A polysomnographic investigation of the relationship between self-reported anxiety sensitivity and rapid eye movement sleep fragmentation

by

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Abstract

Rapid eye movement (REM) sleep is reported to play several roles in cognitive, memory, and emotion-related processes, and to be sensitive to the effects of anxiety-related disorders. The impact that anxiety sensitivity (AS; i.e. one's susceptibility to experience beliefs that anxious symptoms will generate harmful physical, cognitive, or social consequences) might have on REM sleep has seldom been investigated. This study explored the relationship between AS (global and subtypes) and REM fragmentation. Fifty-six participants were included in main analyses; polysomnograms were conducted to obtain REM fragmentation data, and the ASI-3 was administered to assess AS. Although global AS was not predictive of higher REM fragmentation, some AS subtypes were significantly linked with the outcomes. Overall, findings suggest that subtypes of AS may be better predictors of overall sleep dysfunction. Further investigating specific components of AS and their influence on sleep may assist with improving psychological treatment interventions designed for sleep.

Keywords: rapid eye movement sleep, sleep fragmentation, anxiety sensitivity

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Evidence from various epidemiological studies has concluded that up to 50% of individuals in Western populations experience disordered sleep (Hombali et al., 2018). Though most predominant complaints are related to disrupted sleep duration and quality, sleep disorders are also said to generate a high degree of daytime symptoms (e.g., excessive daytime fatigue, napping, headaches, etc.) that interfere with important social, occupational, and academic demands (Short et al., 2015).

For instance, many individuals who experience insomnia – a common sleep disorder characterized by difficulties with sleep initiation or maintenance leading to dissatisfaction with overall sleep quality – have reported that the daytime symptoms that occur as a result of insomnia (e.g., fatigue, irritability, low mood, as well as impairments in attention, concentration, and memory) are often more burdensome than its underlying disruption to sleep itself (Bastien, 2011; Morin et al., 2015). Research has suggested that insomnia and other forms of disrupted sleep are often comorbid with psychopathology (Cox & Olatunji, 2016; Edinger et al., 2009; Insana et al., 2012; Short et al., 2015). As an example, one study found that 60-70% of individuals with either generalized anxiety disorder (GAD) or panic disorder reported sleep-related disturbances (Hombali et al., 2018; Papatrimidou & Linkowski, 2005). Furthermore, Batterham and colleagues (2012) found that disrupted sleep was significantly associated with the incidence of GAD and panic disorder after a 4-year follow-up in an Australian community sample.

Restlessness, unsatisfying sleep, and difficulties with sleep onset and maintenance are also part of the DSM-5 criteria for many stress- and anxiety-related disorders, such as GAD and

post-traumatic stress disorder (American Psychiatric Association, 2013; Cox & Olatunji, 2016). Some evidence has suggested that worry and rumination (e.g., repetitively focusing on a thought) play a role in the development of anxiety-related disorders, and various studies have investigated the impact of these constructs on sleep (McLaughlin & Nolan-Hoeksema, 2011; Olatunji et al., 2013). Carney and colleagues (2010) found that rumination and worry were significantly correlated with insomnia in a sample of clinically referred outpatients and volunteers who were interested in insomnia treatment. Moreover, other studies have proposed that worry alone can prolong sleep latency (Murphy & Peterson, 2015). A meta-analysis compared 7,151 participants with clinical disorders (including anxiety) and normal controls and found that the presence of psychopathology predicted a longer sleep latency as well reductions in total sleep time and sleep efficiency (Benca et al., 1992). Monti and Monti evaluated polysomnographic data of individuals with GAD and found that nearly all participants exhibited some degree of sleep onset and sleep maintenance insomnia (2000).

Overall, the literature suggests that stress and anxiety are among some of the strongest psychopathological contributors to sleep-related disturbances (Hegde et al., 2011). In order to better understand the potential role of anxiety as it pertains to specific sleep-related disturbances, it may be helpful to contextualize this relationship through a broader understanding of the human sleep cycle.

Sleep Architecture

Sleep architecture refers to the way in which an individual's sleep cycle is structured, and concentrates on two types of sleep: non-rapid eye movement (NREM) sleep and rapid-eye movement (REM) sleep (Colten & Altevogt, 2006; Kryger et al., 2011). For humans, NREM sleep comprises 75-80% of the night. NREM sleep has three sub-stages: N1, N2, and N3, each of

which reflects a different degree of cortical activity. REM sleep occupies the remaining 20-25% of the night (Colten & Altevogt, 2006). Each sleep stage manifests unique features pertaining to brain waves, eye movements, and even muscle movement, which subsequently allow for proper differentiation between each stage. Kryger and colleagues (2011) outline that, in healthy individuals, sleep usually begins with a NREM cycle when one enters N1, and N2 and N3 follow successively. Subsequently, they will enter a REM cycle and continue to cycle between NREM and REM throughout the sleep period, with the length of each cycle (including the length of REM episodes) gradually increasing as the sleep period progresses (Kryger et al., 2011).

There are a number of factors that have the capacity to alter the structural organization of one's sleep such as age, gender, medication or substance use, physiological illness, and more (Colten & Altevogt, 2006; Kryger et al., 2011; Lee & Douglass, 2010). For instance, previous work has suggested that although the overall percentage of REM sleep remains relatively stable from early adulthood to the age of 60, it begins to decline afterwards (Floyd et al., 2007; Kryger et al., 2011). Furthermore, a number of studies have suggested that females are more likely to report sleep-related difficulties such as insomnia, frequent awakenings throughout the night, as well as report poor quality sleep overall compared to males (Krishnan & Collop, 2006; Tsai & Li, 2004). What is of particular interest in the present study, however, are preexisting psychopathological variables and the influence they may have on sleep architecture. Previous research has investigated this relationship and found that pathological anxiety was associated with various alterations in NREM sleep. For instance, one study found that generalized anxiety predicted a higher degree of N2 sleep and reductions in both total sleep time (i.e., total amount of time, typically in minutes, spent asleep during the night) and sleep efficiency (i.e. the proportion of time spent sleeping while laying in bed) (Cox & Olatunji, 2016). A lower degree of slow wave

sleep (or N3, a stage that has been theorized to play a role in learning and synaptic homeostasis) as well as increased awakenings throughout the night was observed in patients with GAD compared to their counterparts (Mellman, 2006; Tononi & Cirelli, 2006).

Largely, the relationship between altered NREM sleep and anxiety has been established in the literature to date, however, its impact on REM sleep in particular is not well documented. In order to address this gap in the literature, the present study will examine how specific predisposing psychopathological factors such as anxiety can influence REM sleep architecture. A general overview of REM sleep and its properties, adaptive functions, as well as a brief summary of the literature surrounding REM sleep and anxiety will lay the foundation for understanding the purpose of the current study.

REM Sleep

An individual is categorized as being in REM sleep when the following characteristic features are present during a polysomnogram (PSG): changes in electrical activity in the brain (particularly, a reduction in electroencephalographic [EEG] amplitude), muscle atonia (suppression of muscle tone), rapid eye movements, and, in some cases, an increase in genital activity (Kryger et al., 2011; McCarley, 2007). It is important to note that most of these REM sleep features are phasic, and are only observed intermittently during a REM sleep episode (Ermis et al., 2010). Some intervals exist during REM where rapid eye movements and changes in muscular activity are absent and the only feature observed is the alteration in EEG activity. Thus, REM sleep is divided into two stages: tonic, where characteristic features are absent, and phasic, where characteristic features emerge (Ermis et al., 2010). The most reliable way in which REM sleep can be objectively defined is by examining EEG-related data that is acquired during a PSG. The American Academy of Sleep Medicine (AASM; 2007) manual for the scoring of sleep

and associated events is the most reliable reference used by physicians and sleep technologists to evaluate and score PSG tests (Berry et al., 2016). Accordingly, as per the AASM scoring manual, REM sleep is scored in accordance with the following events: low amplitude, mixed-frequency EEG activity, rapid eye movements ("conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting less than 500 milliseconds", p. 87) occurring anywhere within the epoch, and a decrease in EMG activity occurring congruently with rapid eye movements for the majority of the epoch (Berry et al., 2016).

REM sleep has been theorized to serve many adaptive functions in various cognitive, emotional, and intellectual domains, as well as play a significant role in both the consolidation of learning and memory and affect regulation (Hegde et al., 2011; Lee et al., 2016; Lee & Douglass, 2010; Ting & Malhotra, 2005). Some have suggested that fragmented REM sleep could interfere with memory consolidation and disrupt the learning of complex, novel tasks, even when NREM sleep is otherwise normal and uninterrupted (Lee et al., 2016; Ting & Malhotra, 2005). Furthermore, Walker's (2009) research identified a relationship between REM sleep and an enhancement in declarative memory. It was suggested that the factual and explicit nature of declarative memory might assist an individual with managing negative emotions that accompany traumatic or disquieting memories over time (Walker, 2009). In other words, a healthy amount of REM sleep may bolster the effects of our declarative memory and thus "strip" the unpleasant memories of their negative emotion (Walker, 2009). Such findings are relevant as they provide further support for the detrimental effects that disrupted REM sleep may have on learning, memory, and emotion-related processes. What is primarily of relevance to the present study, however, is whether the presence of underlying anxiety can produce some degree of fragmented sleep (intrusive, recurrent awakenings that occur during the sleep cycle; Shrivastava et al., 2014).

REM Sleep and Anxiety

Sleep fragmentation is typically quantified by looking at the number of arousals that are exhibited by an individual during a PSG study (Paruthi & Chervin, 2010). The American Academy of Sleep Medicine (AASM) scoring manual objectively defines an arousal in REM sleep as "an abrupt shift of EEG frequency including alpha, theta, and/or frequencies greater than 16 Hz (but not spindles) that lasts at least 3 seconds, with at least 10 seconds of stable sleep preceding the change. A concurrent increase in submental EMG lasting at least 1 second [is also required]" (Berry et al., 2016, p. 45). There are several underlying causes of fragmented sleep, such as obstructive sleep apnea (i.e., a chronic sleep disorder characterized by repetitive cessations to breathe during sleep due to an obstruction in the upper airway), periodic limb movement disorder (i.e. when an individual exhibits frequent, repetitive leg movements during sleep), snoring, and more (Wang et al., 2020; Winkelman & Plante, 2010). Previous research has found fragmented sleep to be linked with a variety of difficulties, such as an increase in daytime sleepiness, impairment in psychomotor skills (e.g., short-term memory, reaction time, etc.), and may even increase cortisol levels, which could thus negatively influence mood or even induce anxiety (Bonnet & Arand, 2003; Stamatakis & Punjabi, 2010). In fact, Alkadhi and colleagues (2013) suggest that sleep fragmentation that is present over a prolonged period of time could generate similar effects to complete sleep deprivation over a short period of time. Nonetheless, very little evidence for fragmented REM sleep has been identified in the recent literature, particularly in the context of anxiety (Cox & Olatunji, 2016).

Some earlier research has identified a link between panic disorder and various REM sleep-related difficulties such as reduced REM latency, decreased REM density, as well as a higher degree of movement during REM sleep (Lauer et al., 1992; Mellman & Uhde, 1989; Uhde

et al., 1984). Another study compared outpatients diagnosed with GAD to outpatients diagnosed with depression and found that those with GAD had disrupted REM sleep architecture. Particularly, in comparison to normal control data as published by Williams and colleagues (1974), the patients with GAD demonstrated longer REM sleep latency as well as reduced overall REM percent/activity (Reynolds et al., 1983).

More recently, Hegde and colleagues (2011) examined the link between long-term stress and changes in amygdalo-hippocampal theta (A-HT) activity in rats during REM sleep. The results revealed that chronic induced stress altered total REM-sleep time while no changes were made to NREM sleep. Specifically, a bimodal distribution was observed for REM sleep states among the rats, with some experiencing a reduction in total REM sleep time, while others demonstrated an enhanced REM sleep state after being exposed to stress. It was hypothesized that this discrepancy could be attributed to individual differences in AH-T activity (Hegde et al., 2011). Another study found that mice, who were selectively bred to exhibit high anxiety-related behaviour, demonstrated difficulties remaining awake during their active period and during their sleep period had a high degree of fragmented sleep accompanied by a very unstable pattern of REM-NREM transitions (Jakubcavoka et al., 2012).

Though the aforementioned findings provide some empirical support for the role of anxiety-related variables in disrupted REM sleep, more comprehensive and updated research is required to address the specific question as to whether the relationship between anxiety and REM sleep fragmentation is meaningful. Moreover, such background research becomes relevant when we consider how the nature of most of the presented anxiety-related disturbances are somewhat consistent with a specific construct that the current study will explore – anxiety sensitivity (AS).

Anxiety Sensitivity

AS is defined as a fear of the physiological sensations that are associated with anxiety due to a belief that such will generate adverse physical, cognitive, and/or social consequences (Babson et al., 2008; Baker et al., 2017; Short et al., 2015). Whereas anxiety more generally is defined as underlying feelings of distress and nervousness that are often directed toward potential danger, AS is better represented by beliefs that anxious experiences will generate negative outcomes (Reiss et al., 1986; Rosenberg & Kosslyn, 2014). To illustrate, an individual high in AS may exhibit extreme worry about stomach pain, as they believe it indicates serious illness, or may be overly anxious when they feel they cannot concentrate, as they believe this is caused by serious cognitive deficits (Taylor et al., 2007). A great deal of research has found increased levels of AS to be a relatively stable construct that places individuals at an increased risk for developing clinically significant anxiety and other forms of psychopathology (Hovenkamp-Hermelink et al., 2019; Reiss et al., 1986; Short et al., 2015; Worden et al., 2015). For instance, Taylor and colleagues (2007) identified elevated levels of AS in individuals with panic disorder (PD), social anxiety disorder (SAD), and GAD compared to individuals with no history of anxiety-related disorders. Further, a recent study has found decreases in AS to be linked with a reduction in the severity of anxiety-related symptoms, which signals the possibility that targeting AS in psychotherapeutic settings may be beneficial in treating anxiety symptoms more generally (Hovenkamp-Hermelink et al., 2019).

Preexisting research has also established a link between elevated levels of AS and sleep pathology (Baker et al., 2017). Various research studies have found that heightened AS can sometimes predict insomnia-related symptoms (Short et al., 2015; Weiner et al., 2015). Specifically, individuals high in AS are more prone to exhibiting comorbid sleep anticipatory

anxiety and subsequently display delayed sleep latency (Short et al., 2015; Vincent & Walker, 2001). Though insomnia is most commonly associated with sleep onset-related difficulties, some of these individuals also struggle with sleep maintenance – or sleep fragmentation (Bastien, 2011). To our knowledge, AS in the context of REM sleep fragmentation has not been evaluated. The current study aims to further develop and add to the current literature on AS in a manner that is more specific to REM sleep parameters.

The Anxiety Sensitivity Index (ASI) is the most widely used and psychometrically sound tool administered to assess AS levels (Reiss et al., 1986). The ASI divides AS into 3 sub-factors: physical concerns, cognitive concerns, and social concerns (Baker et al., 2017). The third revision of the ASI, the ASI-3, has been demonstrated to have excellent factorial, content, convergent, discriminant, and criterion-related validities in a number of clinical and non-clinical research studies (Farris et al., 2015; Rifkin et al., 2015; Taylor et al., 2007; Zvolensky et al, 2018). Whereas AS, assessed on a global level, can provide insight into psychopathology more generally, a considerable amount of research has suggested that specific components of AS can be uniquely related to different types of anxiety disorders such as PD (physical sub-factor), SAD (social sub-factor), and GAD (cognitive sub-factor) (Rector et al., 2007; Wheaton et al., 2012). Furthermore, one study found that elevated scores in the physical sub-dimension of the ASI were most linked with PD and agoraphobia diagnoses, elevated scores in the social sub-dimension were most associated with social phobia, and moderately elevated scores in both the social and cognitive sub-domains were most associated with GAD diagnoses compared to those who are not diagnosed with any of such disorders (Rodriguez et al., 2004). Overall, these findings provide further support for the discriminant validity of the physical, social, and cognitive sub-factors of AS in individuals with underlying anxiety.

Past studies have also investigated scores in the three sub-factors and their relationship with various sleep-related disturbances such as increased sleep latency, decreased sleep duration, poor sleep quality, and more (Baker et al., 2017). However, it has been suggested that the cognitive and physical concern subscales are most strongly associated with sleep-related difficulties. For instance, the cognitive concern subscale has consistently been found to be positively related to global sleep dysfunction as measured by the Pittsburg Sleep Quality Index across a number of research studies (Baker et al., 2017; Calkins et al., 2013). Additional research studies have found that higher scores on the physical concern subscale predicted a higher degree of sleep anticipatory anxiety or insomnia-like symptoms (Babson et al., 2008; Short et al., 2015).

Examining AS in the context of sleep is of value as some researchers have suggested that psychotherapeutic treatments aimed to reduce AS may successfully reduce sleep-related disturbances (Keough & Schmidt, 2012; Short et al., 2015; Vincent & Walker, 2001). The results from the current study will contribute to our understanding of the effects of AS and its relevant facets on REM sleep. This could help us better understand the more specific constructs that are more strongly associated with REM sleep fragmentation and assist with tailoring psychotherapeutic strategies accordingly.

Research Hypotheses

The majority of research on AS and its consequences on sleep quality is primarily rooted in insomnia (Short et al., 2015), with little focus on additional sleep-related parameters such as sleep fragmentation, particularly in the context of REM sleep. The current study aims to address this gap in the literature and will examine the relationship between self-reported AS and REM sleep fragmentation. Accordingly, the first hypothesis postulates that as anxiety sensitivity increases, the degree of REM sleep fragmentation will also increase. Furthermore, we aim to

examine how each individual facet of anxiety sensitivity (i.e., physical, social, and cognitive) relates to REM sleep quality. The background literature suggests that the physical and cognitive subscales on the ASI-3 are most strongly linked with sleep dysfunction (Baker et al., 2017). Thus, the second hypothesis predicts that the physical and cognitive dimensions of AS will be most strongly associated with a higher degree of REM sleep fragmentation.

Method

Participants

Fifty-six participants (33 females, 22 males, and 1 transgender male) aged 25-56 years (M = 39.11, SD = 8.83) were included in the current study's main analyses. Participants who had a known diagnosis of REM behaviour disorder or narcolepsy were not eligible to participate, as these are disorders of REM sleep (Lee & Douglass, 2010; Ting & Malhotra, 2005). Participants who reported taking monoamine oxidase inhibitor (MAOI) class drugs (e.g., Zelapar, Marplan, Nardil, Parnate, etc.) were also not eligible as such medications are associated with REM sleep suppression (Mayers & Baldwin, 2005). Given the link that exists between OSA and fragmented sleep, participants who exhibited an apnea-hypopnea index (AHI) that was greater than or equal to 15 were also excluded from the study (Carney et al., 2010; Insana et al., 2012; Wang et al., 2020).

Measures

Anxiety Sensitivity Index-3 (ASI-3)

The ASI-3 (Taylor et al., 2007; see Appendix A) is an 18-item questionnaire that is administered to assess anxiety sensitivity (Rifkin et al., 2015). Respondents are instructed to rate the degree to which they agree with each item on a 5-point Likert-type scale ranging from 0 (very little) to 4 (very much) (Babson et al., 2008; Short et al., 2015). The ASI-3 contains

subscales designed to assess various concerns associated with anxiety-related symptoms, which include physical (e.g. *When my throat feels tight, I worry that I would choke to death*), cognitive (e.g. *When my mind goes blank, I worry there is something terribly wrong with me*), and social concerns (e.g. *I think it would be horrible for me to faint in public*) (Babson et al., 2008; Taylor et al., 2007; Zvolensky et al., 2018). The ASI-3 has demonstrated factorial, convergent, discriminant, and criterion-related validities in research examining both clinical and non-clinical samples (Rifkin et al., 2015; Taylor et al., 2007; Zvolensky et al., 2018).

Demographic Information

A medical history sheet containing information about the participants' age, gender, height, weight, body mass index, sleeping behaviours, caffeine intake, substance use, and brief questions about psychiatric history was collected by the patient's assigned polysomnographic technologist as per the sleep clinic's normal protocol (see Appendix B). As data concerning psychiatric history and caffeine/substance use are relatively brief on the intake medical history form, a supplementary demographics questionnaire was administered to participants (see Appendix C). Specifically, due to the acute effects that alcohol, marijuana, and opiates have on REM sleep architecture and quality (Lee & Douglass, 2010), we asked participants additional questions to screen for possible substance intoxication. Similarly, participants were advised to record the last time they consumed caffeine (as well as the amount that was consumed), as some research has suggested that caffeine consumption as early as 6 hours prior to bedtime can lead to fragmented sleep (Drake et al., 2013). Finally, in order to obtain more specific information on participants' psychiatric history, the supplementary demographics questionnaire asked participants to report any known history of specific depressive-, anxiety-, and other related disorders, and to specify if they were using any psychotropic medication as treatment.

Overnight Polysomnography (PSG)

A PSG is a procedure designed to detect and record physiological data associated with various sleep-related parameters (e.g., sleep continuity, sleep architecture etc.). PSGs are typically conducted to investigate various sleep-related disturbances and play a critical role in the diagnosis of suspected sleep disorders (Bastien, 2011; Colten & Altevogt, 2006; Shrivastava et al., 2014). A PSG is the gold standard sleep assessment tool and is the only measure to date that is able to accurately identify and differentiate each sleep stage (Bastien, 2011). The most standard pieces of equipment essential to proper sleep staging in a PSG include electroencephalographic (EEG) leads to detect brain wave activity, electrooculogram (EOG) leads for eye movement recordings, and electromyogram (EMG) leads to record muscle tone in the submental region (Bastien, 2011; Colten & Altevogt, 2006). Other commonly used measures include electrocardiogram (ECG) leads to measure electrical activity in the heart, an oximeter to detect oxygen desaturation levels, nasal cannulas to measure airflow, abdominal and thoracic belts to examine respiratory effort, EMG leads to measure muscle tone and movement in limbs, and a snore microphone (Bastien et al., 2011).

Following the conventions and policies of the Diagnostic Sleep Clinic, participants were set up for their PSG with the following recording equipment: EEG electrodes on their head to measure brain wave activity, EOG electrodes, EMG electrodes on the chin, EMG tabs on legs, ECG tabs on the chest, an oximeter probe placed on the finger, respiratory effort belts (around the abdomen and around the chest) along with a sleeping position sensor, a snore microphone on the neck, an oral/nasal pressure transducer inserted in the nose/mouth, and a thermistor above the upper lip (see Appendix D for specific electrode/equipment application guidelines for the Diagnostic Sleep Clinic). All equipment was connected to Philips Respironics Alice sleep testing

devices, which remained with the participant in their private sleep room throughout the study. All sleep-related activity and movement that was detected from the device was acquired and displayed through the Sleepware G3 diagnostic software.

The outcome measures that were computed and utilized for the current study are based on data acquired from participants' PSG studies. Accordingly, the current study's analyses focused on the following four measures of REM sleep fragmentation: total arousals REM (i.e. the total number of arousals observed across the entire REM sleep cycle), spontaneous arousals REM (i.e. the number of sudden awakenings that are not related to snoring, limb movements, or respirations observed across the entire REM sleep cycle), arousal index REM (i.e. the average number of arousals observed per hour across all REM sleep episodes), and the percentage of time spent in spontaneous arousals REM (i.e. the sum of time spent in spontaneous arousals across all REM sleep episodes divided by the total duration of all REM sleep episodes x100). A table summarizing each of the outcomes and their corresponding operational definitions can be found in Appendix J.

Procedure

Recruitment was attempted on patients who were attending their scheduled diagnostic overnight PSG test at the Diagnostic Sleep Clinic in North Bay, ON. Upon their arrival, patients were greeted by one of the sleep clinic's technologists and brought to their private room. The technologist subsequently met with each patient in their room to complete the medical history, obtain information on their sleep symptoms, and discuss what to expect from the PSG (see Appendix B). Once the medical history and all other forms required for the medical procedure were completed, patients who met inclusion criterion for the current study (i.e., 25-60 years)

were provided by the technologist with a brief description of the purpose of the current study and asked if they would like to participate (see Appendix E for recruitment script).

Those who expressed potential interest were provided with a package containing a written consent form (see Appendix F), the demographic questionnaire, and the ASI-3 questionnaire to complete by pen and paper independently. Patients who decided they wanted to participate were advised to sign the consent form and complete the measures. If, after reading the consent form that outlines the objectives of the current study in more detail, the patient decided they did not want to participate, they were advised to return the package to their technologist, or simply to leave it blank. The participant was notified that the package should take approximately 5-10 minutes to complete. Those who participated were instructed to return the package to their technologist once consent was provided and all written measures were completed. Once the completed measures were returned to the technologist, the participant was prepped for their PSG.

Upon completion of the PSG the following morning, participants were provided with a debriefing sheet that outlined the purpose and objectives of the current study (see Appendix G). Data obtained from the PSG test was scored by registered scoring technologists using the AASM manual as a reference as per standard clinic protocol (see Appendix H). Once the PSG was scored, the researchers recorded specific variables for analysis.

Participants were instructed to provide their full name and date of birth on a cover sheet that preceded the paper questionnaires (ASI-3 and demographic information questionnaire) in order to be able to match their responses with the PSG results once they were processed. This cover sheet contained a unique ID code for each participant; the remaining pages also had that same unique ID code. Once the PSG study was processed, specific data that were relevant to the current study was extracted and ID-coded to match the participant's questionnaires.

Subsequently, the cover sheet with the identifying information was removed and shredded on site at the Diagnostic Sleep Clinic. All identifiable data is currently being stored on site at the Diagnostic Sleep Clinic.

Results

Data Cleaning

A total of 104 participants were initially recruited for the current study. Two participants aged 22 and 61 were excluded from the sample as they fell outside the target age demographic (25-60 years). Based on predetermined eligibility criteria outlined above, the sample was then split into two subgroups: eligible participants (AHI < 15; $n = 56$) and non-eligible participants (AHI $\geq$ 15; $n = 46$). For descriptive purposes, sample characteristics are outlined for the eligible and non-eligible sub-groups, however analyses of the hypotheses were conducted on the eligible subgroup only.

Sample Characteristics

Participant demographic information and descriptive data are indicated in Table 1. In reviewing the reasons for referral to the sleep clinic, it was noted that 93.1% of these indicated the presence of physiological sleep symptoms (e.g., snoring, witnessed apnea, fragmented sleep, etc.), 3% reported psychological symptoms (i.e. anxiety, PTSD, nightmares, and insomnia), 5% reported cardiac risk factors (e.g. hypertension, arrhythmia, etc.), and 7% reported the presence of other medical-related concerns (e.g. epilepsy, pregnancy, obesity). It is important to note that, for some participants, the referral to the sleep clinic included more than one reason/symptom from the different categories presented. A more detailed summary outlining specific reasons for referral is included in Appendix I.

Additionally, no participants indicated being shift workers and no significant sleep apnea was present. Roughly 35.7% of the sample reported the presence of an anxiety-related diagnosis, and 23.2% reported the presence of a mood-related diagnosis. Approximately 14.3% reported SSRI use, and none endorsed MAOI use (two participants did not provide a response, but their answer was cross-referenced with the medication list provided on the night of their PSG). Due to the effects that alcohol and THC could potentially have on REM sleep, participants were also asked if they had consumed alcohol or THC in the 6 hours prior to their PSG study. Of the 56 eligible participants, 3 (5.4%) reported having consumed alcohol and 4 (7.1%) reported THC use in the past 6 hours. No opioid use in the 24 hours prior to the PSG was reported. Table 2 provides a summary of scored participant PSG data.

ASI-3 Scale Reliability and Descriptives

A scale reliability analysis was conducted to determine the level of internal consistency of the ASI-3. A Cronbach's alpha of $\alpha = .93$ was obtained, indicating high levels of internal consistency. Reliability analyses for the ASI-3 subscales (physical, cognitive, social) also revealed high degrees of internal consistency (see Table 3). A summary of the reliability analyses along with means and standard deviations, for the ASI-3 score and subscale scores, is presented in Table 3. ASI-3 total and subscale scores were calculated in accordance with what is indicated in previous literature (Babson et al., 2008).

Table 1

Sample Characteristics for both AHI Groups and Overall Sample

Characteristic	Group								
	AHI < 15 (*n* = 56)			AHI ≥ 15 (*n* = 46)			Overall (*N* = 102)		
	M	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Age (years)	39.11	8.83	25-56	45.11	8.96	28-60	41.81	9.34	25-60
Gender	*n* (%)			*n* (%)			*n* (%)		
Female	33 (58.9)			21 (45.7)			54 (52.9)		
Male	22 (39.3)			25 (54.3)			47 (46.1)		
Transgender	1 (1.8)			0 (0)			1 (1.0)		
Shift Worker									
Yes	0 (0)			0 (0.0)			0 (0.0)		
No	56 (100.0)			46 (100.0)			102 (100.0)		
SSRI Use									
Yes	8 (14.3)			10 (21.7)			18 (17.6)		
No	47 (83.9)			35 (76.1)			82 (80.4)		
No Response	1 (1.8)			1 (2.2)			2 (2.0)		
[a]Anxiety Disorder Diagnosis									
Yes	20 (35.7)			9 (19.6)			29 (28.4)		
No	32 (57.1)			36 (78.3)			68 (66.7)		
No Response	4 (7.1)			1 (2.2)			5 (4.9)		
[a]Mood Disorder Diagnosis									
Yes	13 (23.2)			11 (23.9)			24 (23.5)		
No	41 (73.2)			34 (73.9)			75 (73.5)		
No Response	2 (3.6)			1 (2.2)			3 (2.9)		

Note. AHI = Apnea Hypopnea Index. SSRI = Selective Serotonin Reuptake Inhibitor.

[a.] Values reflect participant self-report of anxiety and mood disorders diagnosed by a medical professional; any inconsistencies with proper diagnostic categories were recoded accordingly.

Table 2

Means and Standard Deviations for Scored PSG Data for both AHI Groups and Overall Sample

PSG Data	Group AHI < 15 (*n* = 56)	AHI ≥ 15 (*n* = 46)	Overall (*N* = 102)
	M (SD)	*M* (SD)	*M* (SD)
Initial Sleep Onset	27.1 (31.4)	24.6 (25.1)	26.0 (28.7)
Sleep Latency			
N1	27.8 (31.6)	25.4 (25.9)	26.8 (29.0)
N2	33.8 (34.3)	29.0 (23.0)	31.6 (29.7)
N3	66.3 (54.0)	62.6 (51.3)	64.6 (52.5)
REM	156.5 (71.5)	197.0 (101.1)	175.3 (88.4)
[a] Time in Bed	408.5 (44.3)	398.7 (61.6)	404.1 (52.8)
[b] Sleep Period Time	375.8 (63.6)	370.5 (77.4)	373.4 (70.0)
Total Sleep Time			
Overall	306.6 (72.0)	297.9 (73.8)	302.6 (72.6)
SWS	28.8 (23.6)	25.3 (25.6)	27.2 (24.4)
NREM	255.0 (55.0)	256.1 (65.5)	255.5 (59.7)
REM	55.5 (26.4)	42.7 (23.3)	49.6 (25.7)
[c] Sleep Efficiency	74.6 (15.0)	73.5 (16.1)	74.1 (15.4)
WASO	74.8 (40.0)	76.2 (38.4)	75.5 (39.1)
Total Wake Time	102.0 (55.9)	100.8 (45.6)	101.4 (51.2)
[d] # of Episodes			
N1	47.0 (18.2)	69.8 (32.6)	57.3 (28.0)
N2	50.3 (19.1)	64.0 (25.2)	56.5 (23.0)
N3	11.5 (8.4)	10.5 (9.1)	11.0 (8.7)
REM	5.9 (3.4)	6.7 (5.4)	6.3 (4.5)
[e] AHI			
Overall	7.0 (4.0)	46.4 (31.6)	24.8 (29.0)
REM	14.5 (12.3)	54.2 (32.0)	33.0 (30.8)

Note. All PSG data time in minutes, except [d, e,]. REM-related data left blank (n=5) for those without REM sleep during their PSG. [a] Time from lights off (start of sleep study after equipment calibration) until lights on (end of sleep study). [b] Sleep onset to last minute of sleep. [c] Total sleep time divided by time in bed multiplied by 100; data represents a percentage. [d] Data represent occurrences. [e] Data represent an average number of times participant ceased to breathe per hour during sleep. PSG = Polysomnogram. AHI = Apnea-Hypopnea Index. REM = Rapid eye movement. NREM = non-rapid eye movement. SWS = Slow wave sleep. WASO = Wake observed after sleep onset.

Table 3

Reliability Analyses, Means, and Standard Deviations for ASI-3 Scale and Subscales for AHI Groups and for the Overall Sample

	Group								
	AHI < 15 (n = 56)			AHI ≥ 15 (n = 46)			Overall (N = 102)		
	Sum Score *M* (SD)	Mean Score *M* (SD)	α	Sum Score *M* (SD)	Mean Score *M* (SD)	α	Sum Score *M* (SD)	Mean Score *M* (SD)	α
ASI-3 Total	20.6 (14.8)	1.1 (.82)	.93	16.2 (12.2)	.90 (.68)	.92	18.6 (13.8)	1.0 (.77)	.93
Physical	6.8 (5.5)	1.1 (.91)	.87	6.1 (5.3)	1.1 (.93)	.89	6.5 (5.4)	1.1 (.91)	.88
Cognitive	4.8 (5.5)	.80 (.91)	.91	3.3 (4.0)	.54 (.67)	.85	4.1 (4.9)	.69 (.82)	.89
Social	8.7 (6.3)	1.4 (1.1)	.86	7.4 (5.5)	1.2 (.92)	.85	8.1 (5.9)	1.4 (1.0)	.85

Note. Two cases were not included in this table due too many missing values on the ASI-3. α = Cronbach's alpha. AHI = Apnea-Hypopnea Index. ASI-3 = Anxiety Sensitivity Index-3. The ASI-3 scale contains 18 items; the physical, cognitive, and social subscales each contain 6 items. Total scores on the ASI-3 can range from 0-72 (0 to 24 for each subscale; Taylor et al., 2007).

Statistical Analyses

Using the R studio statistical program, separate regression models were conducted to examine the individual relationship between the ASI-3 total and subscale scores on four different REM sleep fragmentation outcomes: total arousals REM, spontaneous arousals REM, arousal index REM, and percent of time spent in spontaneous arousals during REM. Table 4 outlines the results obtained for single predictor models (i.e. ASI-3 total, physical, cognitive, social) and models with multiple predictors present (i.e. ASI-3 indicator, age, SSRI use, THC use) for all REM sleep fragmentation outcome measures. Within the models, the ASI scores were treated as continuous predictors given a lack of previous literature to support the categorical analysis of the ASI-3 subscale data. Furthermore, analyses using mild and high cutoff scores for the ASI total, based on criteria established in previous research (Allan et al., 2014; Farris et al., 2015; McCaul

et al., 2017), were conducted and the pattern of results in the categorical models did not differ significantly from results observed in continuous models.

Total Arousals REM

It was hypothesized that higher levels of AS, or its related facets, would be linked with higher levels of sleep fragmentation during REM sleep. Furthermore, it was predicted that the physical and cognitive subscales of the ASI-3 would be linked with a higher degree of REM sleep fragmentation. A summary of the results is presented in Table 4. When running the models containing only one single ASI-3 predictor (i.e., either total, physical, cognitive, or social), no significant effects were found (all $p_s > .05$). However, when examining the results for the models containing one of the ASI-3 predictors combined with age, SSRI use, and THC use, a slightly different pattern of results was observed. Whereas no significant effects were noted for the ASI-3 total, physical, and social models, significant effects were noted for the model that included the cognitive subscale along with age, SSRI use, and THC use, The results from this model revealed that the cognitive facet of the ASI-3, age, and SSRI use were each significantly predictive of the total number of arousals during REM sleep. More specifically, it appears that higher cognitively focused anxiety sensitivity, a higher age, or reported SSRI use (rather than non-use), were significantly predictive of a lower number of total arousals during REM sleep.

Spontaneous Arousals REM

For the spontaneous arousals REM outcome, no significant effects were noted for all models with a single ASI-3 predictor. When examining the models including multiple predictors, only the model that included the cognitive facet of the ASI-3 revealed significant results, with the ASI-3 cognitive and SSRI use predictors found to be significant. Particularly, a higher degree

of AS in the cognitive facet of the ASI-3 or reported SSRI use were related to a lower degree of spontaneous arousals during REM sleep.

Arousal Index (AI) REM

When analyzing the link between the ASI-3 predictors and AI REM, no significant effects were noted for any of the models with single predictors. Upon examination of the models with multiple predictors (AS indicator, age, SSRI use, and THC use), a significant effect of the social facet of the ASI-3 was observed. That is, those who demonstrated a higher degree of socially driven anxiety sensitivity demonstrated a higher AI compared to their counterparts.

Percent of Time Spent in Spontaneous Arousals REM

For the outcome that recorded the percentage of time spent in spontaneous arousals during REM, no significant effects were observed for any of the single predictor models (i.e., ASI-3 total, physical, cognitive, and social). However, when analyses were performed for models with the multiple predictors (i.e., adding age, SSRI use, THC use), statistical significance ($p_s < .05$) was observed across all ASI-3 models for both age and SSRI use. Individuals who were older or those who endorsed SSRI use were more apt to exhibit a higher proportion of time spent in spontaneous arousals during REM sleep.

Table 4

Summary of Regression Results for Main REM Fragmentation Outcome Measures

	Total Arousals REM			SA REM			Arousal Index REM			Percent Time Spent in SA REM		
	B	*p*	sr^2	B	*p*	sr^2	B	*p*	sr^2	B	*p*	sr^2
Single Predictor Models:												
ASI-3 Total	-.06	.35	.02	-.03	.50	.01	-.05	.48	.01	-.01	.19	.04
ASI-3 Phys	-.78	.43	.01	-.52	.46	.01	-1.6	.14	.04	-.13	.38	.02
ASI-3 Cog	-1.9	.14	.05	-.61	.41	.01	-.30	.81	.001	-.38	.09	.06
ASI-3 Soc	-.66	.50	.01	-.16	.79	.002	-.50	.62	.005	-.05	.72	.003
Multiple Predictor Models:												
	Model R^2: .05			Model R^2: .11			Model R^2: .08			Model R^2: .26		
ASI-3 Total	-.05	.45	.01	-.05	.28	.03	.07	.34	.02	-.001	.94	< .001
Age	-.10	.83	.02	.02	.73	.003	-.07	.53	.01	.03	.04*	.08
SSRI Use	-2.7	.32	03	-3.5	.09	.07	-.83	.77	.001	1.1	.002*	.19
THC Use	-.82	.83	.001	-1.8	.52	.01	5.9	.15	.05	.31	.46	.01
	Model R^2: .05			Model R^2: .04			Model R^2: .06			Model R^2: .28		
ASI-3 Phys	-.68	.51	.01	-.22	.76	.002	-.81	.46	.01	-.01	.92	< .001
Age	-.09	.38	.02	.06	.37	.02	-.04	.73	.002	.03	.01*	.12
SSRI Use	-2.9	.24	.03	-.98	.59	.01	-.82	.75	.002	1.0	.002*	.18
THC Use	-1.0	.79	.001	-1.7	.58	.01	5.0	.23	.03	.31	.45	.01
	Model R^2: .35			Model R^2: .20			Model R^2: .06			Model R^2: .26		
ASI-3 Cog	-4.4	.002*	.18	-1.7	.05*	.08	-.47	.72	.003	-.04	.79	< .001
Age	-.20	.03*	.08	.02	.72	.003	-.07	.51	.01	.03	.04*	.08
SSRI Use	-9.6	.001*	.21	-3.9	.04*	.09	1.5	.68	.004	1.1	.002*	.19
THC Use	-.44	.89	< .001	-1.4	.61	.005	4.9	.22	.03	.31	.46	.31
	Model R^2: .07			Model R^2: .07			Model R^2: .17			Model R^2: .28		
ASI-3 Soc	.52	.59	.01	-.62	.31	.02	2.4	.02*	.12	-.01	.92	< .001
Age	-.15	.15	.05	.06	.39	.02	-.09	.36	.02	.03	.03*	.09
SSRI Use	-2.1	.42	.01	-8.2	.65	.004	-3.2	.29	.02	1.1	.001*	.21
THC Use	.84	.85	.001	-1.7	.59	.01	3.9	.36	.02	.33	.41	.01

Note. REM = rapid eye movement. sr^2 = semi-partial correlation squared. ASI = Anxiety Sensitivity Index. Phys = physical. Cog = cognitive. Soc = social. SSRI = selective serotonin reuptake inhibitor. THC = Tetrahydrocannabinol (cannabis). SSRI and THC use (0 = no use; 1 = use).* $p < .05$.

Exploratory Analyses

In order to further explore the potential impact that AS may have on other sleep-related parameters (i.e., total sleep time and sleep latency), analyses that are not associated with the current study's main research questions were conducted. Only models with all predictors present (i.e., ASI-3 indicator, age, SSRI use and THC use) were utilized for the exploratory analyses. A summary of the results, for both total sleep time and sleep latency, is outlined in Table 5.

Total Sleep Time. All ASI-3 models were run with total sleep time (total NREM time + total REM time plus total movement time) as the outcome. Only age was found to be a statistically significant predictor in each of the models, with increases in age being predictive of less total sleep time.

Sleep Latency. ASI-3 models were also run with sleep latency, the time from the start of the sleep study through the first 30 seconds of sleep, as the outcome. Across each of the four ASI models, age was found to be a significant predictor of sleep latency, with increased age being predictive of shorter sleep latency. In addition, a higher degree of cognitively-focused AS was found to be significantly predictive of longer sleep latency. Finally, longer sleep latency was also observed for those who reported SSRI use (relative to non-users), however this finding was only noted in the model that also included the social facet of AS.

Table 5

Summary of Regression Results for Total Sleep Time and Sleep Latency

	Total Sleep Time			Sleep Latency		
	B	*p*	sr^2	B	*p*	sr^2
Multiple Predictor Models:						
	Model R^2: .19			Model R^2: .35		
ASI-3 Total	.17	.75	.002	.68	.14	.04
Age	-2.6	.005*	.16	-2.4	.003*	.12
SSRI Use	17.2	.43	.01	.08	.08	.05
THC Use	-5.5	.84	.001	.11	.11	.01
	Model R^2: .13			Model R^2: .37		
ASI-3 Phys	.21	.98	< .001	8.7	.23	.02
Age	-2.1	.02*	.11	-2.7	.001*	.21
SSRI Use	5.4	.80	.001	35.8	.06	.06
THC Use	-.24	.99	< .001	-43.0	.11	.04
	Model R^2: .17			Model R^2: .34		
ASI-3 Cog	-15.9	.11	.05	17.5	.03*	.09
Age	-2.2	.01*	.12	-1.7	.02*	.09
SSRI Use	10.6	.61	< .001	31.4	.09	.05
THC Use	1.4	.96	< .001	-44.4	.08	.05
	Model R^2: .13			Model R^2: .44		
ASI-3 Soc	4.9	.52	.008	12.5	.07	.05
Age	-2.0	.02*	.11	-2.8	< .001*	.21
SSRI Use	6.4	.76	.002	58.7	.01*	.11
THC Use	1.0	.97	< .001	-49.1	.06	.05

Note. sr^2 = semi-partial correlation squared. ASI-3 = Anxiety Sensitivity Index-3. SSRI = selective serotonin reuptake inhibitor. THC = Tetrahydrocannabinol (cannabis). Phys = physical subscale. Cog = cognitive subscale. Soc = social subscale. * $p < .05$.

Discussion

Current research regarding the impact that AS may have on REM sleep architecture is quite limited. Although the link between AS and insomnia appears to be well examined in previous literature, very little addresses sleep fragmentation, particularly during REM sleep, and the role that AS may have in altering this sleep process. In order to expand on this area of research, the current study aimed to investigate the link between self-reported AS and REM sleep fragmentation. As such, PSG data were examined in relation to participants' self-reported

levels of AS, both overall and for each individual subscale, in attempt to explore this relationship.

Although higher levels of overall AS were expected to correlate with higher levels of REM sleep fragmentation, it was not found to be significantly predictive of any of the REM sleep fragmentation outcome measures. Previous research has found higher overall AS scores to be linked with a variety of sleep-related difficulties, such as insomnia (i.e., difficulties with sleep onset and sleep maintenance) or sleep anticipatory anxiety (i.e., anxiety and worry about sleep) (Doos Ali Vand et al., 2018; Grace, 2020; Short et al., 2015). The sleep outcome of interest in the current study (i.e., REM fragmentation), however, differs from those previously investigated in the literature. In this study, overall anxiety sensitivity was not found to be significantly predictive of the sleep parameters being investigated. The lack of previous research on anxiety sensitivity and REM fragmentation also does not allow for a more direct comparison of our results with the current literature.

In trying to better understand the influence of anxiety sensitivity in individuals, some researchers have emphasized that focusing on the dimensions of AS may be more relevant than exploring anxiety sensitivity as a global construct (Olthius et al., 2014; Taylor et al., 2007; Wheaton et al., 2012). For instance, Taylor and colleagues (2007) discussed how the three dimensions of AS should also be considered with the overall score when attempting to identify any undiagnosed anxiety disorders or other related problems in nonclinical samples, as the subscales may assist with obtaining specific indices into the type of anxiety they may be experiencing. Therefore, a more general overall indicator of AS may not fully represent or capture the unique, and potentially stronger, influence of the various facets of AS, thus diluting the predictive power of the overall score (Olthius et al., 2014; Sanborn et al., 2020; Taylor et al.,

2007; Wheaton et al., 2012). Accordingly, the second hypothesis predicted that, of the three dimensions of AS, the physical and cognitive ones would be predictive of REM sleep fragmentation.

The results did not reveal any significant relationship between the physical facet of anxiety sensitivity and all four of the study's REM fragmentation outcomes. These findings were not anticipated as previous literature has linked elevated scores on this subscale with sleep difficulties; namely, sleep anticipatory anxiety and insomnia (Dixon et al., 2018; Grace, 2020; Short et al., 2015). Given the paucity of research examining AS in relation to REM fragmentation outcomes, a comparison to findings of previous studies is not possible. Nonetheless, one might consider whether those who exhibit higher levels of physically-focused AS may be more likely to display other types of sleep difficulties, such as problems with sleep onset, as opposed to sleep maintenance.

Whereas the more physically-focused aspects of AS were not found to be predictive of REM fragmentation outcomes, a different pattern was observed for more cognitively focused anxiety sensitivity. In contrast to what was predicted, lower levels of cognitively-focused AS were linked with a higher degree of sleep fragmentation, when assessed using two of the four REM fragmentation outcomes (i.e. total arousals REM and SA REM). Previous research on the role of cognitively-focused AS found that those who displayed higher levels of it were more likely to experience various sleep difficulties related to sleep latency (i.e. length of time it takes to fall asleep), total sleep duration, sleep efficiency (i.e. total time asleep divided by the total time spent in bed), and not REM fragmentation (Calkins et al., 2013; Dixon et al., 2018; Grace, 2020). For example, in their cognitive model of the maintenance of insomnia, Harvey (2002) emphasizes how individuals who exhibit sleep-related difficulties can sometimes experience

excessive worry regarding their sleep deficits during the pre-sleep period and the potential resulting consequences of poor sleep. For individuals with insomnia (a sleep disorder in which difficulty with sleep latency is a huge component), it is theorized that the sympathetic nervous system can sometimes become more activated at night as a result of excessive worry about getting enough sleep or the effects that poor sleep (or sleep deprivation) will have on their daytime functioning. Additionally, Fortier-Brochu and Morin (2014) found that individuals with insomnia were more likely to display mild impairments in attention-related tasks compared to their counterparts.

In more closely examining the ASI-3 items used to assess cognitively-focused AS in this study, it appears that these tend to focus on cognitive dyscontrol (Ghisi et al., 2016) or difficulties with concentration (i.e. *"When I have trouble thinking clearly, I worry that there is something wrong with me"* or *"It scares me when I am unable to keep my mind on a task"*). Participants who obtained higher scores on the cognitive subscale may experience a fear of a lack of control over their sleep and thus, cognitively-focused AS may be more strongly linked with cognitive concerns regarding insomnia or longer sleep latency, as opposed to difficulties with sleep maintenance or fragmentation. As such, exploratory analyses were conducted to examine whether cognitively-focused AS was predictive of sleep latency. Findings suggest that higher scores on the cognitive subscale were linked with a longer sleep latency, which is in line with the aforementioned literature and provides further support for the link between the cognitively-focused AS and difficulties with sleep latency. Overall, based on the aforementioned research examining sleep difficulties, an alternative relationship to consider in future research might be between anxiety sensitivity and indicators of sleep latency.

Moreover, the findings obtained regarding the social subscale (i.e., higher socially-focused AS was linked with higher REM fragmentation as measured by the arousal index (AI) REM outcome) were quite unexpected. Namely, these findings do not align with what was predicted in the current study, nor with any previous research investigating the relationship between the social AS and sleep, especially in the context of the AI. A few previous studies have linked anxiety with a greater AI, but not AS specifically (Bourdet & Goldenberg, 1994; Spence et al., 2004). Although it appears that no research on social anxiety and the AI has been conducted, there is some existing evidence of a link between social anxiety disorder and poor sleep. For instance, repetitive, negative thinking about social judgment has been theorized to lead to reductions in sleep quality (Horenstein et al., 2019). Other research suggests that individuals who exhibit a higher degree of social anxiety-related symptoms may experience distress related to how others may perceive their sleep difficulties, or how physically observable the effects of their sleep loss may impact their image (Buckner et al., 2008; Short et al., 2015). Similarly, the social subscale of the ASI-3 focuses on concerns regarding the way that others may judge or evaluate visible symptoms of anxiety (i.e., *"It's important for me not to appear nervous"* or *"I worry that other people will notice my anxiety"*). For the current study, participants underwent a diagnostic PSG, where they were under the constant supervision of a sleep technologist. So, for individuals who are more apt to experience high levels of social AS, it is possible that the technologist's consistent observation had generated socially anxious experiences in the participant and subsequently impacted the manner in which they slept.

Overall, results from the current study suggest that AS could generate worry regarding one's perceived quality of sleep and how, consequently, poor sleep can be observable and possibly critiqued by others. However, the exact reason as to why these results were found for

the AI REM outcome and not for the other sleep outcomes remains unclear. Research investigating the influence that a high AI may have on daytime functioning and health has mainly been associated with physiological problems such as obstructive sleep apnea, migraines, and cardiac difficulties, with very seldom research that investigates its role on psychopathology, and vice versa (Marca et al., 2006; Mayumi et al., 2019). Additional research investigating the psychological impact of anxiety on the AI specifically should be conducted.

In attempting to understand the potential role of AS in relation to REM sleep fragmentation, it may be worthwhile to consider previous literature supports regarding the impact of age, SSRI use, and THC use on sleep. When more specifically examining the effect of age across all four REM sleep fragmentation outcomes, somewhat differing patterns were observed. As participant age went up, a lower number of total arousals during REM was recorded, when also controlling for the cognitively-focused anxiety sensitivity as well as THC and SSRI use. This was an unexpected finding as several studies have found that many components of sleep tend to worsen with age (Campbell et al., 2007; Espiritu, 2008; Floyd et al., 2007; Kryger et al., 2011; Li et al., 2018). However, some studies have found that although older adults (i.e., 60 years and older) are more prone to awaken more frequently throughout the night, they tend to awaken less from REM and more from NREM compared to younger (i.e., approximately 19-30 years) adults (Espiritu, 2008; Murphy et al., 2000; Pace-Schott & Spencer, 2011). Thus, it is possible that younger individuals in our study displayed a higher degree of arousals during REM, compared to older adults, due to this suggested age-related difference in sleep architecture.

Furthermore, the sleep fragmentation outcome measuring the percentage of time spent in SA during REM appeared to be more prominent with increasing age (Campbell et al., 2007;

Espiritu, 2008; Floyd et al., 2007; Kryger et al., 2011; Li et al., 2018). This particular sleep outcome, compared to the other three investigated in the current study, is the only one that takes REM time into consideration whereas the others measure instances of arousal. Some previous research states that an overall disruption to regular REM activity such as a decrease in REM percent (i.e. overall percentage of REM sleep time observed), REM sleep efficiency (i.e. total time in REM divided by total time spent in bed), and REM latency (i.e. time from sleep onset to onset of first REM episode), tends to occur as we age. Each of these are measures of REM sleep that take time into account (Espiritu, 2008; Ohayon & Vecchierini, 2005; Redline et al., 2004; Van Cauter et al., 2000). Thus, it is possible that older adults are more likely to exhibit changes in REM sleep parameters that are related to time, as opposed to instances of arousal or fragmentation of sleep, as evidenced in all AS models in the current study.

It was also found that the absence of SSRI use revealed a higher number of arousals; however, this finding was only observed in two (i.e. total arousals REM and SA REM) of the four REM fragmentation outcomes when cognitive AS, age, and THC use were controlled for. These results were quite unexpected given previous research establishing a strong link between SSRI use and disruption to REM sleep architecture (Drago, 2008; Wichniak et al., 2017). On the other hand, the REM fragmentation outcome measuring the percentage of time spent in SA during REM was found to be higher for participants who endorsed SSRI use, which is congruent with previous literature (Drago, 2008; Wichniak et al., 2017). The exact reason why this effect was found in this outcome, and not in the other REM fragmentation outcomes, remains unclear. Perhaps, similarly to what was discussed regarding the impact of age on the percent of time spent in SA REM, the time component of this particular REM fragmentation sleep outcome is more vulnerable to the effects of SSRI use. Based on other research, there are a couple of possible

explanations that could provide a better understanding of the variability observed in the current study's results regarding SSRI use. For instance, dosage amount and medication side effects that might be generated by SSRIs, as well possible interactions with any additional medications, can vary significantly in each individual and thus generate a variety of sleep-related difficulties (Wichniak et al., 2017).

Further, no significant findings were observed for THC use predictor on any of the REM sleep fragmentation outcomes in the current study. The literature has emphasized that the effects of marijuana on sleep can vary quite significantly, creating sedative effects in some and promoting wakefulness in others (Lee & Douglass, 2010). As such, the presumed variability in an individual's response to THC and the manner in which it impacts their sleep could help in understanding the current study's findings.

Although the current study's results relating to the predictors of age, SSRI use, and THC use could additionally contribute to our undestanding of REM sleep fragmentation, these should be interpreted with caution, given the relatively small subset of those who reported SSRI and THC use. Future research should focus on investigating the unique influences that SSRI use and THC use might have on REM sleep patterns.

Limitations and Future Directions

This study aimed to examine the role of anxiety sensitivity in relation to REM sleep fragmentation. To this end, the degree of strength or severity of AS scores is an important consideration. In comparing our findings to those of previous research, it appears that the links between anxiety sensitivity and disrupted sleep outlined in some of these studies also reported ASI-3 scores that were higher than those observed in the current study (e.g., Dixon et al., 2018; Doos Ali Vand et al., 2018; Grace, 2020; Petrocchi et al., 2014). That is, it is possible that the

effect of anxiety sensitivity on sleep is observed at higher, or more elevated, levels of anxiety sensitivity, and the relations that were found in the current study may be limited in magnitude by the restricted range in ASI-3 data. Future studies should focus on more closely examining the influence of elevated AS, relative to levels noted in the current study, on REM sleep fragmentation to see whether differences in the pattern of results are observed. It is also worth considering the relevance of a proposed bidirectional relationship between anxiety sensitivity and fragmented sleep (Alvaro et al., 2013; Jansson-Frojmark et al., 2008; Lauriola et al., 2019). Namely, it is difficult to determine whether underlying sleep-related deficits lead to an increased susceptibility to developing AS, or if pre-existing anxiety sensitivity leads to fragmented REM sleep.

In addition, all sleep-related data acquired for this study were reflective of one night of sleep. Although PSG studies are considered to be the most widely used objective measures of sleep, they have been criticized for not best representing an individual's actual sleep patterns, in part due to the fact that they are attempting to sleep in an unfamiliar environment (Bastien, 2011; Herbst et al., 2011). To add to this, several researchers have also discussed a "first night effect", which is a phenomenon that often occurs during an individual's initial PSG study where their typical sleep architecture is altered, and when they are more apt to display lower total sleep times and sleep efficiencies, a reduction in overall REM sleep, and more (Byun et al., 2019; Herbst et al., 2011; Insana et al., 2012).

Furthermore, the current study did not include a large sample size. As indicated in the literature, OSA can often induce or worsen sleep fragmentation (Carney et al., 2010; Insana et al., 2012; Wang et al., 2020). Thus, the sample was reduced from 104 to 56 participants in order to control for the influence that OSA may have had on measures of sleep fragmentation. A larger

sample may better represent the diversity of sleep problems that exist in the general population. On a related note, the participants recruited are all presumed to have underlying sleep difficulties since they are attending a diagnostic testing facility, which also might reduce the generalizability of our findings. Recruiting participants from within the broader community should be considered in future research in order to better account for the potential influence sample bias (Simundic, 2013; Tripepi et al., 2010).

Lastly, considering that previous literature has outlined how arousals and fragmentation during REM sleep versus NREM sleep can vary significantly, it may be worthwhile to incorporate NREM-related arousal data in future research (Espiritu, 2008; Pace-Schott & Spencer, 2001; Murphy et al., 2000). Comparing REM sleep data with other components of the human sleep cycle may add to our knowledge of the unique impact that each stage of sleep may have on various psychological processes, thereby enhancing our understanding of the relationship between sleep and mental health overall.

Conclusion

The current thesis contributes to the paucity of research examining AS in relation to REM sleep-related complaints Whereas the ASI-3 provides information about an individual's degree of AS both globally (i.e., overall score) and in the context of each individual subtype of AS (i.e. physical, cognitive, and social subscales), the findings of the current study support the need to further examine specific components of AS and how they uniquely influence fragmented sleep. Furthermore, although all four of our outcome measures were designed to measure REM fragmentation, each of these assesses this construct in different ways relative to instances of arousals and time. Accordingly, the variability in findings observed amongst each of these four measures further emphasizes the need to explore sleep difficulties from different perspectives, as

each may uniquely contribute to these. Our results have also shed light onto a possible link between AS and difficulties with sleep initiation (i.e. sleep latency). Future research could explore if AS may be more strongly linked with difficulties related to sleep onset, as opposed to those involving sleep maintenance. Overall, the current study outlines the need to further explore the influence that specific components of AS may have on REM fragmentation. Understanding the varying influences that anxiety can have on sleep processes may further the development of psychological treatment options that are tailored to an individual's unique biopsychosocial needs and predispositions, and subsequently improve REM sleep structure and quality.

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Appendix A

Anxiety Sensitivity Index-3

Please circle the number that best corresponds to how much you agree with each item. If any items concern something that you have never experienced (e.g., fainting in public) answer on the basis of how you think you might feel *if you had* such an experience. Otherwise, answer all items on the basis of your own experience. Be careful to circle only one number for each item and please answer all items.

	Very Little	**A little**	**Some**	**Much**	**Very much**
1. It is important for me not to appear nervous.	0	1	2	3	4
2. When I cannot keep my mind on a task, I worry that I might be going crazy.	0	1	2	3	4
3. It scares me when my heart beats rapidly.	0	1	2	3	4
4. When my stomach is upset, I worry that I might be seriously ill.	0	1	2	3	4
5. It scares me when I am unable to keep my mind on a task.	0	1	2	3	4
6. When I tremble in the presence of others, I fear what people might think of me.	0	1	2	3	4
7. When my chest feels tight, I get scared that I won't be able to breathe properly.	0	1	2	3	4
8. When I feel pain in my chest, I worry that I am going to have a heart attack.	0	1	2	3	4
9. I worry that other people will notice my anxiety.	0	1	2	3	4
10. When I feel "spacey" or spaced out I worry that I may be mentally ill.	0	1	2	3	4
11. It scares me when I blush in front of people.	0	1	2	3	4
12. When I notice my heart skipping a beat, I worry that there is something seriously wrong with me.	0	1	2	3.	4
13. When I begin to sweat in a social situation, I fear people will think negatively of me.	0	1	2	3	4
14. When my thoughts seem to speed up, I worry that I might be going crazy.	0	1	2	3	4
15. When my throat feels tight, I worry that I could choke to death.	0	1	2	3	4
16. When I have trouble thinking clearly, I worry that there is something wrong with me.	0	1	2	3	4
17. I think it would be horrible for me to faint in public.	0	1	2	3	4
18. When my mind goes blank, I worry there is something terribly wrong with me.	0	1	2	3	4

Appendix B

Sample Medical History Sheet

Diagnostic Sleep Clinic Tel: 705-472-1967 Fax: 705-472-0689
104 – 60 Champlain St. North Bay Ontario P1B 7M4

Date: _____ Name _____ Sex ___ Age: DOB (D/M/Y):_____

Physician(s): _____ Health Card # : _____ exp date:_____

Height(cm):_____ Weight(kg):_____ BMI:_____ Neck(cm):_____ BP:_____

Social Hx(lives with/occupation /shift work):

Chief Complaint : (SOI/SMI/EDS/etc)	B.T	AM fatigue (# x/wk or mth)
	Rise	AM headache (# x/wk or mth)
	s.l.	Day Fatigue (# x/wk or mth)
	RLS	Napping (# x/wk or mth, # hrs)
	Restless	EDS (when/where)
Snoring	WU x	Cataplexy
Choking/Gasping/Wit.Apnea	Noct. x acc y/n	Sleep Paralysis
Supine/Rt Lt Side/Prone/Everywhere	B2S (s.l.)	Sl.onset/offset hallucinations

Clock watching	Medications (see reverse)
Night sweats	
Chest Pain	
Heartburn	
Wheezing	Head Injury
Coughing	Seizures
Bruxism (mouth guard?)	T & A
Nightmares/Acting out dreams	Migraine
Confusion	FMS/CFS
Sleep walking/talking/night terrors	Nasal Function
	Nasal surgery
	Thyroid
Depression	BP
Anxiety	DM
Irritability	Lipids
Memory	MI
	CHF
Weight Trend	CAD
Exercise	Stroke
	Other:
Coffee	
Tea	
Cola	
Energy Drinks	
Chocolate	
Smoking	
Alcohol/THC	Family Hx: Snoring/Apnea/EDS/RLS/Narcolepsy Father/Mother/Siblings/children/other

CPAP/BiPAP
Pressure:
Mask type and size:
Freq of use/Prob/leak/Dry mouth: Tech:_____

Medications

Medications taken today: (specify medications to help sleep with *)

Other medications: (when required/PRN, once a week, supplements, etc)

Medication allergies:

Appendix C

Demographic Information Form

Name (Please Print): _____

Gender: _____

Date of Birth: _____/_____/_____
(day) (month) (year)

Please answer the following questions to the best of your ability.

1. Have you consumed any caffeine **in the last 6 hours** (e.g. coffee, tea, cola, chocolate, and energy drinks)? ☐ Yes ☐ No

2. If you answered yes, please indicate how much and when each product was consumed in the table below. If you answered no, please skip to question 3.

Note: *One serving = 1 cup (or 250 ml); a large Tim Horton's coffee is 2 servings*

Product	**How much did you have?**	**At what time?** *(Approximately)*
Coffee		
Tea		
Cola (e.g. Coca-Cola, Pepsi, Dr. Pepper)		
Chocolate		
Energy Drinks (e.g. Red Bull, Monster, Rockstar, 5-hour Energy)		

3. Have you consumed any alcohol **in the last 6 hours?** ☐ Yes ☐ No

4. If you answered yes to question 3, please answer the following questions. If you answered no, please skip to question 7.

5. ***At approximately what time did you consume alcohol?*** *(e.g. 5:00 PM)*

_____

6. ***Approximately how much alcohol did you consume?*** *(e.g. 2 beers, one 6oz glass of wine)*

_____

7. Have you used any marijuana products **in the last 6 hours**? ☐ Yes ☐ No

8. If you answered yes to question 7, please answer the following questions. If you answered no, please skip to question 11.

9. ***At approximately what time did you use marijuana?*** *(e.g. 5:00 PM)*

_____

10. ***In what form did you use marijuana?*** *(e.g. edible, joint, etc.)*

_____

11. Have you used any opioid class drugs **in the past day**? (e.g. codeine, morphine, oxycodone, fentanyl, methadone, etc.) ☐ Yes ☐ No

12. ***If you answered yes, please indicate the dose you have taken below:***

_____

13. Are you currently taking any monoamine oxidase inhibitor (MAOI) class drugs? (e.g. Selegiline (Zelapar), Isocarboxazid (Marplan), Phenelzine (Nardil), Tranylcypromine (Parnate), etc.) ☐ Yes ☐ No

If you are unsure about whether or not you are taking any opioid or MAOI class drugs, you can simply list your current medications here:

PSYCHIATRIC HISTORY

14. Have you ever been diagnosed by a medical professional (e.g. family doctor, psychologist) with an **anxiety disorder**? ☐ Yes ☐ No

If you answered yes, please indicate the disorder:

_____

15. Have you ever been diagnosed by a medical professional (e.g. family doctor, psychologist) with a **mood disorder**? ☐ Yes ☐ No

If you answered yes, please indicate the disorder:

_____

16. Are you currently taking any SSRI class antidepressant medications? (e.g. Celexa (Citalopram), Escitalopram (Lexapro), Fluoxetine (Prozac), Sertraline (Zoloft), etc.)
☐ Yes ☐ No

If you are unsure about whether or not you are taking any SSRI class medications, you can simply list your current medications here:

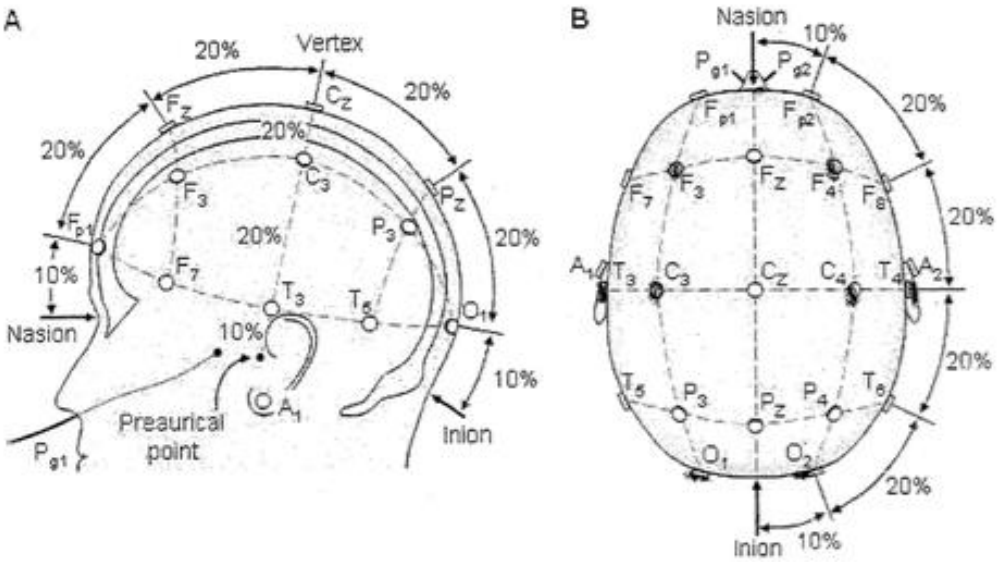
Appendix D

Electrode/Equipment Application Guidelines

EEG electrode placement: using a measuring tape and wax pencil or washable marker, measure head using the10-20 system.

EEG channels to be recorded are: C4M1, C3M2, O1M2, O2M1, F4M1, and F3M2

ELECTRODE PLACEMENT



Marking Cz, Oz, and Fpz(We do not use Cz or Oz to monitor)
After measuring the distance in centimeters from the Nasion to the Inion we wish to make a mark at the top of the head equal to 50% of the total distance (Cz). Then calculate and measure 10% of the distance from the Nasion to the Inion and make marks 10% above the Nasion (Fpz) and the Inion (Oz).

Verifying Cz
Measure in centimeters the distance from preauricular point on one side of the head to the preauricular point on the other side of the head, making sure the tape measure goes through the original mark made for Cz. Place another mark on top of the head that is exactly 50% of the total distance. This position is known as (Cz)and now has been marked from two planes (this verifies the site properly).
DO NOT ADD THIS LEAD

Marking C3 and C4
Now using the total distance measured (preauricular to preauricular), place the tape from Cz to the preauricular point and measure down 20% to mark C3 on the left side of the head and C4 on the right side of the head.

Verifying Oz
Measure the circumference of the head (start from Fpz), marking the 50% location at the back of the head as Oz narked from two planes verifying the site). ***DO NOT ADD THIS LEAD***

3

Marking O1 and O2
From the Oz location measure 5% of the patient's head circumference to the right and mark O2. Measure 5% from Oz to the left and mark O1. Make sure both marks are on the same horizontal plane.

Verifying C3 and C4
Measure from Fpz 5% to each side giving you Fp2 and Fp1. Now measure from Fp2 (right) and go to O2, marking at 50% of the distance the second mark for C4 (marked from two planes verifying the site). Do the same from Fp1 to O1 (left side) marking C3.

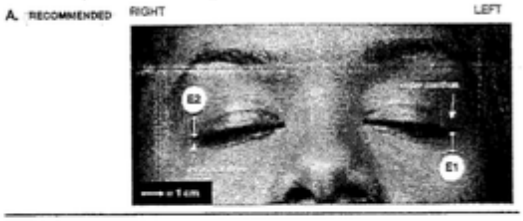
Marking F3 and F4
Measure from Fp2 to C4 (right side) marking 50% (or 25% of Fp2 to O2) for F4. Do the same from Fp1 to C3 (or Fp1 to O1) (left side) to find F3. This can be done quickly as you verify C3 and C4.

Verifying F3 and F4
Using the measuring tape, make a line from FpZ to C4 making an X where the tape crosses the F4 mark. Do the same from FpZ to C3 to verify F3

Placing M1 and M2 leads
M1 is referenced to C4, O2, F4 and REOG and is placed on the prominent bone behind the left ear. M2 is referenced to C3, O1, F3 and LEOG and is placed on the prominent bone behind the right ear.

Placing eye leads*(Derivations: E1-M2, E2-M2)*
The recommended EOG derivations and electrode positions are:(see Figure A)

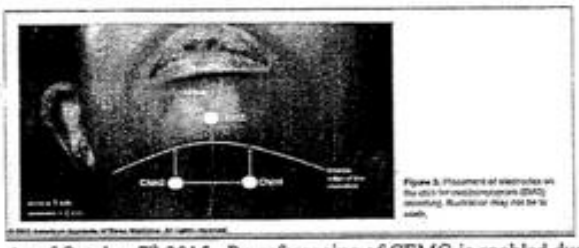
- *Electrode positions: E1 (LEOG) is placed 1 cm below the left outer canthus and E2 (REOG) is placed 1 cm above the right outer canthus*
- *(Pediatric is placed +/- 0.5cm instead of +/- 1cm)*



Placing chin electrodes
Three electrodes should be placed to record chin EMG:

- One in the midline 1 cm above the inferior edge of the mandible (see ChinZ in Figure 3)
- One 2 cm below the inferior edge of the mandible and 2 cm to the right of the midline (see Chin2 in Figure 3)
- One 2 cm below the inferior edge of the mandible and 2 cm to the left of the midline (see Chin1 in Figure 3)
- (Pediatric would be +/- ≈1cm)

The standard chin EMG derivation consists of either of the electrodes below the mandible referred to the electrode above the mandible. The other inferior electrode is a backup electrode to allow for continued display of EMG activity if one of the primary electrodes malfunctions.



As of October 7th 2015: Re-referencing of CEMG is enabled during acquisition (was originally disabled during installation of Alice 6).

Placing leg electrodes

The electrodes should be placed on the belly of the anterior tibialis muscle (you can feel it by asking them to move their foot up and down). The leads should be spaced 2-4 cm apart, located away from any bone and in a straight line. We use special leg EMG tabs (or ECG tabs). The prep sites should be small and separate to avoid forming a salt bridge, the flow of electrical current between the two electrodes. This occurs when two electrodes occupy the same prep site.

Placing ECG leads

Place a right and left lead (subclavicular electrodes) below the midpoint of the clavicle. The leads are indicated on the headbox. The third lead (mid-thorax electrode) is placed in the 8thintercostals space below the midpoint of the clavicle. This is standard lead I position. If hair is present on chest it must be removed with a razor prior to electrode application.

Application of leads:

- Vigorously rub all sites with a cotton tipped applicator soaked in nuprep prior to electrode application; wipe all sites with an alcohol swab and wipe away any remaining residue with a facial tissue.
- Fill electrode cups with elefix cream just prior to applying the leads.
- For C4, C3, F3, F4, O1 and O2 leads place the electrode on the prepared site with slight pressure to expel air and apply prepared gauze on top (with a layer of elefix spread evenly across surface of the gauze). Then rub gauze while keeping electrode in place to ensure the electrode stays on all night.
- Pieces of hypafix tape are used to secure Fpz (ground), REOG, LEOG, chin EMG (in case of facial hair gauze may be used), M1 and M2 leads. ECG tabs are used to apply Leg EMG leads. Hair must be removed from leg lead sites with a razor before placement of electrodes.
- Ask patient to let you know when ready for bed. When the patient is ready for bed have them sit on the edge of the bed. Plug in the headbox.
- Start acquisition. The acquisition will not start unless the headbox is plugged in.
- To measure thoracic and abdominal effort, place one effort band around the chest, above the nipple line; similarly place the other band around the abdomen at the level of the diaphragm. Belts clips should be approximately 14 cm apart before attaching together. This ensures that the belt is adequately tight. If the THO signal is poor you may place this belt under the breast area.
- Place position sensor in the middle of the patient's chest on the thoracic effort band with Velcro.
- Place snore microphone to the right or left of the Adam's apple and secure with medipore tape.
- Place oximeter finger probe on middle finger on hand nearest to the edge of the bed. If patient has poor circulation a multi-site probe may be used on toes.
- Place Thermistor above patient's upper lip. Place oral/nasal pressure transducer in patient's nose and mouth, trimming where necessary for patient comfort. Insert the Transducer in Alice 6 pressure sensor A port. Secure both sensors with a piece of medipore on each side to secure to patient's cheeks.
- Ask the patient to lie down supine.

Appendix E

Recruitment Script

A graduate student at Laurentian University is conducting a sleep study under the supervision of faculty members at the university. They are looking for people between the ages of 25 and 60 to see how individual characteristics can affect sleep in individuals.

If you decide to participate, you will be asked to complete a couple of brief questionnaires that would take a total of approximately 5-10 minutes to complete. They would also require your permission to see your sleep study results.

If you are interested, I can provide you with a consent form with more detailed information. If you decide you would like to participate, you can sign the consent form and complete the questionnaires.

If you decide that you are not interested after reading the consent form, you can just leave the forms blank or return them to me. Your sleep study will not be affected in any way regardless of your participation.

Appendix F

Informed Consent Form

Study Title: Understanding how individual characteristics can affect sleep in individuals

Researchers: Victoria Steadman (MA student in Applied Psychology)
Dr. Chantal Arpin-Cribbie (Associate Professor, Department of Psychology)

The purpose of this study is to learn more about how individual characteristics can affect sleep in individuals. If you choose to participate, you will be asked to complete a basic demographic information form, which will ask a couple of questions about caffeine and substance use (e.g. alcohol, marijuana, etc.), as well as ask a few questions about your psychiatric history. In addition, you will be asked to answer a few questions about some experiences that people sometimes have. These forms should take approximately 5-10 minutes to finish. We will also be looking at information about your sleeping patterns from the medical history sheet that you have just completed with your technologist, and your sleep study results from tonight. You will not be required to do any additional medical procedures if you agree to participate.

Your technologist will then proceed with preparing you for your sleep study. As described to you by your technologist, they will apply electrodes to your scalp, your forehead, behind your ears, and near your temples. These electrodes will be held in place with a wax-like paste and a piece of gauze. These electrodes are designed to record your brain wave activity and eye movements. You will also have electrodes applied to your chin to detect muscle tone in your jaw. Sticky tabs will be applied to your shins to detect movements in your legs. A snore microphone will be placed on the side of your neck with a piece of medical tape to detect any snoring. You will also have sticky tabs applied near your collarbone and on the left side of your ribs to record your heart rhythm. You will have an oximeter probe on your finger so the technologist can keep an eye on your oxygen levels. A belt will be placed around your abdomen and around your chest to record your breathing patterns and to see what positions you are sleeping in. A small tube placed below your nose to record your breathing.

Your technologist will be continuously monitoring your sleep throughout the night and may enter the room to adjust the equipment if there are any malfunctions. Your technologist is available throughout the entire night should you require any assistance. Once your sleep study is complete, your technologist will safely remove all of the equipment. There is likely to be some EEG paste left in your hair or on your skin after the equipment is removed, but this can easily be washed off with soap or shampoo and warm water.

Are there any potential risks involved with participating in this study?

We do not expect this study to cause any harm. If answering any of the questions makes you feel uncomfortable and you feel like you would need help or would like to talk with someone, these are some free places you can contact:

Canadian Mental Health Association
(Toll Free): 1-866-345-0183
(W): http://cmha.ca/find-your-cmha

National and International Help Centers (in your area):
(W): http://www.iasp.info/resources/Crisis_Centres

A polysomnogram test (or sleep study) is considered the gold standard sleep assessment tool that is widely used across the world. It is a non-invasive test and there are no known potential risks. Very occasionally, some individuals will be sensitive to the products used and a minor skin reaction may occur. Should this be the case, please inform your technologist and they will adjust or remove the equipment, and you can follow-up with your personal health care provider if you decide it is necessary. Occasionally, participants will also find this equipment to be uncomfortable. If you experience any discomfort, please inform your technologist so they can assist with making you feel more comfortable.

All of your responses to the questionnaires and sleep study results will be kept confidential. Your personal information (i.e. name and date of birth) will be collected on the questionnaires in order to match them with your sleep study results. Once the information has been paired, your name and date of birth will be removed and will be replaced with a numbered ID code to remove your personal information from the data used in this research. Your identifying personal information will not be removed from the Diagnostic Sleep Clinic files. All identified data will be stored at the Diagnostic Sleep Clinic. It is up to you to decide whether or not you would like to participate in this study. If you decide to participate, you are able to stop or withdraw your information at any point in time without any penalty. The decision to not participate will not affect your sleep study.

By signing this document below, I am giving my consent to participate in a research study being conducted by researchers from Laurentian University. I am also giving my consent for the researchers to extract information from my medical history sheet and from my sleep study at the Diagnostic Sleep Clinic. Prior to signing, I assert that I had the opportunity to read this document completely and have received answers to any questions that I had pertaining to my participation.

_____
Name (Please Print)

_____
(Signature)

_____
(Date)

If you wish to receive a summary of the results once this study is complete, please provide your e-mail address below:

_____
(E-mail Address)

If you have any further questions about the study, the researchers' contact information is provided below. Your technologist can provide you with a photocopy of this form if you would like to keep one.

Victoria Steadman – vsteadman@laurentian.ca

Dr. Chantal Arpin-Cribbie – carpincribbie@laurentian.ca or (705) 675-1151 ext. 6702

If you have any questions concerning research ethics, you can contact the Ethics Officer at Laurentian University (Sudbury) at 1-800-461-4030 ext. 2435 or e-mail at ethics@laurentian.ca

Appendix G

Debriefing Sheet

Thank you for participating in our research study. The primary purpose of our research was to evaluate how self-reported anxiety may be linked to disrupted REM sleep. Specifically, we are interested in examining whether the presence of anxiety sensitivity can lead to fragmented rapid eye movement (REM) sleep. REM sleep is a unique stage of sleep in which we observe rapid eye movements, muscular paralysis, and vivid dreaming. This particular stage of sleep has been theorized to serve many adaptive functions in various domains such as learning- and memory-related processes, as well as emotion regulation.

Anxiety sensitivity is defined as a fear of the physiological sensations that are associated with anxiety (e.g. rapid heart rate, sweaty palms, dizziness, etc.) and how these might have physical, cognitive, or social consequences in one's life. For example, an individual who is high in anxiety sensitivity may be more likely to be extremely worried when they experience various physical sensations.

No research to date has examined how anxiety sensitivity can impact REM sleep. We hope to develop this research by examining this relationship in the current study. To do this, you were asked to complete the Anxiety Sensitivity Index 3 (ASI-3), the most widely used tool that is administered to assess anxiety sensitivity in individuals. The questions within the ASI-3 are divided into 3 sub-factors of anxiety sensitivity: physical concerns, cognitive concerns, and social concerns. This study will examine how lower and higher scores relate to the degree of REM sleep fragmentation (multiple awakenings during REM sleep).

We ask you please to not discuss any information regarding this study with any other patients at the sleep clinic, as they may also be participants in this research study. Knowledge of its purpose may have an impact on performance and our results.

If you have any further questions about your participation in this study, please contact Victoria Steadman (vsteadman@laurentian.ca). You may also contact the supervising researcher Dr. Chantal Arpin-Cribbie at carpincribbie@laurentian.ca or at (705) 675-1151 ext. 6702.

Thank you again for your time and participation,

Victoria Steadman

Appendix H

Scoring Worksheets

Diagnostic Sleep Clinic

Polysomnography Data

Recording Identification

Patient name:		**Acq:**	
First name:		**Type:**	
Sex:		**Started:**	
Birth date:		**Stopped:**	
Patient age:		**Duration:**	
Height:	cm	**Epworth:**	/ 24
Weight:	kgs	**Referring physician:**	
BMI:	kg/m^2	**Interpreting**	
Recording Tech:		**Scoring Tech:**	

Procedure

Polysomnography was conducted on the night of 23/06/2019. The following parameters were monitored: frontal, central and occipital EEG, electrooculogram (EOG), submentalis EMG, nasal and oral airflow, anterior tibialis EMG, body position and electrocardiogram. Additionally, thoracic and abdominal movements were recorded by inductance plethysmography. Oxygen saturation (SpO2) was monitored using a pulse oximeter. The tracing was scored using 30 second epochs. Hypopneas were scored per AASM definition VIII.4.B (3% desaturation).

Sleep Data

LIGHTS OFF (LO) : PM LIGHTS ON (LON) : AM

LATENCIES	From Lights Off (min)	DURATIONS			
Sleep Onset	min	Time in Bed:	min		
N1 :	min	Sleep Period Time:	min	Sleep Efficiency:	%
N2 :	min	Total Sleep Time:	min	WASO:	min
N3 :	min	SWS Time:	min	TWK Time (tot):	min
REM :	min	REM Time:	min	Inter-Sleep WK:	%
		NREM Time:	min	Stage Shifts:	

Sleep Stage Distribution

	Episodes (# of)	Duration (min)	TIB (%)	TST (%)
WK (SPT):				
WK (TIB) :				
REM:				
N1 :				
N2 :				
N3 :				

Oximetry Summary

Average SpO_2 (TST):	%	Total Sleep Time 90 - 100%:	min
Average SpO_2 (TIB):	%	Percent Sleep Time 90 - 100%	%
# Desaturations:		Total Sleep Time 80 - 89%:	0.00 min
Desaturation Index:	/hr	Percent Sleep Time 80 - 89%	0.00%
Min SpO_2 Value During TIB:	%	Total Sleep Time <88%:	0.00 min
Min SpO_2 value with resp.	**%**	Percent Sleep Time <88%	0.00%

Respiratory Data

	CA	OA	MA	Apnea	Hypop*	A+ H	RERA	Total
Number:	0	0	0	0			0	
Mean Dur : (sec)	0.0	0.0	0.0	0.0			0.0	
Max Dur (sec):	0.0	0.0	0.0	0.0			0.0	
Total Dur (min) :	0.0	0.0	0.0	0.0			0.0	
% of TST:	0.0	0.0	0.0	0.0			0.0	
Index (#/h TST) :	**0.0**	**0.0**	**0.0**	**0.0**			**0.0**	
REM Count:	0	0	0	0			0	
NREM Count:	0	0	0	0			0	
REM Index (#/h):	**0.0**	**0.0**	**0.0**	**0.0**			**0.0**	
NREM Index (#/h):	0.0	0.0	0.0	0.0			0.0	

*Above Index Values Based on Total Sleep Time ■ Hypopneas scored based on 3% or greater desaturation

Leg Movements Summary

	Count	Index (#/h)
Total Leg Movements:		
PLMS:	0	N/A
PLMS Arousals:	0	N/A

Arousal Summary

	REM	NREM	Arousals	Awakenings	Ar + Aw	Ar + Aw Index
Respiratory:						
Leg Movements:	0	0	0	0	0	0.0
Spontaneous:						
Total:						
Arousal Index:						

Events occurring during Wake are not included in the table above.

Body Position Summary

	Sleep (min)	TST (%)	REM (min)	NREM (min)	CA (#)	OA (#)	MA (#)	HYP (#)	AHI (#/h)	RERA (#)	RDI (#/h)	Desat (#)
Supine					**0**	**0**	**0**			**0**		
Non-Supine		0	0.00		0.00	0.00	0.00	0.00	0.00	0	0.00	
Left:	0.0	0.00	0.0	0.0	0	0	0	0	0.0	0	0.00	0
UP:			0.0	1.0	0	0	0	0	0.0	0	0.00	

DIAGNOSTIC SLEEP CLINIC 60 Champlain Street, NORTH BAY, Ontario, Canada P1B7M4 Tel: (705) 472-1967 Fax: (705) 472-0689

Definitions

Apnea And Hypopnea Index: (AHI) Total number of apneas + hypopneas / hour of sleep.

The AHI is categorized as mild (AHI 5-15), moderate (AHI 15-30) and severe (AHI >30) based on the current consensus of the American Academy of Sleep Medicine (Sleep 1999; 22:667-689).

Respiratory Disturbance Index: (RDI) Total number of apneas + hypopneas + respiratory event-related arousals / hour of sleep.

The RDI is categorized as mild (RDI -15), moderate (RDI 15-30) and severe (RDI >30) based on the current consensus of the American Academy of Sleep Medicine (Sleep 1991; 14:540-5).

Apnea: Cessation of airflow for 10 seconds or longer.

Hypopnea: Decrease in airflow for 10 seconds or longer associated with decrease in SpO_2 by more than 3% and/or arousal from sleep.

Respiratory Event-Related Arousal: (RERA) Increase in respiratory effort or flattening of the inspiratory portion of the nasal pressure or PAP device flow waveform lasting 10 seconds or longer, leading to arousal from sleep when the sequence of breaths does not meet criteria for an apnea or hypopnea.

Index: Number of events per hour.

Periodic Limb Movement Index (PLMI) **Mild** = Index 5-25, **Moderate** = Index 26-50, **Severe** = Index >50 or PLM arousal index of >25/h.

International classification of sleep disorders, revised: diagnostic and coding manual. Rochester, MN: American Sleep Disorders Association, 1997

Arousal or Microarousal: Lightening of sleep for more than 3 seconds.
Arousal Index: Number of arousal per hour.
Time In Bed (TIB): Time from lights off till lights on.
Sleep Period Time (SPT): Sleep onset to last minute of sleep.
Total Sleep Time (TST): REM + NREM + Movement Time.
REM Sleep: Rapid Eye Movement Sleep.
NREM Sleep: Non Rapid Eye Movement Sleep (stages 1 + 2 + 3 + 4 sleep).
Delta Sleep: Stage 3 + 4 sleep. Also called deep sleep or slow wave sleep.
Sleep Efficiency: 100 x TST/TIB. Should be greater than 90%.
Sleep Latency: Time from the start of study to the first epoch (30 seconds) of sleep.
REM latency: Time from sleep onset to REM sleep onset.
CPAP: Continuous Positive Airway Pressure.
BiPAP: Bi-level Positive Airway Pressure.

DIAGNOSTIC SLEEP CLINIC 60 Champlain Street, NORTH BAY, Ontario, Canada P1B7M4 Tel: (705) 472-1967 Fax: (705) 472-0689

Normative Data for Sleep in Adults

Normal sleep latency 10 to 20 minutes

Normal REM latency is greater than 70 minutes.

Tables 1 and 2 below are summary data from one example of referential normal values, full data sets available in *The effects of age and ethnicity and sleep-disordered breathing on sleep architecture. Redline S, KirscherHL, Quan SF, et al. Arch Intern Med 2004; 164:406-418.*
Table 3 is Ontogency of Sleep Stage Percentage taken from: *EEG of Human Sleep: Clinical Applications by R.L. Williams, I.Karacan, and C.J. Hursch.*

Table 1: Sleep efficiency based on age

Age	Efficiency
37-54	85.7 (±8.3)
55-60	83.3 (±8.9)
61-70	80.6 (±11.7)
>70	79.2 (±10.1)

Table 2: Arousal index based on age

Age	Arousal Index
37-54	16.0 (±8.2)
55-60	18.4 (±10)
61-70	20.3 (±10.5)
>70	21.0 (±11.6)

Table 3: Sleep architecture based on age

Percentage of Each Sleep Stage for Different Age Groups*

	Ages 3-5	Ages 6-9	Ages 10-12	Ages 13-15	Ages 16-19	Ages 20-29	Ages 30-39	Ages 40-49	Ages 50-59	Ages 60-69	Ages 70-79
Wake	**0.88** 1.66	**0.27** 0.7	**1.55** 1.32	**1.1** 1.01	**1.87** 1.28	**1.26** 0.53	**1.47** 1.84	**6.29** 1.63	**4.33** 4.95	**7.73** 8.93	**16** 11.69
Stage 1	**1.94** 2.3	**2.3** 2.3	**3.65** 2.28	**4.25** 3.01	**4.2** 3.74	**4.44** 4.18	**5.71** 4.17	**7.56** 5.64	**7.56** 4.85	**9.73** 7.69	**9.47** 6.59
Stage 2	**48.12** 41.98	**47.95** 47.88	**46.16** 49.36	**44** 48.66	**49.05** 49.43	**45.54** 52.37	**56.89** 53.77	**54.75** 54.01	**61.71** 57.8	**56.79** 54.78	**55.59** 52.22
Stage 3	**2.59** 3.4	**3.6** 3.13	**5.24** 2.95	**5.53** 5.2	**5.76** 5.65	**6.21** 5.27	**5.67** 6.42	**5.37** 7.51	**3.23** 6.49	**2.06** 4.5	**1.36** 6.3
Stage 4	**16.21** 18.91	**18.55** 16.68	**17.01** 16.66	**18.42** 16.49	**17.28** 17.78	**14.55** 12.42	**6.79** 7.58	**3.18** 4.564	**1.69** 4.14	**0.6** 2.67	**0** 3.74
REM	**30.26** 31.75	**27.33** 29.31	**26.39** 27.43	**26.7** 25.63	**22.02** 22.12	**28** 23.52	**23.47** 26.22	**22.85** 26.67	**21.48** 21.77	**23.09** 21.43	**17.68** 19.46

***MALE**
FEMALE

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Appendix I

Reason for Referral Categories

Reason for Referral	*n*	*%*
Physiological Sleep Symptoms	203	93.1
Snoring	38	18.7
Witnessed Apnea	10	4.9
Positive Stop-Bang Score	1	.5
Daytime Fatigue	37	18.2
Non-Refreshing Sleep	27	13.3
Morning Headaches	15	7.4
Napping	17	8.4
Kicking/Moving at Night	18	8.9
Fragmented Sleep	19	9.3
Choking/Gasping at Night	15	7.4
Restless Legs Syndrome	1	.5
Previous Sleep Apnea Diagnosis	5	2.5
Psychological Symptoms	3	1.4
Anxiety	1	33.3
PTSD/Nightmares	1	33.3
Insomnia	1	33.3
Cardiac Risk Factors	5	2.3
Hypertension	2	40
New Onset Atrial Fibrillation	1	20
Tachycardia	1	20
Arrhythmia	1	20
Other	7	3.2
Epilepsy	1	14.3
Grave's Disease	1	14.3
Polycythemia/High Hematocrit	1	14.3
Facial Trauma	1	14.3
Pregnancy	1	14.3
Miscarriage	1	14.3
Bariatric Surgery Referral/Obesity	1	14.3

Note. Overall $N = 56$. PTSD = Post-Traumatic Stress Disorder. Please note that for some participants, the referral included more than one reason/symptom from different categories presented.

Appendix J

Operational Definitions for REM Sleep Fragmentation Outcomes

Outcome Variable	Operational Definition
Total Arousals REM	The total number (frequency) of arousals observed across the entire REM sleep cycle.
Spontaneous Arousals REM	The number (frequency) of spontaneous arousals observed across the entire REM sleep cycle. Spontaneous arousals are sudden awakenings that are not related to snoring, limb movements, or respirations.
Arousal Index (AI) REM	The average number of arousals observed per hour across all REM sleep episodes.
Percentage of Time Spent in Spontaneous Arousals REM	The sum of time spent in spontaneous arousals across all REM sleep episodes divided by the total duration of all REM sleep episodes x 100.

Note. REM = rapid eye movement. The AASM scoring manual objectively defines an arousal in REM sleep as "an abrupt shift of EEG frequency including alpha, theta, and/or frequencies greater than 16Hz (but not spindles) that lasts at least 3 seconds, with at least 10 seconds of stable sleep preceding the change. A concurrent increase in submental EMG lasting at least 1 second [is also required]" (Berry et al., 2016).