.39	2.56	2.79	2.85	2.56	2.22
	SD	0.97	1.16	1.27	0.98	1.31	0.96	1.30

Note: Depicted are the average item ratings on the Dream Experiences Survey v. 2 by night. Values reflect means and standard deviations for all 44 participants who completed part 2 of the study (night's 1-4). All items were 5-point Likert-type scales. For nights 5-7, fewer participants completed the DES-2. For hypothesis testing, item ratings were averaged across nights to produce one score per item for each participant.

Table 8: Mindfulness and DES-2 Correlations

| DES-2 Measure	MAAS Total	PHLMS Aware	PHLMS Accept
Intensity	-.18	.09	.32*
Visual	-.05	.16	.07
Auditory	.00	-.11	.51***
Tactile	-.04	.26*	.14
Taste/Smell	-.15	.24	.02
Vestibular	-.23	.21	.15
Sensory	-.12	.22	.25
Happiness	.21	.16	-.16
Sadness	.02	.06	.36*
Anger	-.15	-.19	.37*
Fear/Apprehension	-.05	.16	.31*
Confusion	-.24	-.05	.24
Negative Emotion	-.10	.02	.40**
Coherence	.22	.22	-.29*
Attention	.29*	.39**	-.22
Volition	.18	.37**	.15
Control	.01	.23	.04
Reflection	.07	.39**	-.06
Self-awareness	.17	.32*	-.15
Participation	.23	-.16	-.03
Bizarreness	-.24	.01	.06
Lucidity	-.05	.05	.05
Dream mindfulness	.18	.42**	-.13

* *p<.05*
** *p<.01*
*** *p<.001*

Note: Depicted are correlations between mindfulness measures and DES-2 variables. Higher MAAS Total scores indicated of greater general mindfulness. Higher PHLMS awareness subscale scores indicated greater recent mindful awareness. Lower PHLMS acceptance scores indicated greater recent mindful acceptance. For all DES-2 scales, higher values indicated higher levels of that construct.

Figure 1: Mean Dream Mindfulness X PHLMS Awareness Subscale
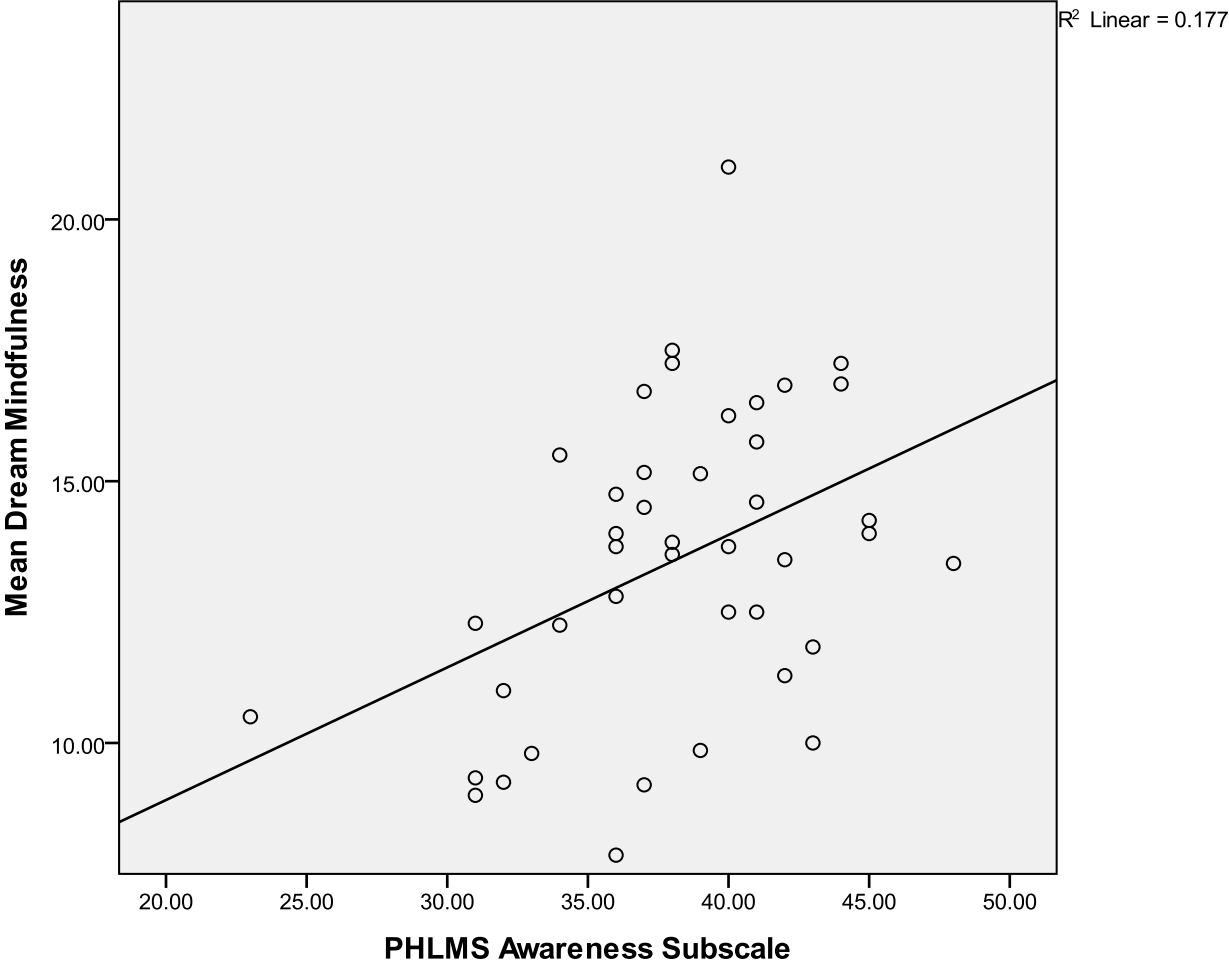
Note: Depicted is the scatter plot of average dream mindfulness scores by PHLMS awareness scores with the linear least-squares regression line fit to the data.

Figure 2: DES-2 Attention X PHLMS Awareness Subscale
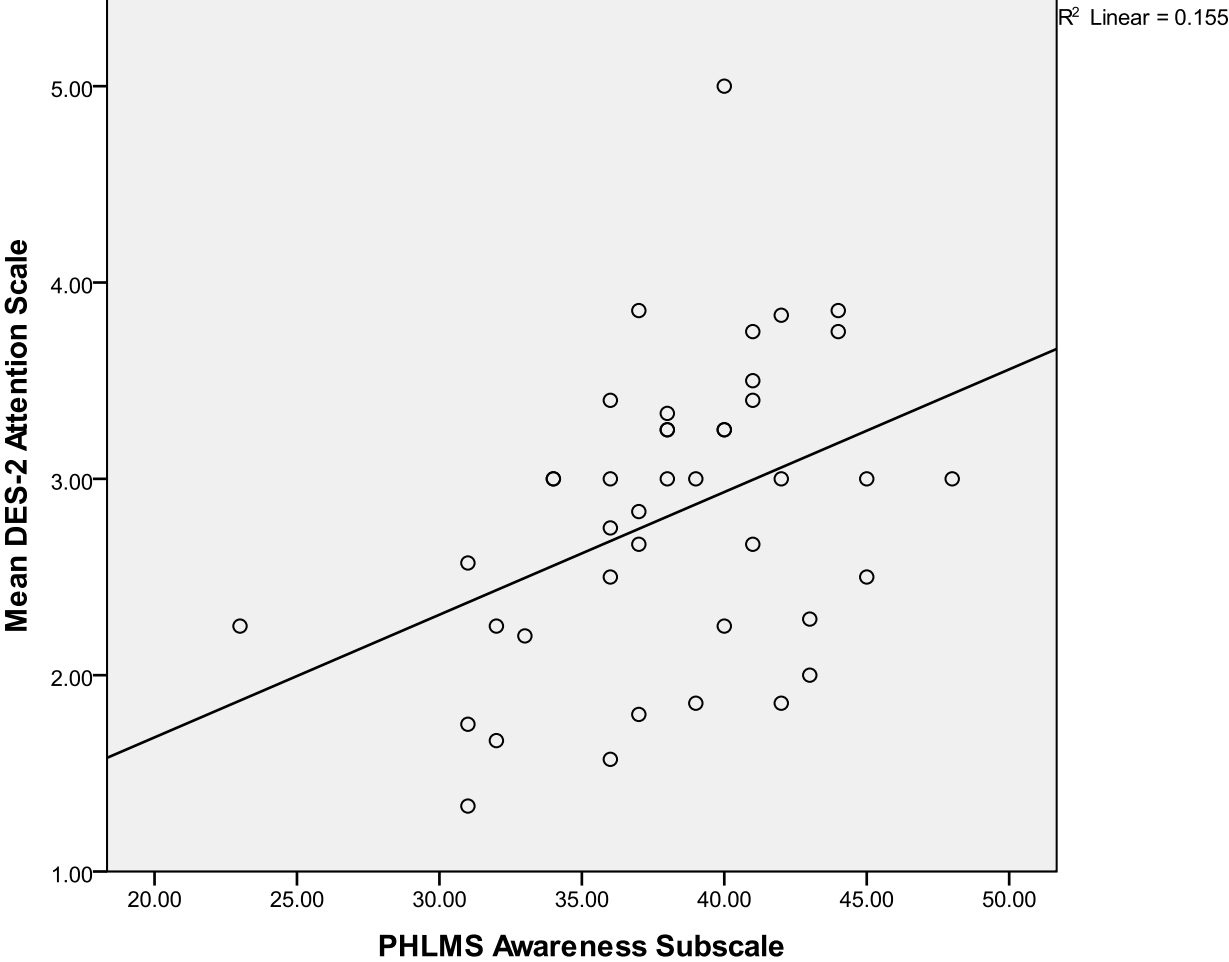
Note: Depicted is the scatter plot of average ratings of dream attention on the DES-2 attention by PHLMS awareness scores with the linear least-squares regression line fit to the data.

Appendix A

Demographics Questionnaire

*1. Please provide the following information for contact purposes. You will be assigned a unique numerical identifier which will be associated with all information collected from you.

Name:

Address:

Address 2:

City/Town:

State:

ZIP:

Country:

Email Address:

2. What is your date of birth?

	MM	DD	YYYY
Date of Birth:		/	/

3. What is your sex?

◯ Male

◯ Female

◯ Other

*4. Are you right- or left-handed?

◯ Right

◯ Left

◯ Ambidextrous

5. Do you have any problems with your vision?

◯ Yes

◯ No

If yes, please describe

*6. Are you a native English speaker?

◯ Yes

◯ No

Other (please specify)

✱7. How old are you? (Please provide your answer in whole numbered years)

[text box]

✱8. What time do you typically go to bed at night?

	HH	MM	AM/PM

Typical sleep time should be between 9 PM - 12 AM, otherwise be sure to check with RR about eligibility

[ ] : [ ] [   ]

✱9. What time do you typically awaken in the morning?

	HH	MM	AM/PM

Typical time of awakening should be between 6 AM and 9 AM, otherwise check with RR about eligibility

[ ] : [ ] [   ]

✱10. Do you have any trouble with falling asleep at night?

◯ Yes

◯ No

If 'Yes', How long does it typically take you to fall asleep? How often do you have difficulty? How long have you been having problems?

[text box]

✱11. Do you have any trouble with staying asleep through the night?

◯ Yes

◯ No

If 'Yes', How frequently do you wake in the night? How often do you have difficulty? How long does it take you to fall back to sleep? How long have you been having problems?

[text box]

*12. Do you have any trouble with awakening in the morning?

◯ Yes

◯ No

If 'Yes', How long does it typically take you to get out of bed in the morning? How often do you have difficulty? How long have you been having problems?

13. Do you use caffeine?

◯ Yes

◯ No

If yes, please describe

*14. Have you ever been evaluated by a doctor for problems with your sleep or daytime wakefulness?

◯ Yes

◯ No

If 'Yes', Please describe the problems. Please give an approximate date of your last evaluation. Please list your diagnosis and date is applicable.

*15. Have you ever performed shift work (i.e. overnight work shifts)?

◯ Yes

◯ No

If 'Yes', When was this work? How frequently, and for how long did you work this?

*16. Have you travelled across time zones in the past 3 months?

◯ Yes

◯ No

If 'Yes', When did you travel? What was the time difference? How long were you away? How long it has been since you returned?

*17. Have you experienced any disruption of your sleep/wake routine in past 30 days?

◯ Yes

◯ No

If 'Yes', please describe.

18. How many dreams do you typically recall per night? (please enter a whole number)

Dreams/Night

*19. Do you record your dreams in any way?

◯ Yes

◯ No

If 'Yes', how often do you record your dreams, and if you use a dream journal would you be willing to submit any prior dream reports?

*20. How much detail do you typically remember from your dreams?

◯ I recall that I had a dream, but cannot recall any details

◯ Bits and pieces

◯ Some of it

◯ Most of it

◯ I can recall nearly all of the detail from the dream

*21. How often do you have nightmares?

◯ Never

◯ Rarely

◯ Sometimes

◯ Frequently

◯ All the time

*22. Have you had any history of alcohol or drug abuse in the past year?

◯ Yes

◯ No

*23. Have you ever been diagnosed with any psychiatric illness?

◯ Yes

◯ No

If 'Yes', Describe your diagnosis. What was the date of your diagnosis? Did you receive any treatment?

[text box]

*24. Have you ever been diagnosed with any neurological problem or disease?

◯ Yes

◯ No

If 'Yes', Describe your diagnosis. What was the date of your diagnosis? Did you receive any treatment? and

[text box]

*25. Do you have any history of traumatic brain injury (e.g. motor vehicle accidents, falls, sports concussions, etc.?)

◯ Yes

◯ No

the If 'Yes', Describe your diagnosis. What was the date of your diagnosis? Did you receive any treatment?

[text box]

*26. Do you currently have any acute or chronic, debilitating medical conditions?

◯ Yes

◯ No

If 'Yes', Describe your diagnosis. What was the date of your diagnosis? Did you receive any treatment?

[text box]

*27. Are you currently taking any medications?

◯ Yes

◯ No

If 'Yes', What is the name/type of your medication? What is the reason for taking this medication? What is the length of time that you have been on this medication?

[text box]

*28. Do you now or have you ever practiced any form of meditation?

◯ Yes

◯ No

If 'Yes', What kind of meditation do you practice (transcendental meditation, mindfulness meditation, zen, etc.)? How long have you practiced? What is the typical duration of your meditation? When do you meditate, and how frequently do/have you practice(d)?

[text box]

29. Do you play video games?

◯ Yes

◯ No

If yes, how many hours per week?

[text box]

*30. Have you ever heard of and/or have you experienced lucid dreaming?

◯ Yes

◯ No

If 'Yes', Where have heard you about lucid dreaming? If you have had lucid dreams, how many have you had?

Appendix B

Dream Experiences Survey v. 2

*1. ID#:

*2. What time did you...

	HH	MM	AM/PM
Go to bed last night?		:	
Wake up this morning?		:	

*3. How many dreams did you have last night?

Total number of dreams:

*4. Please provide a report, written in the present tense, of one of your dreams from last night.

**Consider including a title and try to recall as much as you can without embellishing upon the actual dream narrative.

Dream Type

*5. How much of this dream can you RECALL?

- ( ) Nothing
- ( ) More than nothing but less than half of it
- ( ) About half of it
- ( ) More than half but less than all of it
- ( ) All of it

*6. Was this dream a NIGHTMARE?

- ( ) Yes
- ( ) No

*7. How INTENSE would you rate this dream relative to other dreams you've had?

	Not intense at all				The most intense dream I've had
Intensity	( )	( )	( )	( )	( )

*8. How close were you to realizing you were dreaming during this dream?

	Not at all				I realized I was dreaming
Lucidity	( )	( )	( )	( )	( )

Dream Experience Scales

If this was a lucid dream, please answer the following questions with regard only to the lucid portion of your dream (i.e. the portion during which you were aware that you were dreaming)

*9. Did you experienced any of the SENSATIONS listed below? If so, please indicate the highest degree of intensity with which it occurred at any time during the dream.

	Not at all				Most intense
Vision	○	○	○	○	○
Hearing	○	○	○	○	○
Touch	○	○	○	○	○
Taste/Smell	○	○	○	○	○
Vestibular (balance or sense of body moving in space)	○	○	○	○	○

*10. Please indicate the highest level of intensity with which you experienced the following EMOTIONS:

	Not at all				Most intense
Happiness	○	○	○	○	○
Sadness	○	○	○	○	○
Anger	○	○	○	○	○
Fear/Apprehension	○	○	○	○	○
Confusion	○	○	○	○	○

Other (please specify)

[   ]

*11. Which best describes how COHERENT the story-line/narrative of your dream was?

○ Incoherent (no story-line or many disconnected story-lines with entirely disconnected events).

○ Moderately coherent (a vague story-line or multiple story-lines with mostly disconnected events).

○ Coherent (a single, clear story-line with some disconnected events).

○ Very coherent (nearly all events related to a single story-line).

○ Fully coherent (all events fit into a single story-line)

*12. Which best describes the degree of control you had over your ATTENTION during the dream?

( ) None at all, simply reacting

( ) Almost none, able to maintain attention to one thing briefly

( ) A moderate amount, able to maintain attention more than once

( ) Very controlled, able to maintain and shift attention

( ) Full control, able to maintain attention to multiple things and shift attention at will

Other (please specify)

[   ]

*13. To what degree were you aware of and able to make and act on CHOICES in this dream?

( ) Unaware of choices, did not take any deliberate action.

( ) Some awareness of choices but no deliberate action.

( ) Full awareness of choices, but no deliberate action

( ) Full awareness of choices, some deliberate actions

( ) Full awareness of choices, most or all deliberate action.

*14. Which best describes your degree of CONTROL over the objects, other people, and setting(s) in this dream?

( ) None at all

( ) Very little, able to interact without controlling appearance or behavior of objects, people, or setting(s)

( ) A moderate amount, of control, able to interact and control the appearance or behavior of a single person, object, or setting of the dream.

( ) A lot of control, able to interact and control the appearance or behavior of more than one person, object, or setting of the dream.

( ) Full control, able to interact and control the appearance or behavior of most or all persons, objects, and setting(s).

Other (please specify)

[   ]

*15. How much did you THINK about the events of this dream while you were dreaming?

( ) Not at all

( ) Very little

( ) A moderate amount

( ) A lot

( ) Throughout the entire dream

✱16. Which best describes your level of SELF AWARENESS of your own sensations, behavior, appearance, thoughts, or feelings in this dream?

◯ Not at all

◯ Very little

◯ A moderate amount

◯ A lot

◯ I was fully aware

✱17. How much were you actively PARTICIPATING in the events of the dream?

◯ I was not present as a character in the dream

◯ I was present, but did not participate (i.e. mostly watching)

◯ I was present and participated some of the time

◯ I was present and participated most of the time

◯ I was present and actively participated the entire time

✱18. How much of this dream was comprised of BIZARRE experiences?

◯ None of it, indistinguishable from waking reality

◯ Very little, one or two bizarre experience but mostly indistinguishable from waking reality

◯ Some of it, a few bizarre experiences

◯ Much of it, many bizarre experiences, very unlike waking reality

◯ All of it, the entire dream was bizarre, completely unlike waking reality

Other (please specify)

Appendix C: The Mindful Awareness and Attention Scale

This measure is in the public domain and can be found at:

http://www.ppc.sas.upenn.edu/mindfulnessscale.pdf

Appendix D: The Philadelphia Mindfulness Scale

This measure is in the public domain and can be found at:

http://theselfimprovementsite.com/tools/PhiladelphiaMindfulnessScale.pdf