2018

THE ROLE OF COUPLE SLEEP CONCORDANCE IN SUBJECTIVE SLEEP QUALITY: ATTACHMENT AS A MODERATOR OF ASSOCIATIONS

Taylor L. Elsey
University of Kentucky, tlel223@g.uky.edu
Digital Object Identifier: https://doi.org/10.13023/ETD.2018.071

STUDENT AGREEMENT:

I represent that my thesis or dissertation and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained needed written permission statement(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine) which will be submitted to UKnowledge as Additional File.

I hereby grant to The University of Kentucky and its agents the irrevocable, non-exclusive, and royalty-free license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless an embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

REVIEW, APPROVAL AND ACCEPTANCE

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's thesis including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Taylor L. Elsey, Student

Dr. Peggy S. Keller, Major Professor

Dr. Mark Fillmore, Director of Graduate Studies

THE ROLE OF COUPLE SLEEP CONCORDANCE IN SUBJECTIVE SLEEP QUALITY: ATTACHMENT AS A MODERATOR OF ASSOCIATIONS

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Arts and Sciences at the University of Kentucky

By

Taylor L Elsey

Lexington, KY

Director: Dr. Peggy S Keller, Professor of Psychology

Lexington, KY

2018

ABSTRACT OF THESIS

THE ROLE OF COUPLE SLEEP CONCORDANCE IN SUBJECTIVE SLEEP QUALITY: ATTACHMENT AS A MODERATOR OF ASSOCIATIONS

Sleep is not a solitary activity for the majority of adults, this impacts sleep quality, health, and well-being. Couples experience sleep concordance, or a synchronization of sleep-wake times, which can improve and diminish sleep quality (Gunn et al., 2015). This study explores the association between sleep concordance and sleep quality by examining attachment style as a moderator. Daily sleep diaries were completed by 179 heterosexual couples. Sleep concordance was calculated by dividing total time partners were in bed together by total time at least one partner was in bed each day. Data were analyzed using a multilevel model described by Bolger and Laurenceau (2013). There was a positive association between daily sleep concordance and sleep quality for men. Women with higher secure attachment style scores reported greater sleep quality, and women with higher insecure attachment style scores reported lower sleep quality. Among women with higher secure attachment style scores and lower avoidant attachment style scores there was a negative association between mean sleep concordance and sleep quality. There was no association between sleep concordance and sleep quality for higher anxious attachment scores. Future research is needed to address causal relationships. Findings indicate men and women may experience sleep concordance differently.

KEYWORDS: sleep concordance, subjective sleep quality, attachment style, romantic relationships

Taylor L Elsey
Signature

March 26, 2018
Date

THE ROLE OF COUPLE SLEEP CONCORDANCE
IN SUBJECTIVE SLEEP QUALITY:
ATTACHMENT AS A MODERATOR OF ASSOCIATIONS

By

Taylor L Elsey

________Dr. Peggy S Keller________
Director of Thesis

________Dr. Mark Fillmore________
Director of Graduate Studies

_________March 26, 2018_________
Date

For my Orbit

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The majority of adults spend most of their nights sleeping beside their partner. Recent research on couple sleep has highlighted the impact one partner can have on another partner's sleep and ultimately their health and well-being (Gunn et al. 2016; Troxel et al., 2016; Gunn et al. 2015; Rosenblatt, 2012). The current study examined sleep concordance, specifically the percentage of time partners spend in bed together out of their total time in bed, as a predictor of subjective sleep quality. Research suggests that greater sleep concordance will be associated with greater subjective sleep quality for couples (Richter et al., 2016). However, sleep concordance may not affect everyone in the same way. This study investigates attachment style as a moderator of the association between sleep concordance and sleep quality. First, sleep science is reviewed, with special focus on the importance of sleep for human functioning and health, the importance of subjective measures of sleep quality, and recent research on the social aspects of sleep. Next is a review of attachment theory, including research on infancy through adulthood, then the current study is described. Ultimately, understanding the way humans experience sleep together is an essential piece to understanding the impact sleep has on our daily lives, health, and welfare.

Sleep Science

Basic Sleep Physiology

Sleep is a great enigma of science. Every species for which sleep has been studied has been observed to sleep, or enter a sleep-like state, even bacteria (Nicolau et al., 2000). Children spend more than half of their development asleep (Mindell, Meltzer, Carskadon & Chervin, 2009), and a third of our lifetime will be spent sleeping (Sejnowski &

Destexhe, 2000). If we go without sleep for too long, we die (Rechtschaffen, Gilliland, Bergmann & Winter, 1983). Sleep is obviously extremely important, but how does it work? While we sleep, our brains go through a cyclical series of stages comprised of two main parts: Non-Rapid Eye Movement (NREM) and Rapid Eye Movement (REM) sleep (Dement & Kleitman, 1957). According to the National Sleep Foundation (Phillips & Gelula, 2006), the beginning of the sleep cycle, stage 1, is the lightest stage, during which eye movements slow down and our brains produce theta and alpha waves, initiating the transition to sleep. Stage 2 takes up about 50% of our total sleep time. Throughout this stage, eye movements come to a stop, breathing and brain waves slow down, and occasional increases in rapid brain waves, known as sleep spindles, occur. Stage 3 is when our brains begin to produce slow delta waves, stopping eye and muscle movements, and making it very difficult to wake up. During stage 4, our brains almost exclusively produce delta waves. This slow wave or deep sleep in stages 3 and 4 is the most restorative sleep of the cycle. In the first cycle of sleep we spend about 45-90 minutes in stages 3 and 4, and as the night goes on, the time in these stages gets shorter. About 90 minutes after falling asleep we enter REM sleep. During REM sleep, our brains become active and this is where most dreaming occurs. Eyes rapidly move back and forth, heart rate and blood pressure see a spike, muscles become temporarily paralyzed, and breathing becomes sporadic. Regions of our brain associated with emotion regulation and expression experience a significant increase in activity, similar to waking levels (Aserinsky & Kleitman, 1953). This is when our brains store and process emotional information from daily life into long term memory (Palmer & Alfano, 2017; Goldstein & Walker, 2015; Hobson & Pace-Schott, 2002). On average, we go through 5 or 6 REM stages a night lasting around an hour each, with the first REM cycle lasting the shortest amount of time, and the other REM periods getting longer as deep sleep periods get shorter (Phillips & Gelula, 2006).

The National Sleep Foundation reports that adults should sleep for seven to nine hours per night (Phillips & Gelula, 2006). The National Health Interview Survey (Luckhaupt, Tak & Calvert, 2010) however found that almost half of adults slept less, indicating inadequate sleep. Inadequate sleep can take the form of total sleep deprivation (i.e. total loss of sleep for a specific period of time), sleep restriction (i.e. decreased sleep within a specific period of time), and sleep fragmentation (i.e. disrupted sleep during a specific period of time; Womack, Hook, Reyna & Ramos, 2013). Total sleep deprivation is typically studied by bringing participants into a sleep laboratory, while sleep restriction and fragmentation can be studied in more natural settings. Sleep is often assessed using polysomnograms, which include electrodes to measure brain waves, oxygen in the blood, heart rate, breathing, eye movements, and muscle movements during sleep. Sleep can also be assessed at home via activity measures (e.g. actigraphs), or self-report measures (e.g. questionnaires, sleep diaries; Brown, 2008). Sleep disorders and age are common reasons for sleep restriction and/or sleep fragmentation. As we get older, stages 3 and 4 of sleep become shorter and eventually stop entirely, meaning we experience less restorative sleep as we age. A person may be diagnosed with a sleep disorder if they experience difficulties with their ability to fall asleep, stay asleep, or wake from sleep.

Sleep Disorders

According to the National Sleep Foundation (Phillips & Gelula, 2006) it is estimated that sleep disorders cost Americans over $100 billion annually due to less productivity, medical costs, sick days, and damage to property or the environment. The DSM-V (American Psychiatric Association, 2013) describes two types of sleep disorders: dyssomnias and parasomnias. Dyssomnias have to do with problems falling/staying asleep, and excessive sleepiness. They include insomnia, hypersomnolence, narcolepsy, circadian rhythm sleep disorder, and breathing related sleep disorders. Insomnia disorder is characterized by failure to achieve a restful night's sleep, and about 75 million American adults indicate that they experience insomnia (Pagel & Kram, 2010). This could be from problems falling asleep, going back to sleep, waking too early, or not achieving restful sleep. Insomnia may be caused by hyperarousal of the sympathetic nervous system, and it has successfully been treated by both pharmacological and nonpharmacological therapies (Wetter, Beitinger, Beitinger & Wollweber, 2010). Hypersomnolence disorder on the other hand, is when a person is getting an adequate amount of sleep, but continues to suffer from excessive sleepiness that negatively impacts their daily functioning. More dangerously, people diagnosed with narcolepsy experience two to six episodes of uncontrollable restful sleep a day, during which cataplexy, or temporary muscle paralysis, occurs (American Psychiatric Association, 2013). This means that people unpredictably fall asleep whether they're in a safe place or not. Narcolepsy is thought to be acquired by some environmental stressors that cause functional changes in the central nervous system (Wetter et al., 2010). Circadian rhythm sleep disorder is different from other dyssomnias, in that problems are due to environmental changes instead of internal dysfunctions. These environmental changes (e.g. travel/jet lag, shift work, time changes) cause disturbances in sleep due to the person's circadian rhythm being out of sync with their environment, and can be episodic, recurrent, or persistent (American Psychiatric Association, 2013).

There are three main types of breathing related sleep disorders, where physical abnormalities cause disruptions during sleep (American Psychiatric Association, 2013). The most common of these is obstructive sleep apnea (OSA), where the anatomy of the upper airway creates an obstruction causing breathing to stop. A diagnosis of sleep apnea involves at least 15 of these respiratory events per hour. Obesity is often a cause of OSA, as the loss of muscle tone in the neck during sleep leads to airway collapse due to the weight of the neck (Gami, Caples & Somers, 2003). The primary treatment for OSA is continuous positive airway pressure (CPAP) administered through a mask that is worn while sleeping. Tonsils can also cause OSA and removal of tonsils is a common treatment approach for children (Brouillette, Fernbach & Hunt, 1982). In central sleep apnea (CSA), the brain stops transmitting signals to the muscles that allow you to breathe, bringing breathing to a stop (American Psychiatric Association, 2013). A CPAP may help with CSA. However, the cause is commonly due to an existing condition or severe illness, and treatment of that condition/illness is often the best treatment for CSA. The final breathing related sleep disorder is a mix of OSA and CSA. Diagnosing the correct type of breathing related disorder is essential to implementing the correct treatment (American Psychiatric Association, 2013).

Parasomnias have to do with problems in control over physiological systems or behavior during sleep (American Psychiatric Association, 2013). They include nightmare disorder, NREM sleep arousal disorder, REM sleep behavior disorder, and restless leg syndrome. Nightmare disorder is when a person has severe fear or anxiety over frightening dreams that repeatedly occur throughout sleep, causing them to wake fully alert. People with NREM sleep arousal disorders experience partial arousal during sleep. This can be in the form of sleep terrors or sleepwalking. People who have sleep terrors wake suddenly from sleep, generally screaming or crying from fear, without memory of the event that caused them to wake. Sleepwalking is characterized by recurring complex motor behavior while asleep. During these episodes, people are generally unresponsive to communication efforts by others, and upon waking, they may experience confusion and disorientation, rarely remembering the events that occurred. REM sleep behavior disorder is when a person does not experience the temporary muscle paralysis associated with REM sleep. This can result in small, to more complex movements that may cause injury to oneself or one's sleeping partner. Restless leg syndrome is one of the most common sleep movement disorders, and is a complex genetic disorder with heredity estimates of about 50% (Wetter et al., 2010). It causes uncomfortable feelings in a person's legs, that create strong urges for movement, which make it difficult for them to fall asleep (American Psychiatric Association, 2013).

Sleep and Daytime Functioning

Sleep gives our body and our brain an opportunity to rest and restore and has an enormous impact on daytime functioning. Sleep is inextricably interlinked with emotion, behavior, and cognition (Beattie, Simon, Espie & Biello, 2015; Goldstein & Walker, 2015; Tempesta et al., 2010; Banks & Dinges, 2007; Harrison & Horne, 2000; Dinges et al., 1997). Indeed, almost all mood, anxiety, and addiction disorders occur alongside at least one sleep abnormality and many include these abnormalities as criteria for diagnosis (Goldstein & Walker, 2015). Suicidal thoughts and behaviors closely coincide with sleep complaints and one of the top 10 warning signs of suicide is alterations in sleep (Joiner, 2007). Emotional encounters pose a much larger challenge when sleep is inadequate (For a review see: Palmer & Alfano, 2017; Beattie et al., 2015; Goldstein & Walker, 2015; Kahn, Sheppes & Sadeh, 2013). For example, sleep restriction (i.e. greater than 24h sleep loss) is associated with reduced emotion recognition, higher emotional reactivity, and less emotional expressiveness (Palmer & Alfano, 2017). Inadequate sleep is associated with greater negative affect, irritability, and stress (Goldstein & Walker, 2015). Even during low-stress situations (i.e. low difficulty cognitive tasks with less time restraints and more performance feedback) participants reported greater stress, anxiety, and anger after a night of total sleep deprivation (Minkel et al., 2012). Inadequate sleep decreases the chance of being in a positive emotional mindset and reduces the outward expression of positive emotions (Palmer & Alfano, 2017; Beattie, Simon, Espie & Biello, 2015; Kahn, Sheppes & Sadeh, 2013; Minkel et al., 2012).

Sleep loss negatively influences behavior during social interactions by heightening impulsive reactions, especially to negative emotions. For example, one night of total sleep deprivation caused participants to quickly react to negative stimuli (i.e. negative emotional words in a go/nogo task; Anderson & Platten, 2011). Further, total sleep deprivation is associated with maladaptive fear responses, risk taking behaviors, and a tendency to overvalue rewards and undervalue losses (Goldstein & Walker, 2015; Womack et al., 2013). Cognitively, inadequate sleep negatively impacts attention, concentration, productivity, impulse control, decision making ability, and working memory (Palmer & Alfano, 2017; Womack et al., 2013; Harrison & Horne, 2000; Dinges et al., 1997). People have trouble delaying gratification (Killgore et al., 2008) and are more willing give up large rewards, in favor of smaller ones involving less energy, following a night of total sleep deprivation (Libedinsky et al., 2013). For example, when people report being sleepy, they are more likely to prefer high calorie foods, and are more inclined to overeat (Killgore et al., 2013). Sleep is a complex activity deeply intertwined with health, emotion, behavior, and cognition; thus, the way sleep quality is defined and measured is also complex and important.

Sleep Quality

The current study will focus on subjective sleep quality, an important aspect of sleep that plays an equally important role in daily functioning and health. Subjective sleep quality refers to the subjective feeling of how well one slept and how rested one feels. It is typically measured in terms of ease of waking, alertness on waking, and feeling rested and refreshed on waking (Harvey et al., 2008; Argyropoulos et al., 2003; Pilcher, Ginter & Sadowsky, 1997). It has been linked to physical and mental health, affect, emotion regulation, psychological well-being, cognitive performance and life satisfaction (Tavernier & Willoughby, 2015; Lemola & Richter, 2013; Bastien et al., 2003; Moore, Adler, Williams & Jackson, 2002; Pilcher & Ott, 1998). Self-reported poorer sleep quality is associated with lower subjective well-being, greater negative affect and more mood disturbances (Lemola, Ledermann & Friedman, 2013). Regestein and colleagues (2004) found that low self-reported sleep quality was associated with trouble concentrating, and being more tired, clumsy and irritable the following day. Additionally, self-reported poor sleep quality was strongly associated with psychological and somatic distress, and cognitive impairment, even when actigraphy indicated good sleep. Meaning, these associations were stronger for subjective measures of sleep quality than for objective measures.

Research on the link between objectively measured sleep and subjectively measured sleep has been mixed (Argyropoulos et al., 2003). Some studies found an association between objective and subjective sleep measures (Lemola, Ledermann & Friedman, 2013; Vitiello, Larsen & Moe, 2004; Åkerstedt, Hume, Minors & Waterhouse, 1994) while others have found no association (Regestein et al., 2004; Jean-Louis, Kripke & Ancoli-Israel, 2000). In clinical practice, patients commonly complain of poor sleep despite no abnormal polysomnographic readings (Argyropoulos et al., 2003). Importantly, discrepancies between subjective estimates of sleep and objective measures of sleep are generally in sleep onset latency and the number of wake episodes during the night (Baker, Maloney & Driver, 1999). People can accurately recall their total sleep time but have trouble recounting their number of awakenings at night (Argyropoulos et al., 2003). Subjective sleep quality measures predicted physical health, mental health, affect, psychological well-being, life satisfaction, sleepiness, and functioning on waking better than subjective sleep quantity measures (Pilcher, 2000; Pilcher, Ginter & Sadowsky, 1997). Additionally, subjective measures of sleep may be just as impactful on depression as objective measures (Mayers, Grabau, Campbell & Baldwin, 2009). Regardless of objective sleep quality, it is apparent that subjective sleep quality plays a role in daily life and health (Pilcher, Ginter & Sadowsky, 1997). It is important because sleep needs vary across persons, and subjective measures give insight into a person's perception of their sleep, depending on their own individual needs (Baker, Maloney & Driver, 1999). Additionally, it may indicate cognitive impairment, health problems, and psychological or somatic distress where objective measures of sleep do not (Regestein et al., 2004; Bastien et al., 2003; Pilcher, 2000; Pilcher, Ginter & Sadowsky, 1997).

Social Aspects of Sleep

Although sleep, a solitary activity, is often studied at the individual level, the majority of adults (approximately 70% of American adults; National Sleep Foundation, 2011) sleep beside a romantic partner (Troxel, Robles, Hall & Buysse, 2007). According to *At Day's Close: Night in Times Past* (Ekirch, 2006), historically, co-sleeping was thought to have been incentivized through the benefits of warmth, comfort and security in the darkness of night. Women in particular felt that co-sleeping helped ensure survival (Rosenblatt, 2012). Sleep is a vulnerable state that is antithetical to vigilance (Dahl, 1996; Troxel, 2010). While asleep, persons are unaware of the presence of predators, thieves, and dangerous changes in the environment. Thus, people need to feel safe in order to relax enough to fall asleep. Romantic partners can operate as stress-buffers, reducing psychological and physiological arousal before sleep (Troxel, 2010). Sleeping beside a partner increases feelings of security and comfort, making sleep onset easier, and allowing for sounder sleep (Troxel, Buysse, Hall & Matthews, 2009).

For couples, sleeping together is about more than just sleep. Sleeping beside a partner promotes intimacy, attachment, and closeness, possibly through the neurohormone oxytocin (Troxel, 2010). Sometimes referred to as the social or love hormone, oxytocin is crucial for maternal and social bonds/attachments throughout the lifespan (see MacDonald & MacDonald, 2009 for a review). Produced by the paraventricular nucleus of the hypothalamus, an area central to regulation and arousal during sleep, oxytocin works in two ways (Troxel, 2010; Lancel, Kromer & Neumann, 2003). It can be secreted by the pituitary into the blood and act as a peripheral (i.e. outside the central nervous system) hormone. It can also act as a neurotransmitter, interacting with oxytocin receptors in different areas of the brain and spinal cord to influence behavior (MacDonald & MacDonald, 2009). The oxytocin that is released at bedtime to initiate sleep attenuates stress, and works as a reward system reinforcing attachment behaviors (Gunn et al., 2016; Troxel, 2010; Sbarra & Hazan, 2008). For many couples, the majority of their time together is spent in bed, due to the busyness of life (Rosenblatt, 2012). It becomes a time for relationship maintenance and renewal. In fact, the bed may be the only place couples can meet essential physical intimacy needs such as cuddling, holding each other, touching, and sexual intercourse. It is here that they foster a close, loving, familiar companionship through conversations about personal issues, and physical intimacy. The shared bed can act as a nest where people fall into a routine, forget about dangers, and feel safe, secure, and comforted enough to fall asleep (Rosenblatt, 2012).

Sleep is a partially socially regulated behavior. Often without even noticing, couples who sleep together construct hundreds of rules regarding sleep created from societal norms, their own personal histories, and their couple dynamic (Schwartz, 1970). They must continue to learn to sleep together, acknowledging and addressing differences, adapting to changes, and accommodating each other's bed sharing needs throughout the relationship (see Rosenblatt, 2012 for a review). Bed sharing is often wrought with struggle, problem-solving, and compromise. Together, partners must make decisions about the environment of the bed itself (e.g. size, firmness, bedding, when and how it should be made, temperature), how space will be shared in bed (e.g. who sleeps on what side, territory in bed, allowing children in the bed) and what behaviors are acceptable in bed (e.g. talking, touching, what to wear, if the bed is made). Additionally, they need to navigate the initiation to bedtime (e.g. is it a set time, who will initiate, do both partners go at the same time), and necessary tasks to be completed before bed (e.g. who turns off the lights, who sets the alarms, who checks security). During sleep, they negotiate tossing and turning, bathroom breaks, snoring, sleep talking, grinding/clenching teeth, and the various sleep disorders mentioned above. One partner may be a morning person and the other a night owl, one may be a light sleeper and the other a hard sleeper. One person can develop sleep problems due to the sleep problems of their partner. Certainly, partners have to power to help or impede sleep. In order to have a successful long-term relationship, partners must learn to accommodate and tolerate one another, and this is no different in bed (Rosenblatt, 2012). Thus, understanding the shared bed experience is essential to understanding intimate relationships.

Sleep Concordance

The timing, movements and physiological effects of physically sleeping beside a partner play a critical role in sleep quality (Gunn et al., 2016; Meadows et al., 2005). Consistent with research on the biological interdependence of couples (Liu, Rovine, Klein & Almeida, 2013; Saxbe & Repetti, 2010), romantic partners experience coregulation, or a “reciprocally maintained physiological process that serves to maintain psychological and biological homeostasis of individuals in a relationship” (Gunn et al., 2015, p. 933; Sbarra & Hazan, 2008). One aspect of this coregulation is sleep concordance (Adams & Cromwell, 1978), and recent studies have started focusing on the interdependence of couple sleep (Troxel, Braithwaite, Sandberg & Holt-Lunstad, 2016;

Gunn et al., 2015; Meadows et al., 2009). There are two main measures of sleep concordance: overall synchronicity in movements throughout the night, generally measured objectively, and overlap in actual sleep-wake times, often measured subjectively (Gunn et al., 2015). The current study will focus on overlap in sleep-wake times as the measure of sleep concordance.

Couples have a greater amount of coregulation in their sleep-wake times than randomly matched pairs (Spiegelhalder et al., 2016). In one study that measured couple sleep using actigraphy, they found that partners go to sleep and wake up at approximately the same time (Gunn et al., 2016; Gunn et al., 2015). People who typically sleep with their partner have significantly longer sleep times, and earlier bed times than those who typically sleep apart (Pankhurst & Horne, 1994). Although partners' preferred bedtimes often do not match, the variance in their actual bedtimes, sleep latency, and wake episodes are best explained at the couple level (Meadows et al., 2009). Additionally, concordance in sleep-wake times is not associated with individual morningness/eveningness preference (Gunn et al., 2015). Taken together, this suggests that members of co-sleeping couples may alter their actual bed times to be earlier, despite their preference, in order to match their partner. This concordance in sleep-wake times may contribute to longer total sleep time (Meadows et al., 2009).

Couples also experience concordance in movements and wake episodes while co-sleeping (Meadows et al., 2009). Around one-third of movements while sleeping with a partner are shared, and people who sleep alone have significantly less movements during the night than those sleeping with their partner (Pankhurst & Horne, 1994). Although couples prefer to sleep together, objective measures of sleep via actigraphs revealed worse sleep when sleeping with partners compared to alone (Pankhurst & Horne, 1994). One study however, found that most couples do not notice the concordance of their movements during sleep (Meadows et al., 2009). Specifically, despite the negative impact objectively (i.e. increased number of movements during sleep), participants rated sleep as subjectively better when sleeping with their partner compared to alone. Many couples report difficulty sleeping separately (Rosenblatt, 2012). Recently, a study found that men and women have greater subjective *and* objective sleep quality when sleeping together (Spiegelhalder et al., 2016). Overall, research shows that when co-sleeping, partners report higher subjective sleep quality, whether or not measures of objective sleep quality are higher (Richter et al., 2016). Thus, it is hypothesized that greater sleep-wake concordance (i.e. overlap in sleep-wake times), will be associated with greater subjective sleep quality and that this association will be moderated by attachment.

Attachment Theory

Attachment theory began as a conceptualization by Bowlby (1969) with the purpose of explaining the process of infants' emotional attachment to their primary caregiver. It is now a leading theoretical framework for understanding how and why humans interact the way they do in their closest relationships, especially during times of stress, threat or danger (Hazan & Shaver, 1987; Ainsworth, 1978; Bowlby, 1969, 1973, 1980). Bowlby (1969) noticed striking similarities between human and primate infants, leading him to investigate evolutionary reasons for the attachment formed between infants and caregivers. He described attachment as a behavioral system (i.e. set of behaviors, that although dissimilar, serve the same purpose) that uses proximity to increase reproductive success (Sroufe & Waters, 1977). After being born, an infant has a limited number of abilities (e.g. crying, smiling, making eye contact) that they use to keep caregivers close for protection from danger and for care (Hazan & Shaver, 1987). Proximity increases feelings of love for the caregiver, further fostering the infant's survival (Hazan & Shaver, 1994). This affective bond is a "psychological tether" tying the infant and caregiver together (Sroufe & Waters, 1977).

The goal of this behavioral system is maintaining felt security (Bartholomew, 1990; Ainsworth, Blehar, Waters & Wall, 1978; Sroufe & Waters, 1977). Halfway through the infant's first year, they develop locomotion (e.g. directed reaching, grabbing, signaling, snuggling) allowing for more intentional and affective proximity seeking (Bartholomew, 1990). By the age of one, the infant has begun to form what Bowlby (1982) called "working models" of their attachment figure and themselves. The infant's working model is formed from interactions with the caregiver based on how responsive, reliable, and warm they are (Ainsworth et al., 1978; Sroufe & Waters, 1977). Knowing a caregiver is consistently available and reactive leads to deep feelings of security, giving greater value to the relationship (Bowlby, 1982). Infants grow to prefer their caregiver, and begin to experience distress upon separation (even short-term), due to an understanding that their caregiver exists despite being outside of their awareness (Bartholomew, 1990). Upon separation, Bowlby (1973) observed that infants go through a predictable set of behaviors: protest (i.e. crying, searching, resisting soothing efforts by others), despair (i.e. apparent sadness, passiveness), and detachment (i.e. being defensive, actively avoiding mother on return). In terms of survival, the infant expresses distress to attract the caregiver (protest), however, if there is no sign of achieving proximity the infant expresses passive sadness (despair) in order to avoid physical exhaustion and detection by predators. Finally, if it is clear their attachment figure is gone, the infant will resume normal activity (detachment) and find a new attachment figure if possible (Hazan & Shaver, 1994).

Ainsworth and Bell (1977) developed the strange situation task in order to test Bowlby's theories. She was particularly interested in how and when infants pursued proximity, if that proximity comforted them, and how they explored when around their caregiver. Infants were brought into the laboratory to encounter a series of 8 events. They first (1) entered an unfamiliar room with their mother, (2) begin to play, and after some time (3) a stranger enters. Shortly thereafter, (4) the mother leaves the child in the room with the stranger, and later (5) returns. Once the mother returns, the stranger leaves, and eventually (6) the infant is left alone in the room, for (7) the stranger to return first, and (8) then the mother. Three patterns of attachment were identified from observations of the strange situation task (specifically the infant's behavior on reunion): secure, anxious/ambivalent, and avoidant (Ainsworth et al., 1978). Sensitivity and warmth to infant signals by caregivers are the most important factors in infant attachment classification (Bartholomew, 1990). The quality of these early attachments can be determined by how much the infant relies on their caregiver for security (Ainsworth et al., 1978). Caregivers can be reliably responsive (secure), reliably unresponsive (avoidant), or inconsistently responsive (anxious/ambivalent; Main, Kaplan & Cassidy, 1985; Ainsworth et al., 1978). Forming a secure attachment relationship with caregivers is a major developmental task during the first year of life, and an inability to do so leads to consequences throughout the lifespan (Ainsworth, 1982, 1989; Bowlby, 1977, 1982; Sroufe & Waters, 1977). Children use interactions with their caregiver over time to continue to create their working models, judging (1) whether their attachment figure is responsive and reliable, and (2) whether the self is worthy of responsiveness (Bowlby, 1973). The child's working model of themselves and their attachment figure continues to build as they develop. These early attachment models are the basis for later personality formation and increasingly inform social interactions, emotion regulation strategies, and relationships outside just family (Bartholomew, 1990).

Infants and children who are securely attached have caregivers who are consistently responsive and sensitive to their signals and needs. These infants successfully use their primary caregiver as a secure base from which they independently explore and overcome challenges (Mikulincer & Shaver, 2003). They utilize proximity seeking behaviors when in need, and have confidence that their caregivers will respond appropriately (Bartholomew, 1990). In the strange situation task (Ainsworth & Bell, 1977), securely attached infants felt comfortable exploring the room and interacted with the stranger while their mother was present. When their mother left the room, they became distressed and avoided contact with the stranger. Any attempts by the stranger to soothe the infant were unsuccessful. When their mother reentered the room, these infants sought proximity, and were successfully soothed by their mother's efforts (Ainsworth & Bell, 1977). Over time a securely attached child's confidence that their caregiver will respond with support and protection if needed grows, and they increasingly use their caregiver as a secure base from which they can venture out and explore the world around them (Ainsworth, 1972). Additionally, they form a view of the self as someone worthy of such responsiveness. The development of perspective taking and language skills around the age of 3 or 4 allows children to better communicate and convey their own plans while taking into account the plans of their caregiver (Bartholomew, 1990). Further, as locomotive abilities advance, the child is able to explore farther and longer from their secure base without distress. This exploration encourages flexibility and problem-solving (Sroufe & Waters, 1977). Interactions with attachment figures create expectations for responsiveness and support which inform feelings of self-worth and security throughout development (Ainsworth et al., 1978).

Anxiously attached infants have mothers who are unreliable and insensitive when attending to their signals and needs (Bartholomew, 1990; Hazan & Shaver, 1987). These infants cling to their caregivers, but do not receive feelings of security and support from them. They have trouble exploring their environment independently, and when distressed, they are resistant/unresponsive to attachment figures attempts to help and comfort them (Ainsworth, 1972). In the strange situation task (Ainsworth & Bell, 1977), anxiously attached infants were hesitant to explore and avoided the stranger, whether their mother was present or not. When their mother left the room, they became severely distressed and upon her return, they sought proximity but were resistant to efforts to soothe (by both the mother and the stranger; Ainsworth & Bell, 1977). These infants frequently display protest behaviors, cry more than usual, and experience greater levels of anxiety (Hazan & Shaver, 1987; Bowlby, 1973). As anxiously attached children develop, their caregiver's inconsistencies heighten internal feelings that the self is unworthy of love and support, and increase fears of abandonment (Bartholomew, 1990). Although they may avoid social contact out of fear of disapproval and a lack of confidence that others will respond reliably, their anxiety continues to encourage them to vigilantly seek proximity to others (Hazan & Shaver, 1994; Bartholomew, 1990).

Infants who are avoidantly attached have mothers who are consistently unresponsive and insensitive. They are often opposed to physical contact, emotionally unavailable, and act harshly and critically towards their infant (Bartholomew, 1990; Ainsworth et al., 1978). Due to the unavailability and unresponsiveness of attachment figures in times of need, avoidant children do not look to their attachment figures for help or support (Ainsworth, 1979). During the strange situation task (Ainsworth & Bell, 1977), avoidant infants explored the environment independently from their mother. Upon separation, they expressed little distress, and continued to play despite the presence of the stranger. They seemed uninterested when the mother returned, often avoiding proximity. If they did experience distress, they rarely communicated that to their caregiver, and were equally as soothed by their mother as they were by the stranger (Ainsworth & Bell, 1977). Avoidantly attached infants frequently display detachment behaviors, and maintain an independence from caregivers both physically and emotionally (Behrens, Hesse & Main, 2007; Hazan & Shaver, 1987). Over time, the unresponsiveness and rejection these children experience leads them to avoid their caregivers, relying heavily on themselves (Hazan & Shaver, 1994; 1987). This instills a positive model of the self, further decreasing their perception of the need for social contact and close relationships especially during times of distress (Bartholomew, 1990).

Attachment in Adulthood

Attachment styles and working models formed in childhood continue to impact relationships into adulthood (Ainsworth, 1982, 1989). These styles persist throughout the lifespan with a fair amount of stability, but they are subject to change as attachment bonds change (Hazan & Shaver, 1994; Ainsworth, 1989; Bowlby, 1973). Bartholomew (see Figure 1; 1990, p. 163) explained how early working models of the self and caregivers influence working models of the self and others throughout development. Drawing on Bowlby's (1982) conceptual model and works by Main (1985) and Hazan and Shaver (1987). He described how positive models of the self (i.e. low dependence; see left column of Figure 1) create feelings that one is worthy of love and responsiveness, while positive models of others (i.e. low avoidance; see top row of Figure 1) instill feelings of trust and availability. Those with negative models of the self (i.e. high dependence; see right column of Figure 1) feel they are unworthy of attention and love, while negative models of others (i.e. high avoidance; see bottom row of Figure 1) instill feelings of rejection and unworthiness. Thus, creating the four adult attachment patterns, as described by Bartholomew (see the four boxes in Figure 1; 1990).

Figure 1: Bartholomew's Styles of Adult Attachment (1990)

		MODEL OF SELF (Dependence)	
		Positive (Low)	**Negative** (High)
MODEL OF OTHER (Avoidance)	**Positive** (Low)	**SECURE** Comfortable with intimacy and autonomy	**PREOCCUPIED** Preoccupied (Main) Ambivalent (Hazan) Overly dependent
	Negative (High)	**DISMISSING** Denial of Attachment Dismissing (Main) Counter-dependent	**FEARFUL** Fear of Attachment Avoidant (Hazan) Socially avoidant

Here, secure attachment (i.e. low avoidance, low dependence; see top left box of Figure 1) is represented by positive models of the self and other, leading to high quality relationships and high self-esteem. This is similar to secure attachment in infancy (Ainsworth et al., 1978). Anxious/ambivalent attachment in infancy is similar to what

Bartholomew calls preoccupied in adults (i.e. low avoidance, high dependence; see top right box of Figure 1). It is represented by an over dependence on others and feelings of unworthiness (Bartholomew, 1990; Ainsworth et al., 1978). Avoidant attachment in infancy is similar to the final two subtypes described by Bartholomew in adulthood: fearful and dismissing (1990; Ainsworth et al., 1978). Fearful (i.e. high avoidance, high dependence; see bottom right box of Figure 1) is represented by fears of rejection fueling avoidance of social interactions. Dismissing (i.e. high avoidance, low dependence; see bottom left box of Figure 1) is similar to work by Main (1985) where an individual is overly self-reliant and denies the need for social contact.

In adolescence, young people begin to search for a new type of attachment bond, engaging reproductive, caregiving, and attachment systems to find a partner from their peers (Ainsworth, 1989). Forming this type of attachment is a primary goal of adolescent and adult development, and can exist alongside primary attachments from childhood (Ainsworth, 1982). It is characterized by a strong disposition to seek proximity to a certain individual by using attachment behaviors, especially in emergencies or times of distress (Bowlby, 1982). These attachments generally last a relatively long time, and much like attachments to early caregivers, one's partner gives feelings of security and comfort and is not interchangeable with anyone else (Ainsworth, 1989). Separation from or loss of this partner would cause great distress, however closeness can be maintained across distance and time, and reunion brings joy (Ainsworth, 1982). Hazan and Shaver (1987) applied work by Bowlby and Ainsworth to adult relationships describing 3 similar adult attachment styles also called: secure, avoidant, and anxious. In adult relationships, secure attachment is represented by the ability and desire to form close relationships, and a propensity for trust. Adults with a secure attachment style pursue and sustain high quality, enduring, stable relationships (Feeney, 2002; Mikulincer & Shaver, 2003). People with anxious attachment in adulthood struggle with an overwhelming desire to form an attachment bond with a partner but consistently fear unreciprocated love (Hazan & Shaver, 1994). They hyperactively search for approval from others and consistently fear abandonment (Mikulincer & Shaver, 2003). Avoidant attachment in adulthood is characterized by a need for control, and an aversion to close, intimate relationships (Mikulincer & Shaver, 2003). They maintain emotional distance and do not communicate well in their relationships with others, leading to less trusting, stable relationships (Hazan & Shaver, 1987). Attachment styles may play a role in why sleep concordance leads to better sleep quality for some and less sleep quality for others.

Attachment and Sleep

Individuals with secure attachment style feel they can rely on their partner for safety and protection (Sbarra & Hazan, 2008). This encourages them to sleep with their partner and allows them to feel secure enough to fall asleep more easily (Dahl & El-Sheikh, 2007). Additionally, one of the main characteristics of secure attachment style is the coregulation or synchronization of physiological processes between individuals in romantic relationships (e.g., cortisol levels; Gunn et al., 2015). Their ability to form, and keep, high quality, close relationships (Feeney, Noller & Patty, 1993) may allow them to utilize the benefits of coregulation during sleep. Thus, there may be a positive association between sleep concordance and sleep quality for people who score higher on secure attachment style. Individuals with anxious attachment style exhibit a high amount of vigilance in their relationships and may not receive the stress-buffering and secure feelings normally associated with sleeping beside one's partner (Troxel et al., 2007). Further, concerns about the stability of their relationship and the availability of their partner that are characteristic of anxious attachment style may cause them to ruminate at night, creating disruptions in their sleep, lowering their overall subjective sleep quality whether together or apart (Carmichael & Reis, 2005). The preoccupation and rumination characteristic of individuals with anxious attachment style may inhibit the positive effects of sleep concordance (Mikulincer & Shaver, 2003). Although they may not receive the benefits of sleep concordance, research has shown that when temporarily separated from their bed partner, people with anxious attachment style have greater increases in sleeping problems and take longer to recover upon reunion than those with secure attachment style (Diamond, Hicks & Otter-Henderson, 2008). Thus, it is expected that there will be little to no association between sleep concordance and sleep quality among individuals who score higher on anxious attachment style. Finally, due to their aversion to closeness (Mikulincer & Shaver, 2003), a negative association is expected between greater sleep concordance and sleep quality for those who score higher on avoidant attachment style.

The Current Study

The goal of the current study is to shed light on sleep concordance's relationship with subjective sleep quality. Sleep is an extremely vital component of physical and mental health and well-being (Troxel et al., 2016; 2010). It is essential for proper functioning of emotions, behaviors, cognition, the endocrine and immune systems (Luckhaupt, Tak & Calvert, 2010). With sleep taking up such a large portion of peoples' lives, and many couples spending the majority of their time together in bed, it is crucial to understand the shared bed experience (Rosenblatt, 2012). Attachment styles may play an important role in why sleep concordance has been associated with greater sleep quality for some and may contribute to lower sleep quality for others. It is hypothesized that the association between sleep concordance and sleep quality will be positive in the context of higher scores on secure attachment style, small or non-existent for people with higher scores on anxious attachment style, and negative for people with higher scores on avoidant attachment style. There has been some speculation, but no research, examining attachment as a moderator of the association between sleep concordance and sleep quality. However, there has been some research on related issues. Indeed, attachment style is related to biological coregulation (Sbarra & Hazan, 2008), sleep concordance (Gunn et al., 2015; Troxel, 2010), and subjective sleep quality (Diamond, Hicks & Otter-Henderson, 2008; Carmichael & Reis, 2005). Gunn and colleagues (2015) found that heterosexual couples had higher sleep-wake concordance if the husband was anxiously attached, but only if the wife reported low marital satisfaction. Studies found no association between avoidant attachment and subjective sleep problems (Carmichael & Reis, 2005), or sleep-wake concordance (Gunn et al., 2015). Therefore, a goal of this study is to further explain the link between sleep concordance and sleep quality by examining the role of attachment.

METHOD

Participants

Data are from a larger study of child and family functioning. Families were 179 heterosexual couples, living with their partner or spouse. Families were recruited through school systems, after school programs, flyers, mailed post-cards, and family referrals. Women's ages ranged from 22 to 52 years (*M* = 38, *SD* = 7), and men's ages ranged from 24 to 59 years (*M* = 40, *SD* = 7). The majority of participants were White (77% of women, 70% of men). The remaining participants identified themselves as Black/African American (13.4% of women and men), Hispanic/Latin (1% of women, 1.9% of men), Asian (1% of women, 2.4% of men), Native American (0.5% of women and men), and other (1.4% of women, 1.9% of men). The families were predominately middle class, with the median family annual income between $40,000 and $54,999. Of the couples, 85.6% of them were married, and time living together ranged from less than a year to 31 years with an average length of 13 years (*SD*= 6).

Procedure

This study was approved by the University of Kentucky's Institutional Review Board. To begin the study, a research assistant went to the family's home in order to obtain informed consent and assent. Then couples were given a form about sleep and functioning to fill out daily for seven days. The seven-day diary assessment was above the 5 days necessary in order to achieve a reliable assessment (Acebo, 1999). The two extra days increased the chances of couples completing at least 5 days of diaries. The research assistant explained the daily form and answered any questions couples may have had. Couples were called daily to remind them to complete the form. Following the last night of the seven-day assessment (typically the next day, but within a week of the last night), couples came into the laboratory. During part of this three-hour lab visit, couples completed a series of questionnaires.

Measures

Sleep Concordance. Sleep concordance was computed following procedures described by Gunn and colleagues (2015). These procedures were modified for a diary format. Each day couples completed a form indicating their bedtime ("What time did you go to bed last night?"), and wake-time ("What time did you wake up this morning?"). To establish a value for sleep-wake concordance, I first calculated a total dyadic rest interval (TDRI), or the total amount of time at least one partner was in bed for each day. Therefore, the earlier partner bedtime and later partner wake time was identified and the difference between the two in minutes provided the TDRI. Next, I computed a total sleep concordance interval (TSCI), or the total amount of time both partners were in bed together for each day. Therefore, the later partner bedtime and earlier partner wake time was identified, and the difference between them in minutes provided the TSCI. Finally, I computed a sleep-wake concordance percentage score [(TSCI/TDRI) * 100] for each day and this is what was used for analyses. Therefore, a value of 60% meant that the couple was concordant for 60% of their total dyadic rest interval on that day. Both partners receive the same sleep concordance score (M=74%, SD=23).

Attachment. The Spousal Attachment Styles Questionnaire (SASQ; Becker, Billings, Eveleth & Gilbert, 1997) was used to assess attachment. The SASQ contains three subscales: fearful (avoidant) attachment (Cronbach's α=0.82), preoccupied (anxious) attachment (Cronbach's α=0.88) and secure attachment (Cronbach's α=0.80) for a total of 25 items. Each item was rated on a seven-point Likert scale from 1 “strongly disagree” to 7 “strongly agree”. An example of the avoidant attachment subscale (*M*=12, *SD*= 7; *M*=13, *SD*=8, for men and women respectively) is “I find it difficult to trust others completely”. An example of the anxious attachment subscale (*M*=17, *SD*=9 for men and M=13, *SD*=8, women) is “I find others are reluctant to get as close as I would like”. Each of these subscales included 6 items. The secure attachment subscale (*M*=42, *SD*=8 for men and *M*=41, *SD*=9for women, *SD*=8) consisted of 7 items. An example item is “It is easy for me to get emotionally close to others”.

Sleep Quality. Sleep quality was assessed using 4 items, each on a scale from 1 to 10: (1) “What was the quality of your sleep?”, with 10 being the best quality; (2) “How difficult was it for you to get up today?”, with 10 being the most difficult; this item was subsequently reverse scored; (3) “How alert were you when you first woke up?”, with 10 being wide awake; and (4) “How rested and refreshed were you when you first woke up?”, with 10 being the most refreshed. Scores were summed for an overall sleep quality score for each day (Cronbach’s α=0.83). Scores ranged from 7 to 40 (*M*= 23 for men and *M*=22 for women, *SD*= 5).

Data Structure

For the analysis of these data, I used the multilevel model for intensive longitudinal data from distinguishable dyads described by Bolger and Laurenceau (2013) The analysis dataset consisted of 179 (couples) x 2 (persons) x ≈7 (days) ≈ 2,506 observations. Not all participants were completely compliant with diary completion, therefore some diaries are missing. The data were stacked with male and female partners’ data in separate rows rather than separate variables. There was a unique ID for each couple, and a unique ID for each partner within the dyad. *Days* indicated the day of the diary assessment (1 through 7). Consistent with the requirements of the modeling procedure, there were three indicators of participant gender. *Gender* indicated a 1 for the female partner and 0 for the male partner. The variables *female* and *male* were dummy coded indicator variables, where *female* was 0 for male rows and 1 for female rows and *male* was be the opposite. The dependent variable was sleep quality. The predictor of interest was sleep concordance.

Days were centered such that day 0 was the first diary day. Consistent with best practice in multi-level modeling, I created within- and between- subjects versions of the sleep concordance percentage variable separately for male and female partners (although sleep concordance percentage score is the same for both). The mean concordance for each couple was computed and served as the between-couple effect of sleep concordance (entered at level 2). This mean concordance was also subtracted from each daily sleep concordance score for a couple, providing the within-couple effect of sleep concordance (entered at level 1).

Statistical Model

Data were analyzed using a multilevel model for dyadic diary data that treats the three levels of distinguishable dyadic diary data (days nested within persons nested within couples) as two levels of random variation (Bolger & Laurenceau, 2013). The lower level represents variability due to within-person repeated measures for male partners and female partners. The within-person level combines into one an equation linking within-subject variation in sleep concordance to within-subject variation in sleep quality for the man and another equation for the woman. Each time point in the male equation has a corresponding time point in the female equation, therefore, the male and female residuals at any time point are allowed to correlate. The upper level represents between-couples variability across male partners and across female partners. The between-couple level includes the differences in the random intercept and random slopes for the male and female level-1 equations (see Lauranceau & Bolger, 2005, for more details). Each of the predictor variables (i.e. between- and within- couples sleep concordance, and attachment) appears in interaction terms with the dummy variables *male* and *female*. The function of these dummy variables is to select only the male or female portions of the data matrix allowing for male and female submodels. The stacking of the data and the use of these dummy variables allowed me to fit both the male and female models simultaneously. For the use of both the *male* and *female* dummy codes, the overall regression intercept was removed. From the model, I wanted to know, separately for male and female partners, whether the percentage of sleep concordance on a particular day predicted greater sleep quality that day and whether there were between-couple differences in these effects.

Interactions were tested by including (a) the effect of attachment on the within-person effect of sleep concordance, and (b) the cross-product between attachment and the between-person effect of sleep concordance. Separate models were fit for each of the three attachment scales. Significant interactions were probed using the online utility for multi-level models developed by Preacher, Curran & Bauer (2006). Interactions were plotted to show associations between sleep concordance and sleep quality at + and – 1 SD on the moderator. Although the study is correlational and causality cannot be inferred, the terms “effect” were used throughout the description and discussion of results to be consistent with how MLM findings are typically described and to simplify presentation. The general model is presented below as two separate equations, however they were input as one model:

$$SlqualM_{ij} = \gamma_{00M} + \gamma_{01M}SlconcordM_{.j} + \gamma_{02M}attachmentM + \gamma_{10M}\left(SlconcordM_{ij} - SlconcordM_{.j}\right) + \gamma_{11M}attachmentM + \gamma_{12M}attachmentM * SlconcordM_{.j} + \zeta_{0jM} + \zeta_{1jM}\left(SlconcordM_{ij} - SlconcordM_{.j}\right) + \epsilon M_{ij}$$

$$SlqualF_{ij} = \gamma_{00F} + \gamma_{01F}SlconcordF_{.j} + \gamma_{02F}attachmentF + \gamma_{10F}\left(SlconcordF_{ij} - SlconcordF_{.j}\right) + \gamma_{11F}attachmentF + \gamma_{12F}attachmentF * SlconcordF_{.j} + \zeta_{0jF} + \zeta_{1jF}\left(SlconcordF_{ij} - SlconcordF_{.j}\right) + \epsilon F_{ij}$$

Preliminary Analyses

Descriptive statistics and correlations among study variables are presented in Table 1. Sleep quality was not related to sleep concordance for women, but it was positively associated with seep concordance for men. Sleep quality was positively associated with secure attachment style for both women and men. There was no association between the other two attachment styles and sleep quality. Sleep concordance was positively associated with secure attachment style and negatively associated with avoidant attachment style for both men and women; additionally, anxious attachment style was negatively associated with sleep concordance for women. Each attachment style scale was negatively associated with the others, with the exception of avoidant attachment style and anxious attachment style for men, which were positively associated.

Table 1: Correlations Among Study Variables

Measure	M(SD)	1	2	3	4	5
1. Sleep Quality	23.44 (4.82) 21.92 (5.10)	-	0.08**	0.07**	-0.03	0.001
2. Sleep Concordance	73.79 (22.92) 73.79 (22.92)	-0.03	-	0.10**	-0.11**	-0.04
3. Secure Attachment	41.83 (7.62) 40.70 (8.70)	0.07*	0.11**	-	-0.74**	-0.54**
4. Avoidant Attachment	12.31 (7.45) 12.76 (7.86)	-0.05	-0.13**	-0.78**	-	0.48**
5. Anxious Attachment	16.67 (9.34) 13.48 (7.63)	-0.28	-0.18**	-0.56**	-0.58**	-

Note: Men are the top M(SD) and above the diagonal, women are the bottom M(SD) and below the diagonal
**$p<.01$, *$p<.05$

The intra class correlation of sleep quality was high for both men, ICC=0.70, and women, ICC=0.62, meaning that 70% and 62% of the variance in sleep quality was due to between person differences in men and women, respectively. This indicates a substantial dependence of observations and the need for multi-level modeling. Univariate outliers were evaluated by looking at values greater than 3 standard deviations above or below the mean for any of the study variables. Although 67 values were selected using this criterion, none of these observations were clear outliers. Growth plots were evaluated and there were no visually apparent time trends in the data. QQ-plots indicated that level 1 (see Figure 2 for an example) and level 2 (see Figure 3 & 4 for an example of intercept residuals and day to day sleep concordance residuals respectively) residuals were normally distributed.

Figure 2: Level 1 Residuals

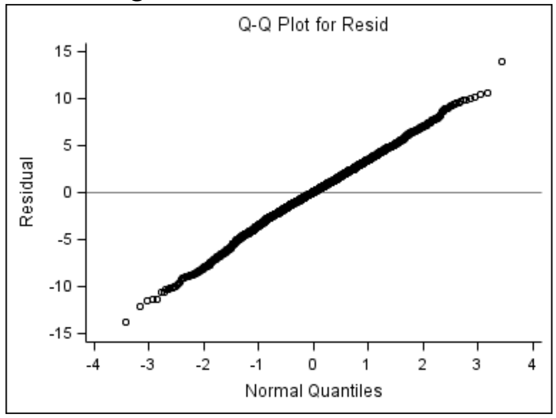


Figure 3: Level 2 Residuals, Intercept

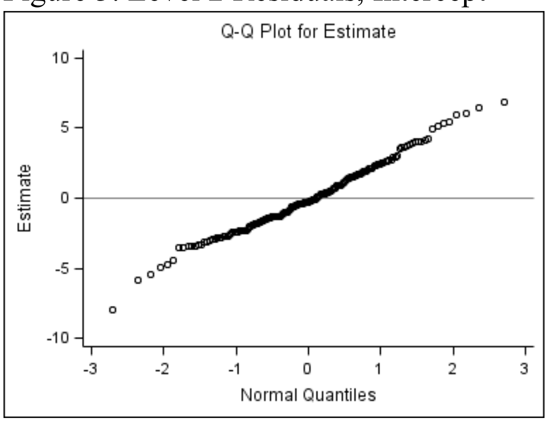
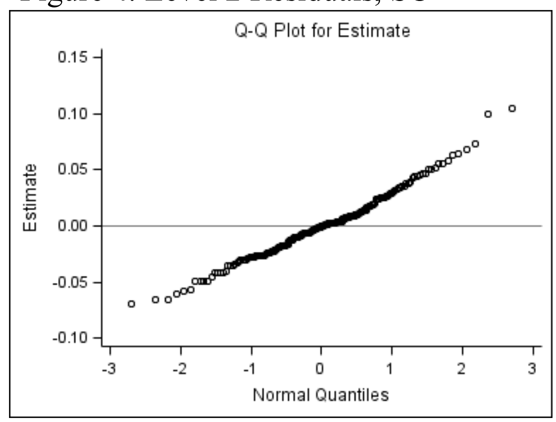


Figure 4: Level 2 Residuals, SC



Note: Example QQ-plots are each for male secure attachment, SC = sleep concordance

Level 1 missing data were handled using full information maximum likelihood (FIML). FIML obtains parameter estimates by maximizing the likelihood function of the dataset with missing values. Missing data rates at level 1 were low to moderate, so this method was appropriate. Only 1.5% of men and women only responded to two or three diary days, 3.5% of women and 1.5% of men completed four diary days, 7% of women and 6% of men completed five diary days, 14.5% of men and women completed six diary days, and 66% of men and women completed all seven diary days. Missingness was not associated with any of the predictor variables in the model. There was less than 10% missing data on all level 2 variables included in the final model. Thus, casewise deletion of missing cases was used for simplicity, as the benefits of a more complicated approach (such as multiple imputation) are minimal with such a small percentage of missing data. The effects of confounding variables were evaluated by fitting a preliminary model including all potential confounds as predictors of sleep quality (see Table 2). Of these covariates, none were a significant predictor of sleep quality so they were not included in the final model.

Table 2: Covariates

	B		*SE*		*t*	
	Men	Women	Men	Women	Men	Women
<u>Level 1:</u>						
Caffeine	0.03	0.02	0.17	0.22	0.14	0.10
Nap	-1.07	-0.22	0.61	0.57	-1.76	-0.39
Sick	0.82	-0.24	1.10	0.86	0.75	-0.28
Sleep Alone	1.06	0.62	0.60	0.81	1.76	0.76
<u>Level 2:</u>						
Years Living	0.03	-0.02	0.08	0.08	0.40	-0.28
Age	0.01	0.02	0.06	0.07	0.18	0.28
Income	-0.01	0.10	0.15	0.13	-0.08	0.73
Marital Status	-1.81	-0.97	1.10	1.10	-1.65	-0.88
Drinking Problem	0.05	-0.12	0.11	0.14	0.48	-0.85
Depression	-0.01	-0.001	0.05	0.04	-0.20	-0.04

Note: $df = 912$; $*p < .05$

RESULTS

Results for moderation by secure, avoidant, and anxious attachment style subscales are presented in tables below (Table 3, 4, and 5 respectively). The upper portion of these tables represents the fixed or average effects across people for the model. As indicated by the model intercepts, on days with an average amount of sleep concordance, men and women reported sleep quality levels between 21 and 23, or the near the middle of the scale. Nights with greater sleep concordance were related to greater sleep quality for men, B=0.02, ps=0.01 to 0.04. There was no main effect of sleep concordance on sleep quality for women.

Women who scored higher on the secure attachment subscale (see table 3) reported greater sleep quality, B=0.34, p=0.009. Additionally, there was an interaction between women's secure attachment style and the person mean of sleep concordance, B=-0.004, p=0.02. Among women with lower scores on the secure attachment subscale there was no association between greater person mean of sleep concordance and daily sleep quality. Among women with higher scores on the secure attachment subscale (0.76 standard deviations above the mean), there was a negative association between greater person mean of sleep concordance and daily sleep quality. This interaction is shown in Figure 5. There was no main effect of secure attachment style for men, however, there was an interaction between men's secure attachment style and daily sleep concordance, B= 0.003, p= 0.03. Among men with lower scores on the secure attachment subscale there was no association between greater daily sleep concordance and daily sleep quality. Among men with moderate to higher scores on the secure attachment subscale (beginning at least 0.06 standard deviations below the mean), there was a positive association between greater daily sleep concordance and greater daily sleep quality. This interaction is shown in Figure 6.

Women who scored higher on the avoidant attachment subscale (see table 4) reported lower sleep quality, B=-0.37, p=0.005. Additionally, there was an interaction between women's avoidant attachment style and the person mean of sleep concordance, B=0.005, p=0.01. Among women with lower scores on the avoidant attachment subscale (0.58 standard deviations below the mean), there was a negative association between greater person mean of sleep concordance and daily sleep quality. For higher scores on the avoidant attachment subscale, there was no association between women's mean sleep concordance and daily sleep quality. This interaction is shown in Figure 7. For men, there was no association between the avoidant attachment style subscale and sleep quality, nor did the avoidant attachment style subscale interact with daily variation in sleep concordance or the person mean of sleep concordance in the prediction of sleep quality.

Women who scored higher on the anxious attachment subscale (see table 5) reported lower sleep quality, B=-0.23, p=0.05. The anxious attachment style subscale did not interact with daily variation in sleep concordance or the person mean of sleep concordance in the prediction of sleep quality. For men there was no association between the anxious attachment style subscale and sleep quality, nor did the anxious attachment style subscale interact with daily variation in sleep concordance or the person mean of sleep concordance in the prediction of sleep quality

Figure 5: Female Secure Interaction

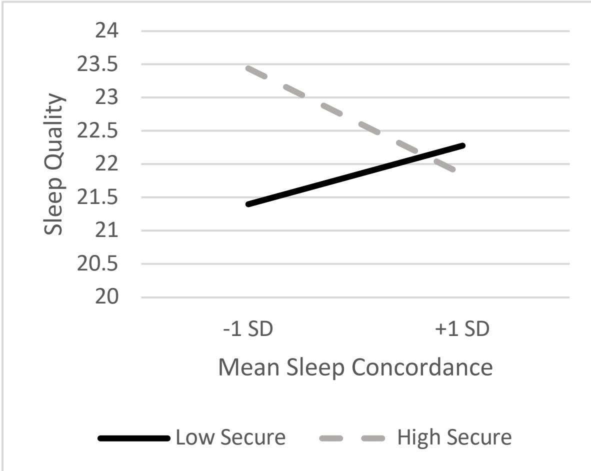


Figure 6: Male Secure Interaction

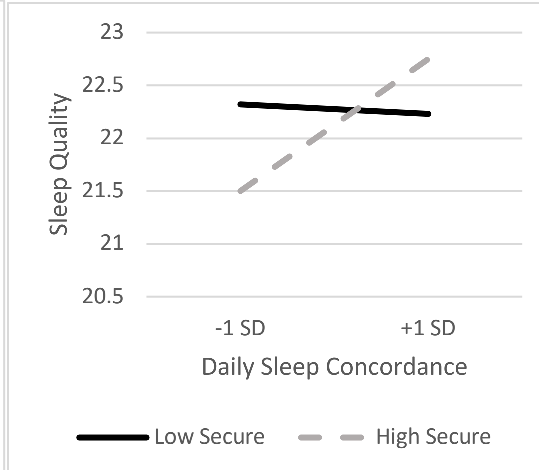
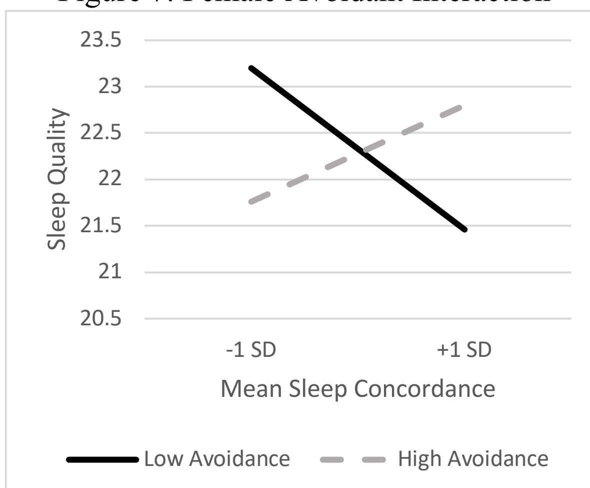


Figure 7: Female Avoidant Interaction



The lower portion of the tables provide the random effects or estimates of between- couples variability around the fixed effects. I will summarize these results for each of the attachment style subscales together. Random effects are reported as within- and between- couples variances and covariances. I will first focus on the between-couples random effects. There was substantial and significant variability around the intercepts of both male and female partners. In other words, overall sleep quality differed between people even after including the predictors in the model. Additionally, there was significant variation in the effect of daily sleep concordance for both men and women. Male and female intercepts were significantly related (i.e., men with greater overall sleep quality tended to be partnered with women who had greater overall sleep quality) even after controlling for scores on the attachment style subscales. The effect of daily sleep concordance for men was related to the effect of daily sleep concordance for women when controlling for scores on the attachment style subscales. For the within- couple random effects, significant level 1 residual variances indicate that the models have not accounted for all of the day to day variation in sleep quality, and the covariance between men's and women's level 1 residuals indicates that there is an association between men's and women's daily sleep quality even after controlling for the predictors in the model.

Table 3: Estimates for Dyadic Multilevel Model of Subjective Sleep Quality as a Function of Sleep Concordance Percentage Moderated by Secure Attachment Style for Male and Female Dyad Partners

					CI95	
Fixed Effects	Estimate	(*SE*)	*t*	*p*[a]	Lower	Upper
M_Intercept	22.20	(1.09)	20.28***	<.0001	20.04	24.36
F_Intercept	22.98	(1.03)	22.31***	<.0001	20.94	25.01
M_SC Slope	0.02	(0.01)	2.05*	0.04	0.00	0.04
F_SC Slope	0.001	(0.01)	0.04	0.97	-0.02	0.02
Mean M_SC Slope	0.02	(0.01)	1.10	0.27	-0.01	0.04
Mean F_SC Slope	-0.01	(0.01)	-0.99	0.32	-0.04	0.01
M_Secure	-0.01	(0.09)	-0.14	0.89	-0.20	0.17
F_Secure	0.34	(0.13)	2.62**	0.009	0.09	0.60
M_Secure*SC	0.003	(0.001)	2.20*	0.03	0.00	0.00
F_Secure*SC	-0.0003	(0.001)	-0.28	0.78	0.00	0.00
M_Secure*Mean SC	0.001	(0.001)	0.55	0.58	0.00	0.00
F_Secure*Mean SC	-0.004	(0.002)	-2.29*	0.02	-0.01	0.00
					CI95[b]	
Random Effects	Estimate	(*SE*)	*z*	*p*[a]	Lower	Upper
Level-2 (between-couples)[c]						
M_Intercept Variance	8.26	(1.21)	6.85***	<.0001	6.33	11.25
F_Intercept Variance	6.52	(1.11)	5.88***	<.0001	4.79	9.38
M_SC Slope Variance	0.003	(0.002)	1.98*	0.02	0.00	0.01
F_SC Slope Variance	0.006	(0.002)	2.50*	0.01	0.00	0.02
M-F Intercept Covariance	2.23	(0.83)	2.68*	0.01	0.60	3.85
M-F Slope Covariance	0.004	(0.001)	2.72*	0.01	0.00	0.01
Level-1 (within-couples)						
M_Residual Variance	17.76	(0.94)	18.88***	<.0001	16.05	19.75
F_Residual Variance	14.00	(0.73)	19.15***	<.0001	12.67	15.55
M-F Residual Covariance	1.72	(0.59)	2.94**	0.003	0.57	2.87
Autocorrelation	0.11	(0.03)	3.39**	0.001	0.05	0.17

Note: N= 199 couples, 7 days. M= male partner, F= female partner SC= sleep concordance. ****p*<.001, ***p*<.01, **p*<.05. Estimates are unstandardized.

[a] All *p*-values are two-tailed except in the case of variances, where one-tailed *p*-values are used (because variances are constrained to be non-negative).

[b] Confidence intervals for variances were computed using the Satterthwaite method (see Littell, Miliken, Stroup, Wolfinger & Schabenberger, 2006).

[c] Covariances between male intercepts and male SC slopes, female intercepts and female SC slopes, male intercepts and female SC slopes, and female intercepts and male SC slopes were estimated but not included for the sake of brevity due to the fact that none of them were significant.

Table 4: Estimates for Dyadic Multilevel Model of Subjective Sleep Quality as a Function of Sleep Concordance Percentage Moderated by Avoidant Attachment Style for Male and Female Dyad Partners

					CI_{95}	
Fixed Effects	Estimate	(*SE*)	*t*	p^a	Lower	Upper
M_Intercept	21.01	(1.10)	20.10***	<.0001	19.86	24.18
F_Intercept	23.04	(1.04)	22.25***	<.0001	20.99	25.08
M_SC Slope	0.02	(0.01)	2.24*	0.02	0.00	0.04
F_SC Slope	-0.001	(0.01)	-0.08	0.94	-0.02	0.02
Mean M_SC Slope	0.02	(0.01)	1.28	0.20	-0.01	0.05
Mean F_SC Slope	-0.01	(0.01)	-1.04	0.30	-0.04	0.01
M_Avoidant	0.04	(0.09)	0.50	0.62	-0.13	0.21
F_Avoidant	-0.37	(0.13)	-2.84**	0.005	-0.63	-0.12
M_Avoidant*SC	-0.002	(0.001)	-1.28	0.20	0.00	0.00
F_Avoidant*SC	0.001	(0.001)	0.96	0.34	0.00	0.00
M_Avoidant*Mean SC	-0.001	(0.001)	-0.60	0.55	0.00	0.00
F_Avoidant*Mean SC	0.005	(0.002)	2.53**	0.01	0.00	0.01
					$CI_{95}{}^b$	
Random Effects	Estimate	(*SE*)	*Z*	p^a	Lower	Upper
Level-2 (between-couples)[c]						
M_Intercept Variance	8.23	(1.20)	6.87***	<.0001	6.33	11.23
F_Intercept Variance	6.58	(1.12)	5.89***	<.0001	4.84	9.46
M_SC Slope Variance	0.003	(0.002)	2.02*	0.02	0.00	0.01
F_SC Slope Variance	0.01	(0.002)	2.31*	0.01	0.00	0.02
M-F Intercept Covariance	2.63	(0.85)	3.11**	0.002	0.97	4.29
M-F Slope Covariance	0.003	(0.001)	2.05*	0.04	0.00	0.01
Level-1 (within-couples)						
M_Residual Variance	17.67	(0.94)	18.81***	<.0001	15.96	19.66
F_Residual Variance	14.08	(0.73)	19.26***	<.0001	12.75	15.64
M-F Residual Covariance	1.94	(0.58)	3.30**	0.001	0.79	3.10
Autocorrelation	0.11	(0.03)	3.37**	0.001	0.05	0.17

Note: N= 199 couples, 7 days. M= male partner, F= female partner SC= sleep concordance. ****p*<.001, ***p*<.01, **p*<.05. Estimates are unstandardized.

[a] All *p*-values are two-tailed except in the case of variances, where one-tailed *p*-values are used (because variances are constrained to be non-negative).

[b] Confidence intervals for variances were computed using the Satterthwaite method (see Littell, Miliken, Stroup, Wolfinger & Schabenberger, 2006).

[c] Covariances between male intercepts and male SC slopes, female intercepts and female SC slopes, male intercepts and female SC slopes, and female intercepts and male SC slopes were estimated but not included for the sake of brevity due to the fact that none of them were significant.

Table 5: Estimates for Dyadic Multilevel Model of Subjective Sleep Quality as a Function of Sleep Concordance Percentage Moderated by Anxious Attachment Style for Male and Female Dyad Partners

					CI_{95}	
Fixed Effects	Estimate	(*SE*)	*t*	p^a	Lower	Upper
M_Intercept	21.78	(1.13)	19.31***	<.0001	19.56	24.01
F_Intercept	22.90	(1.07)	21.35***	<.0001	20.78	25.02
M_SC Slope	0.02	(0.01)	2.64*	0.01	0.01	0.04
F_SC Slope	-0.0002	(0.01)	-0.01	0.10	-0.02	0.02
Mean M_SC Slope	0.02	(0.01)	1.45	0.15	-0.01	0.05
Mean F_SC Slope	-0.01	(0.01)	-0.99	0.32	-0.04	0.01
M_Anxious	0.09	(0.11)	0.88	0.38	-0.12	0.32
F_Anxious	-0.23	(0.12)	-1.97*	0.05	-0.46	0.00
M_Anxious*SC	-0.001	(0.001)	-1.38	0.17	0.00	0.00
F_Anxious*SC	0.001	(0.001)	0.88	0.38	0.00	0.00
M_Anxious*Mean SC	-0.001	(0.001)	-0.91	0.36	0.00	0.00
F_Anxious*Mean SC	0.003	(0.002)	1.74	0.08	0.00	0.01
					$CI_{95}{}^b$	
Random Effects	Estimate	(*SE*)	*Z*	p^a	Lower	Upper
Level-2 (between-couples)[c]						
M_Intercept Variance	8.34	(1.10)	6.90***	<.0001	6.40	11.32
F_Intercept Variance	7.04	(1.15)	6.11***	<.0001	5.24	9.98
M_SC Slope Variance	0.003	(0.002)	2.08*	0.02	0.00	0.01
F_SC Slope Variance	0.006	(0.002)	2.48*	0.01	0.003	0.02
M-F Intercept Covariance	2.50	(0.85)	2.94**	0.003	0.83	4.17
M-F Slope Covariance	0.004	(0.001)	2.71*	0.01	0.00	0.01
Level-1 (within-couples)						
M_Residual Variance	17.80	(0.93)	19.05***	<.0001	16.10	19.78
F_Residual Variance	14.04	(0.73)	19.33***	<.0001	12.71	15.57
M-F Residual Covariance	1.84	(0.58)	3.17**	0.001	0.70	2.97
Autocorrelation	0.10	(0.03)	3.21**	0.001	0.04	0.17

Note: N= 199 couples, 7 days. M= male partner, F= female partner SC= sleep concordance. ****p*<.001, ***p*<.01, **p*<.05. Estimates are unstandardized.

[a] All *p*-values are two-tailed except in the case of variances, where one-tailed *p*-values are used (because variances are constrained to be non-negative).

[b] Confidence intervals for variances were computed using the Satterthwaite method (see Littell, Miliken, Stroup, Wolfinger & Schabenberger, 2006).

[c] Covariances between male intercepts and male SC slopes, female intercepts and female SC slopes, male intercepts and female SC slopes, and female intercepts and male SC slopes were estimated but not included for the sake of brevity due to the fact that none of them were significant.

DISCUSSION

The goal of this study was to investigate the association between couple sleep concordance and sleep quality by including individual attachment style as a moderator. The results were partially consistent with hypotheses. Men reported better sleep quality on nights when they were more concordant, but there was no significant main effect of sleep concordance for women. For men with higher scores on the secure attachment subscale, there was a positive association between daily sleep concordance and sleep quality. Women who scored higher on the secure attachment style subscale reported higher sleep quality. There was a negative association between mean sleep concordance and sleep quality, however, for women with higher scores on the secure attachment style subscale. Women who scored higher on the anxious or avoidant attachment style subscales reported lower sleep quality. There was a negative association between sleep concordance and sleep quality for women who reported lower levels of avoidant attachment style. There was no association between sleep concordance and sleep quality for men or women who scored higher on the anxious attachment style subscale. Findings suggest that there may be differences in the ways men and women experience sleep concordance and that it may be important to improve dyadic sleep for both men and women.

Men reported better sleep quality on nights when they were more concordant. For men who scored higher on the secure attachment style subscale, daily sleep concordance was positively associated with sleep quality. This was consistent with predictions and adds to previous research that men sleep longer and wake up later when sleeping with their partners (Spiegelhalder et al., 2016; Meadows et al., 2009). Sleeping beside a partner may be particularly beneficial for men's sleep and ultimately their health and well-being, especially for those with higher levels of secure attachment style. Men in co-sleeping couples may alter their bed time or wake time to match their partners, contributing to longer total sleep time (Meadows et al., 2009). Additionally, they may fall asleep more easily due to the stress relieving feelings of comfort and security gained by sleeping beside their partner (Troxel, 2010; Troxel, Buysse, Hall & Matthews, 2009). This main effect was not observed for women. Previous research has shown that women report more disruptions due to their partner than men, and men move more than women (Pankhurst & Horne, 1994). Sleep quality (subjective and objective) is negatively impacted by sleeping beside a partner for women (Dittami et al., 2007). It is possible that the disruptions women experience from sleeping beside a partner counteract the benefits of sleep concordance on sleep quality. Together, these findings suggest that improvement in dyadic sleep may be important for both men and women, however, stronger support for causal relationships is needed. Future directions should pay attention to potential gender differences in the experience of sleep concordance and may benefit from including both subjective and objective measures of sleep concordance (i.e. overlap in sleep-wake times and overlap in movements) to address possible gender differences in the experiences of movement throughout the night.

Women who scored higher on the secure attachment style subscale reported higher sleep quality and women who scored higher on the insecure attachment style subscales reported lower sleep quality. This adds to previous research that there is a positive association between secure attachment style and sleep quality (Troxel et al., 2007) and a negative association between anxious and avoidant attachment styles and sleep quality (Carmichael & Reis, 2005). Cognitive pre-sleep arousal may be a possible explanation for such findings. One study found that while trying to fall asleep, “good sleepers” tend to think about nothing in particular, while people with insomnia think more about worries and problems (Harvey, 2000). People with secure attachment style have positive models of the self and others and maintain trusting, intimate, high-quality relationships (Feeney, Noller & Patty, 1993; Bartholomew, 1990). Perhaps women who endorse greater secure attachment style do not experience as many troubling thoughts and concerns at bedtime that prevent them from falling asleep (Carmichael & Reis, 2005). The discomfort intimacy and closeness bring avoidantly attached people, and hyperactive worrying characteristic of anxiously attached people may cause women with higher levels of insecure attachment styles to ruminate on such concerns while trying to fall asleep (Troxel et al., 2007; Carmichael & Reis, 2005; Mikulincer & Shaver, 2003). Future research may include cognitive pre-sleep arousal as a possible explanation for such associations.

As expected, sleep concordance was not associated with sleep quality for women with higher levels of anxious attachment style. Unexpectedly, however, among women with higher scores on the secure attachment style subscale and lower scores on the avoidant attachment style subscale, mean sleep concordance was negatively associated with sleep quality. These findings were unexpected. One possible explanation for each of these findings is, for women, there were main effects of attachment styles and sleep quality. Perhaps women who have higher scores on the secure attachment style subscale and lower scores on the insecure attachment style subscales already report such good sleep quality, that sleeping beside their partner reduces, or at the very least does not improve their sleep quality. Similarly, perhaps women who have higher scores on the insecure attachment style subscales have such poor sleep quality already, that sleeping beside their partner neither helps nor hurts them. Additionally, each of the attachment style subscales were skewed, which may have made differences between high and low levels of attachment styles more difficult to detect. The majority of participants in this study were toward the higher range of secure attachment style scores, and toward the lower range of insecure attachment style scores. Low variability like this can restrict the range of scores, attenuating observed associations, contributing to low power. Overall, a pattern that emerged from these results is that there is room for improvement when co-sleeping for women with varying degrees of attachment styles. There were no interactions between the insecure attachment style subscales with any of the study variables for men. Future research may benefit from oversampling those who score lower on the secure attachment style subscale and higher on the insecure attachment style subscales to get a more complete picture.

Overall, these findings suggest that there may be gender differences in the ways sleep concordance and attachment style are associated with sleep quality. Previous studies examining sex differences in sleep have shown that although women report longer total sleep times, going to sleep earlier, and falling asleep earlier than men (Krishnan & Collop, 2006), they also report a greater need of sleep, more awakenings during the night, and less sleep quality than men (Lindberg et al., 1997; Reyner & Horne, 1995). Women more commonly than men have problems maintaining sleep, do not feel refreshed in the morning, and experience excessive sleepiness during the day (Lindberg et al., 1997). Possible explanations for such sex differences include hormonal fluctuations, affective disorders, nighttime pain, sleep disorders, and family obligations (Hantsoo, Khou, White & Ong, 2013; Yoshioka et al., 2012). The changes in hormones women experience across their lifetime and within a month are associated with changes in sleep patterns (Krishnan & Collop, 2006). Puberty has been associated with an increase in sleep problems only in girls (Kunutson, 2005), pregnancy is associated with more awakenings and respiratory disturbances (Wise, Polito & Krishnan, 2006), and menopause is associated with insomnia (Moline, Broch, Zak & Gross, 2004). Additionally, the hormonal level and temperature changes of particular phases of the menstrual cycle have been associated with subjective sleep quality (Krishnan & Collop, 2006). More women experience anxiety, depression and nighttime pain than men; all of which are associated with lower objective and subjective sleep quality (Mindell, Meltzer, Carskadon & Chervin, 2009). Insomnia and restless leg syndrome disproportionately affect women and women have more sleep complaints than men (Krishnan & Collop, 2006). Some research has suggested that women have greater instances of caregiving and household responsibilities at night which may influence their ability to fall and stay asleep (Yoshioka et al., 2012; Lindberg et al., 1997). Along with previous research, findings from this study point to a difference in the way men and women experience sleep, especially when sleeping together.

It is important to interpret these findings in light of study limitations. This study had a correlational research design, thus, causal inferences cannot be drawn. It is possible that the reverse direction of association is also true. Men who have higher sleep quality may be more likely to sleep with their partner. Similarly, women who endorse greater secure attachment style and less insecure attachment style who have lower sleep quality may be more likely to sleep with their partner. Participants in this study were American, heterosexual, predominantly white, middle-class couples with children. Other populations may exhibit a different pattern of results, so future studies with more diverse populations are needed to address these issues more directly. Interestingly, industrialized Western societies are the minority when it comes to bed sharing, with the majority of the world sharing their bed with both spouses and children (Mindell, Sadeh, Kohyama & How, 2010). These cultures and cultures where bed sharing is not the norm may benefit from the added feelings of security and intimacy or suffer from the increased number of movements and disturbances when co-sleeping. Another limitation is that, due to the complexity of the model, gender differences were not tested directly. Results suggest that sleep concordance, sleep quality, attachment and the associations between them may be different for men and women. It is possible that the differences in associations that were observed are due to chance and their significance needs to be tested in future research. Additionally, the majority of participants endorsed higher levels of the secure attachment subscale than the insecure attachment subscales. The low amount of variability in attachment style levels may have impacted the significance of results. Finally, future studies should include other variables that may moderate or mediate associations between sleep concordance and sleep quality, such as sexual contact (see Dittami et al., 2007), stress, relationship conflict (see Troxel et al., 2007), oxytocin (see Troxel, 2010), cognitive pre-sleep arousal, and objective measures of sleep quality (see Gunn et al., 2015).

Despite limitations, these findings add to research on dyadic sleep by suggesting the importance sleep concordance may have for men's subjective sleep quality, the importance attachment styles may have for women's subjective sleep quality, and overall the importance of addressing couple sleep issues for both partners. Sleep concordance has benefits beyond impacting sleep quality (Gunn et al., 2015). It promotes intimacy and attachment, giving couples much needed alone time when they may not get it elsewhere, and has important implications for physical and mental health, daily functioning, and well-being (Troxel, 2010). Future research is needed to uncover more about causal relationships, however these results suggest there may be gender differences in the relationships between sleep concordance, attachment style, and sleep quality.

REFERENCES

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Wolfson, A. R., Hafer, A., & Carskadon, M. A. (1999). Estimating sleep patterns with activity monitoring in children and adolescents: how many nights are necessary for reliable measures?. *Sleep*, *22*(1), 95-103.

Adams, B. N., & Cromwell, R. E. (1978). Morning and Night People in the Family: A Preliminary Statement. *The Family Coordinator*, *27*(1), 5–13.

Ainsworth, M. S. (1972). Attachment and dependency: A comparison. In J. L. Gewirtz, *Attachment and dependency.* Oxford, England: V. H. Winston.

Ainsworth, M. S. (1979). Infant–mother attachment. *American psychologist*, *34*(10), 932.

Ainsworth, M. S. (1982), Attachment: Retrospect and prospect. In C. M. Parkes & J. Stevenson-Hinde (Eds.), *The place of attachment in human behavior*, (pp. 3-30). New York: Basic Books.

Ainsworth, M. S. (1989). Attachments beyond infancy. *American psychologist*, *44*(4), 709.

Ainsworth, M. D. S., & Bell, S. M. (1977). Infant crying and maternal responsiveness: A rejoinder to Gewirtz and Boyd. *Child Development*, 1208-1216.

Ainsworth, M. D. S., Blehar, M. C., Waters, E., & Wall, S. (1978). *Patterns of attachment: A psychological study of the Strange Situation*. Hillsdale, NJ: Erlbaum.

Åkerstedt, T., Hume, K. E. N., Minors, D., & Waterhouse, J. (1994). The meaning of good sleep: a longitudinal study of polysomnography and subjective sleep quality. *Journal of Sleep Research*, *3*(3), 152-158.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Anderson, C., & Platten, C. R. (2011). Sleep deprivation lowers inhibition and enhances impulsivity to negative stimuli. *Behavioural brain research*, *217*(2), 463-466.

Argyropoulos, S. V., Hicks, J. A., Nash, J. R., Bell, C. J., Rich, A. S., Nutt, D. J., & Wilson, S. J. (2003). Correlation of subjective and objective sleep measurements at different stages of the treatment of depression. *Psychiatry Research*, *120*(2), 179-190.

Aserinsky, E., & Kleitman, N. (1953). Regularly occurring periods of eye motility, and concomitant phenomena, during sleep. *Science*, *118*(3062), 273-274.

Baker, F. C., Maloney, S., & Driver, H. S. (1999). A comparison of subjective estimates of sleep with objective polysomnographic data in healthy men and women. *Journal of psychosomatic research*, *47*(4), 335-341.

Banks, S., & Dinges, D. F. (2007). Behavioral and physiological consequences of sleep restriction. *Journal of clinical sleep medicine: JCSM: official publication of the American Academy of Sleep Medicine*, *3*(5), 519.

Bartholomew, K. (1990). Avoidance of intimacy: An attachment perspective. *Journal of Social and Personal relationships*, *7*(2), 147-178.

Bastien, C., Fortier-Brochu, E., Rioux, I., LeBlanc, M., Daley, M., & Morin, C. M. (2003). Cognitive performance and sleep quality in the elderly suffering from chronic insomnia Relationship between objective and subjective measures. *Journal of Psychosomatic Research*, *54*, 39–49.

Beattie, L., Simon, K. D., Espie, C. A., & Biello, S. M. (2015). Social interactions, emotion and sleep: A systematic review and research agenda. *Sleep Medicine Reviews*, *24*, 83–100.

Becker, T.E., Billings, R.S., Eveleth, D.M., & Gilbert, N.W. (1997). Validity of scores on three attachment style scales: Exploratory and confirmatory evidence. *Educational and Psychological Measurement, 57*, 477–493.

Behrens, K. Y., Hesse, E., & Main, M. (2007). Mothers' attachment status as determined by the Adult Attachment Interview predicts their 6-year-olds' reunion responses: A study conducted in Japan. *Developmental Psychology*, *43*(6), 1553-1566.

Bolger, N., & Laurenceau, J. P. (2013). Intensive longitudinal methods. *New York, NY: Guilford*.

Bowlby, J. (1969). Attachment and loss: Attachment. *New York: Basic*.

Bowlby, J. (1973). Attachment and loss: Volume 2: Separation, anger and anxiety. *New York: Basic*

Bowlby, J. (1980). Attachment and loss: Volume 3: Loss, sadness and depression. *New York: Basic*.

Bowlby, J. (1982). *Attachment and loss: Vol 1. Attachment* (2nd ed.). New York: Basic Books. (Original work published 1969)

Brouillette, R. T., Fernbach, S. K., & Hunt, C. E. (1982). Obstructive sleep apnea in infants and children. *The Journal of pediatrics*, *100*(1), 31-40.

Brown, T. S. H. (2008). *The effects of natural sleep debt on current mood, working memory, and risk-taking propensity*. University of Maryland, College Park.

Carmichael, C. L., & Reis, H. T. (2005). Attachment, Sleep Quality, and Depressed Affect. *Health Psychology*, *24*(5), 526–531.

Dahl, R. E. (1996). The regulation of sleep and arousal: Development and psychopathology. *Development and Psychopathology, 8*, 3–27.

Dahl, R. E., & El-Sheikh, M. (2007). Considering Sleep in a Family Context : Introduction to the Special Issue. *Journal of Family Psychology*, *21*(1), 1–3.

Dement, W., & Kleitman, N. (1957). The relation of eye movements during sleep to dream activity: an objective method for the study of dreaming. *Journal of experimental psychology*, *53*(5), 339.

Diamond, L. M., Hicks, A. M., & Otter-Henderson, K. D. (2008). Every time you go away: changes in affect, behavior, and physiology associated with travel-related separations from romantic partners. *Journal of Personality and Social Psychology*, *95*(2), 385–403.

Dinges, D. F., Pack, F., Williams, K., Gillen, K. A., Powell, J. W., Ott, G. E., Aptowicz, C. & Pack, A. I. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4–5 hours per night. *Sleep*, *20*(4), 267-277.

Dittami, J., Keckeis, M., Machatschke, I., Katina, S., Zeitlhofer, J., & Kloesch, G. (2007). Sex differences in the reactions to sleeping in pairs versus sleeping alone in humans. *Sleep and Biological Rhythms*, *5*, 271–276.

Ekirch, A. R. (2006). *At day's close: night in times past*. WW Norton & Company.

El-Sheikh M, Kelly R, Raurer A. (2013). Quick to berate, slow to sleep: Interpartner psychological conflict, mental health, and sleep. *Health Psychology 32*, 1057–66.

Feeney, J. A. (2002). Attachment, marital interaction, and relationship satisfaction: A diary study. *Personal Relationships*, *9*(1), 39-55.

Feeney, J. A., Noller, P., & Patty, J. (1993). Adolescents' interactions with the opposite sex: Influence of attachment style and gender. *Journal of Adolescence*, *16*, 169–186.

Gami, A. S., Caples, S. M., & Somers, V. K. (2003). Obesity and obstructive sleep apnea. *Endocrinology and Metabolism Clinics*, *32*(4), 869-894.

Goldstein, A. N., & Walker, M. P. (2015). The Role of Sleep in Emotional Brain Function. *Annual Review Clinical Psychology, 10*, 679–708.

Gunn, H. E., Buysse, D. J., Hasler, B. P., Begley, A., & Troxel, W. M. (2015). Sleep Concordance in Couples is Associated with Relationship Characteristics. *Sleep*, *38*(6), 933–939.

Gunn, H. E., Buysse, D. J., Matthews, K. A., Kline, C. E., Cribbet, M. R., & Troxel, W. M. (2016). Sleep – Wake Concordance in Couples Is Inversely Associated With Cardiovascular Disease Risk Markers. *Sleep*, *40*(1), 1–10.

Gunn, H. E., Troxel, W. M., Hall, M. H., & Buysse, D. J. (2014). Interpersonal distress is associated with sleep and arousal in insomnia and good sleepers. *Journal of Psychosomatic Research*, *76*, 242–248.

Hantsoo, L., Khou, C.S., White, C. N., Ong, J.C. (2013). Gender and cognitive-emotional factors as predictors of pre-sleep arousal and trait hyperarousal in insomnia. *Journal of Psychosomatic Res 74*(4). 283-289.

Harrison, Y., & Horne, J. A. (2000). The impact of sleep deprivation on decision making: a review. *Journal of experimental psychology: Applied*, *6*(3), 236.

Harvey, A. G. (2000). Pre-sleep cognitive activity : A comparison of sleep-onset insomniacs and good sleepers. *British Journal of Clinical Psychology*, *39*, 275–286.

Harvey, A. G., Stinson, K., Whitaker, K. L., Moskovitz, D., & Virk, H. (2008). The Subjective Meaning of Sleep Quality: A Comparison of Individuals with and without Insomnia. *Sleep*, *31*(3), 383–393.

Hasler, B. P., & Troxel, W. M. (2010). Couples' Nighttime Sleep Efficiency and Concordance: Evidence for Bidirectional Associations With Daytime Relationship Functioning. *Psychosomatic Medicine*, *72*, 794–801.

Hazan, C., & Shaver, P. R. (1987). Romantic love conceptualized as an attachment process. *Journal of personality and social psychology*, *52*(3), 511.

Hazan, C., & Shaver, P. R. (1994). Attachment as an organizational framework for research on close relationships. *Psychological inquiry*, *5*(1), 1-22.

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

Jean-Louis, G., Kripke, D. F., & Ancoli-Israel, S. (2000). Sleep and quality of well-being. *Sleep*, *23*(8), 1115-1121.

Joiner, T. E. (2007). Sleep disturbances and suicide risk: A review of the literature. *Neuropsychiatric Disease and Treatment*, *3*(6), 735–743.

Kahn, M., Sheppes, G., & Sadeh, A. (2013). Sleep and emotions: bidirectional links and underlying mechanisms. *International Journal of Psychophysiology*, *89*(2), 218-228.

Killgore, W. D., Kahn-greene, E. T., Lipizzi, E. L., Newman, R. A., Kamimori, G. H., & Balkin, T. J. (2008). Sleep deprivation reduces perceived emotional intelligence and constructive thinking skills, *9*, 517–526.

Killgore, W. D., Schwab, Z. J., Weber, M., Kipman, M., DelDonno, S. R., Weiner, M. R., & Rauch, S. L. (2013). Daytime sleepiness affects prefrontal regulation of food intake. *Neuroimage*, *71*, 216-223.

Krishnan, V., & Collop, N. A. (2006). Gender differences in sleep disorders. *Current opinion in pulmonary medicine*, *12*(6), 383-389.

Knutson, K. L. (2005). The association between pubertal status and sleep duration and quality among a nationally representative sample of US adolescents. *American Journal of Human Biology*, *17*(4), 418-424.

Lancel, M., Krömer, S., & Neumann, I. D. (2003). Intracerebral oxytocin modulates sleep–wake behaviour in male rats. *Regulatory peptides*, *114*(2), 145-152.

Laurenceau, J. P. & Bolger, N. (2005). Using diary methods to study marital and family processes. *Journal of Family Psychology*, *19*, 86-97.

Lemola, S., & Richter, D. (2013). The Course of Subjective Sleep Quality in Middle and Old Adulthood and Its Relation to Physical Health. *Journal of Gerontology: Psychological Sciences*, *68*(5), 721–729.

Lemola, S., Ledermann, T., & Friedman, E. M. (2013). Variability of Sleep Duration Is Related to Subjective Sleep Quality and Subjective Well-Being : An Actigraphy Study. *PLoS ONE*, *8*(8), 1–9.

Libedinsky, C., Massar, S. A., Ling, A., Chee, W., Huettel, S. A., & Chee, M. W. (2013). Sleep deprivation alters effort discounting but not delay discounting of monetary rewards. *Sleep*, *36*(6), 899-904.

Lindberg, E., Janson, C., Gislason, T., Björnsson, E., Hetta, J., & Boman, G. (1997). Sleep disturbances in a young adult population: can gender differences be explained by differences in psychological status?. *Sleep*, *20*(6), 381-387.

Littell, R. C., Milliken, G. A., Stroup, W. W., Wolfinger, R. D., & Schabenberger, O. (2007). *SAS for mixed models*. SAS institute.

Liu, S., Rovine, M. J., Klein, L. C., & Almeida, D. M. (2013). Synchrony of diurnal cortisol pattern in couples. *Journal of Family Psychology*, *27*(4), 579–588.

Luckhaupt, S. E., Tak, S., & Calvert, G. M. (2010). The prevalence of short sleep duration by industry and occupation in the National Health Interview Survey. *Sleep*, *33*(2), 149-159.

Macdonald, K., & Macdonald, T. M. (2010). The Peptide That Binds : A Systematic Review of Oxytocin and its Prosocial Effects in Humans. *Harvard Review Psychiatry*, *18*, 1–21.

Main, M., Kaplan, N., & Cassidy, J. (1985). Security in infancy, childhood, and adulthood: A move to the level of representation. *Monographs of the society for research in child development*, 66-104.

Mayers, A. G., Grabau, E. A., Campbell, C., & Baldwin, D. S. (2009). Subjective sleep, depression and anxiety: inter-relationships in a non-clinical sample. *Human Psychopharmacology: Clinical and Experimental*, *24*(6), 495-501.

Meadows, R., Arber, S., Venn, S., Hislop, J., & Stanley, N. (2009). Exploring the interdependence of couples' rest-wake cycles: an actigraphic study. *Chronobiology International*, *26*(1), 80–92.

Meadows, R., Venn, S., Hislop, J., Stanley, N., & Arber, S. (2005). Investigating couples' sleep: An evaluation of actigraphic analysis techniques. *Journal of Sleep Research*, *14*(4), 377–386.

Mikulincer, M., & Shaver, P. R. (2003). The Attachment Behavioral System in Adulthood: Activation, Psychodynamics, and Interpersonal Processes. *Advances in Experimental Social Psychology*, *35*, 53–152.

Mindell, J. A., Meltzer, L. J., Carskadon, M. A., & Chervin, R. D. (2009). Developmental aspects of sleep hygiene: findings from the 2004 National Sleep Foundation Sleep in America Poll. *Sleep medicine*, *10*(7), 771-779.

Mindell, J. A., Sadeh, A., Kohyama, J., & How, T. H. (2010). Parental behaviors and sleep outcomes in infants and toddlers: a cross-cultural comparison. *Sleep medicine*, *11*(4), 393-399.

Minkel, J. D., Banks, S., Htaik, O., Moreta, M. C., Jones, C. W., McGlinchey, E. L., Simpson, N. S., & Dinges, D. F. (2012). Sleep deprivation and stressors: evidence for elevated negative affect in response to mild stressors when sleep deprived. *Emotion*, *12*(5), 1015.

Moline, M. L., Broch, L., Zak, R., & Gross, V. (2003). Sleep in women across the life cycle from adulthood through menopause. *Sleep medicine reviews*, *7*(2), 155-177.

Moore, P. J., Adler, N., Williams, D. R., & Jackson, J. S. (2002). Socioeconomic Status and Health : The Role of Sleep. *Psychosomatic Medicine*, *64*, 337–344.

National Sleep Foundation. (2011). *2011 Sleep in America®Bedroom Poll*. Washington, DC: National Sleep Foundation; 2011.

Nicolau, M. C., Akaarir, M., Gamundı, A., Gonzalez, J., & Rial, R. V. (2000). Why we sleep: the evolutionary pathway to the mammalian sleep. *Progress in Neurobiology*, *62*(4), 379-406.

Pagel, J. F., & Kram, G. (2010). Insomnia: differential diagnosis and current treatment approach. In *GABA and Sleep*(pp. 363-381). Springer Basel.

Palmer, C. A., & Alfano, C. A. (2017). Sleep and emotion regulation: An organizing, integrative review. *Sleep Medicine Reviews*, *31*, 6–16.

Pankhurst, F. P., & Horne, J. A. (1994). The Influence of Bed Partners on Movement During Sleep. *Sleep*.

Phillips, B., & Gelula, R. (2006). Sleep-wake cycle: Its physiology and impact on health. National Sleep Foundation; 2006.

Pilcher, J. J. (2000). Self-report Sleep Habits as Predictors of Subjective Sleepiness. *Behavioral Medicine*, (February 2000), 161–168.

Pilcher, J. J., Ginter, D. R., & Sadowsky, B. (1997). Sleep quality versus sleep quantity: relationships between sleep and measures of health, well-being and sleepiness in college students. *Journal of psychosomatic research*, *42*(6), 583-596.

Pilcher, J. J., & Ott, E. (1998). The relationships between sleep and measures of health andwell-being in college students: a repeated measures approach. *Behavioral Medicine*, *23*(4), 170-178.

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interaction effects in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics*, *31*, 437-448.

Rechtschaffen, A., Gilliland, M. A., Bergmann, B. M., & Winter, J. B. (1983). Physiological correlates of prolonged sleep deprivation in rats. *Science*, *221*(4606), 182-184.

Regestein, Q. R., Friebely, J., Shifren, J. L., Scharf, M. B., Wiita, B., Carver, J., & Schiff, I. (2004). Self-reported sleep in postmenopausal women. *Menopause*, *11*(2), 198-207.

Reyner, A., Horne, J.A. (1995). Gender and age-related differences in sleep logs determined by home-recorded sleep logs and acimetry from 400 adults. *Sleep 18*(2). 127-134.

Richter, K., Adam, S., Geiss, L., Peter, L., & Niklewski, G. (2016). Two in a bed: The influence of couple sleeping and chronotypes on relationship and sleep. An overview. *Chronobiology International*, *33*(10), 1464–1472.

Rosenblatt, P. C. (2012). *Two in a bed: The social system of couple bed sharing*. SUNY Press.

Saxbe, D., & Repetti, R. L. (2010). For better or worse? Coregulation of couples' cortisol levels and mood states. *Journal of Personality and Social Psychology*, *98*(1), 92–103.

Sbarra, D. A., & Hazan, C. (2008). Coregulation, Dysregulation, Self-Regulation: An Integrative Analysis and Empirical Agenda for Understanding Adult Attachment, Separation, Loss, and Recovery. *Personality and Social Psychology Review*, *12*(2), 141–167.

Schwartz, B. (1970). Notes on the sociology of sleep. *The Sociological Quarterly*, *11*(4), 485-499.

Sejnowski, T. J., & Destexhe, A. (2000). Why do we sleep?. *Brain research*, *886*(1), 208-223.

Spiegelhalder, K., Regen, W., Siemon, F., Kyle, S. D., Baglioni, C., Feige, B., Nissen, C., & Riemann, D. (2016). Your Place or Mine? Does the Sleep Location Matter in Young Couples? *Behavioral Sleep Medicine*, *0*(1), 1–9.

Sroufe, L. A., & Waters, E. (1977). Attachment as an organizational construct. *Child development*, 1184-1199.

Tavernier, R., & Willoughby, T. (2015). A longitudinal examination of the bidirectional association between sleep problems and social ties at university: The mediating role of emotion regulation. *Journal of youth and adolescence*, *44*(2), 317-330.

Tempesta, D., Couyoumdjian, A., Curcio, G., Moroni, F., Marzano, C., Gennaro, L. De, & Ferrara, M. (2010). Lack of sleep affects the evaluation of emotional stimuli, *82*, 104–108.

Troxel, W. M. (2010). It's more than sex: exploring the dyadic nature of sleep and implications for health. *Psychosomatic Medicine*, *72*(6), 578–586.

Troxel, W. M., Braithwaite, S. R., Sandberg, J. G., & Holt-Lunstad, J. (2016). Does Improving Marital Quality Improve Sleep? Results from a Marital Therapy Trial. *Behavioral Sleep Medicine*, *0*, 1–14.

Troxel, W. M., Buysse, D. J., Hall, M., & Matthews, K. A. (2009). Marital Happiness and Sleep Disturbances in a Multi-Ethnic Sample of Middle-Aged Women. *Behavioral Sleep Medicine*, *7*(1), 2–19.

Troxel, W. M., Robles, T. F., Hall, M. H., & Buysse, D. J. (2007). Marital quality and the marital bed: Examining the covariation between relationship quality and sleep. *Sleep Medicine*, *11*(5), 389–404.

Venn, S., Arber, S., Meadows, R., & Hislop, J. (2008). The Fourth Shift: Exploring the gendered nature of sleep disruption among couples with children. *British Journal of Sociology*, *59*(1), 79–98.

Vitiello, M. V., Larsen, L. H., & Moe, K. E. (2004). Age-related sleep change: gender and estrogen effects on the subjective–objective sleep quality relationships of healthy, noncomplaining older men and women. *Journal of psychosomatic research*, *56*(5), 503-510.

Wetter, T. C., Beitinger, P. A., Beitinger, M. E., & Wollweber, B. (2010). Pathophysiology of Sleep Disorders. In *GABA and Sleep* (pp. 325-361). Springer Basel.

Wise, R. A., Polito, A. J., & Krishnan, V. (2006). Respiratory physiologic changes in pregnancy. *Immunology and Allergy Clinics*, *26*(1), 1-12.

Womack, S. D., Hook, J. N., Reyna, S. H., & Ramos, M. (2013). Sleep Loss and Risk-Taking Behavior : A Review of the Literature. *Behavioral Sleep Medicine*, *11*, 343–359.

Yoshioka, E., Saijo, Y., Kita, T., Satoh, H., Kawaharada, M., Fukui, T., & Kishi, R. (2012). Gender differences in insomnia and the role of paid work and family responsibilities. *Social psychiatry and psychiatric epidemiology*, *47*(4), 651-662.

VITA

Taylor L Elsey

PLACE OF BIRTH

Stevens Point, WI

EDUCATION

B.A. Psychology, Clemson University, Clemson, South Carolina, December 2012

PROFESSIONAL EXPERIENCE

Graduate Research Assistant, Child and Family Development Lab, University of Kentucky, Lexington, Kentucky. August 2015– Present. Advisor: Dr. P. S. Keller.