2016

Positivity Ratio: Predicting Sleep Outcomes Across The Adult Lifespan

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Positivity Ratio: Predicting Sleep Outcomes Across The Adult Lifespan

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Psychology at Virginia Commonwealth University.

by

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November, 2016

Acknowledgment

I would like to thank my parents for their unending love and support, not only throughout this process, but also throughout my lifetime. I would not be where I am without them. I would also like to thank Dr. Natalie Dautovich for her endless help, direction, and support throughout this project. I truly appreciate Dr. Dautovich's patience, guidance, and mentorship. Finally, I would like to thank my committee members, Dr. Bruce Rybarczyk and Dr. Tracey Gendron, who provided both knowledge from their respective fields and support throughout this process.

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Abstract

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By Janna Lynn Imel, B.A.

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Although sleep has been linked to changes in positive and negative affect across the lifespan, the prediction of sleep from affect has not been explored completely. As such, the main objective of this study was to examine the association between affect and sleep across the adult lifespan, using a novel gauge of affect, the positivity ratio. Both subjective and objective assessments of sleep were used in analyses. This study was an archival analysis of data collected as a part of the Midlife in the United States Study (MIDUS-II), with participants ranging from 34 to 83 years of age. Results revealed the positivity ratio to be a significant predictor of self-reported sleep quality and global sleep, but not of objective sleep measures. Additionally, the positivity ratio was found to increase with age and appears to predict better global sleep and sleep quality across all age groups. Implications of the findings are discussed.

Positivity Ratio: Predicting Sleep Outcomes Across The Adult Lifespan

Approximately 15 years ago, 35% of the general population endorsed having poor or unsatisfactory sleep outcomes (e.g., multiple nightly awakenings, lengthy sleep onset latency, and inadequate total sleep time), with 10%-15% falling into the moderate or severe categories (Sateia, Doghramji, Hauri, & Morin, 1999). More recently, these complaints have increased and insomnia diagnoses are estimated to be three times the amount diagnosed a decade ago (Pandey & Phillips, 2015). Given that poor and inadequate sleep is associated with daytime dysfunction, behavioral and emotional changes, as well as a decline in cognitive functioning (Sateia et al., 1999), sleep difficulties should not be ignored. However, in order for poor sleep outcomes to be properly addressed, more information regarding the factors involved in sleep outcomes must be discussed. Given current demographic trends, age is a particularly relevant factor associated with sleep outcomes that should be examined.

Many individuals experience changes in their sleep as they age (Ancoli-Israel, Poceta, Stepnowsky, Martin, & Gehrman, 1997). For example, increased age is associated with more fragmented and disrupted sleep. It is estimated that 50% of older adults, or 15 million Americans, have some type of problem with their sleep (Ancoli-Israel et al., 1997). Even more striking is that the number of older Americans experiencing sleep problems is only expected to increase, given changing population demographics. By 2030, 20% of Americans will be over the age of 65 (Colby & Ortman, 2014). Even with only a segment of the Baby Boomer population having entered the older adult age bracket, the aging population is already being identified as a possible cause for the rise of insomnia diagnoses (Pandey & Phillips, 2015). As the population continues to age, and sleep disorders continue to prevail in older adults, there is a need for research that investigates potential factors that can promote healthy sleep outcomes across the lifespan.

A potential factor for promoting healthier sleep is positive affective experiences. Sleep has been linked to positive and negative affective outcomes. In particular, sleep has been shown to impact affect and mood (Baglioni, Spiegelhalder, Lombardo, & Riemann, 2010; Bower, Bylsma, Morris, & Rottenberg, 2010; Totterdell, Reynolds, Parkinson, & Briner, 1994), with a considerable body of research supporting the link between depression and sleep (Tsuno, Besset, & Ritchie, 2005). However, research has failed to fully examine the effects of affective states on sleep, particularly at the sub-clinical level. Consequently, compared to research on depression and sleep in clinical samples, less is known about the associations between affect and sleep outcomes in healthy populations. A focus on preventative and protective mechanisms in healthy populations is aligned with goals of Counseling Psychology, which has traditionally focused on client strengths, remedial and preventive approaches, and development across the lifespan (Gelso & Fretz, 1992).

The primary objective of the currently study was to examine the association between affect and sleep across the adult lifespan in a sample of community-dwelling adults through an archival analysis of the nationally representative Midlife in the United States (MIDUS-II) dataset. Specifically, affect was examined using a novel approach – the positivity ratio. The positivity ratio is calculated by creating a ratio of positive affect to negative affect. In regards to sleep, given the poor correlations between objective and subjective sleep data for middle-aged and older adults (Espie, Lindsay, & Espie, 1989; Means, Edinger, Glenn, & Fins, 2003), the present study used both subjective and objective assessments of sleep to capture the multifaceted nature of sleep. Overall, the proposed study attempts to further our understanding of the relationship between affect and sleep within the context of age.

Literature Review

The Relationship Between Affect and Sleep

According to The Circumplex Model of Affect (Russell, 1980), affect can be defined in terms of arousal and valence, which are both associated with sleep outcomes. Arousal is the amount of stimulation that is associated with the experience of affect, while valence explains the pleasantness or unpleasantness of the affective experience (Russell, 1989). Specifically, higher arousal and negative valence are associated with greater sleep difficulties, which will be discussed further in the sections below.

Arousal and sleep. The association between arousal and sleep is supported by a variety of studies (Morin, Rodrigue, & Ivers, 2003; Nicassio, Mendlowitz, Fussell, & Petras, 1985). Specifically, cognitive arousal has been linked to sleep outcomes, with higher cognitive pre-sleep arousal associated with increased spontaneous awakening in middle-aged adults (Chen, Lin, Lee, & Chou, 2011) and younger adults (Shoji, McCrae, & Dautovich, 2013). Older adults show the highest amount of cognitive pre-sleep arousal (Shoji, Tighe, Dautovich, & McCrae, 2015) and a greater association between cognitive arousal and longer sleep onset latency compared to younger adults (Shoji et al., 2013).

In addition to cognitive arousal, emotional arousal has also been linked to poor sleep. Within the emotional arousal domain, high arousal negative affect (e.g., anger and anxiety) has been strongly associated with poor sleep across age groups, as measured by daily sleep diaries and actigraphy (Babson & Feldner, 2015). Specifically, high arousal negative affect has been associated with increased sleep onset latency and awakenings, and reduced sleep efficiency

(Fairholme & Manber, 2015). Regardless of whether the arousal is cognitive or emotional, arousal is hypothesized to predict worse sleep for older adults compared to younger ages, given that older adults tend to spend more time in lighter sleep stages (Benloucif et al., 2004). In addition to examining the association between arousal and sleep, it is also important to consider the association between valence and sleep across age groups.

Valence and sleep. Across the small number of studies examining positive affect and sleep throughout the adult lifespan, it appears that positive affect predicts better sleep outcomes. For example, older adults with higher levels of positive affect have endorsed fewer sleep problems on the Pittsburgh Sleep Quality Index (PSQI) and reported feeling more refreshed in daily sleep diaries (Fredman, Gordon, Heeren, & Stuver, 2013; Song, Graham-Engeland, Mogle, & Martire, 2015). A similar pattern of results is shown across the adult lifespan with higher positive affect predicting better sleep quality, as measured by actigraphy, and feeling rested in the morning (Ong et al., 2013). Positive affect may lead to better sleep by serving as a protective factor (Ong, Bastarache, & Steptoe, 2015). Specifically, positive affect has been shown to buffer against stress and other psychosocial factors such as self-rated health, age, and gender across the lifespan, resulting in better sleep outcomes (Folkman, 2008; Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Steptoe, O'Donnell, Marmot, & Wardle, 2008).

As with positive affect, negative affect has also been linked to sleep outcomes across the lifespan, with higher levels of negative affect predicting poorer sleep outcomes. For example, older adults endorsing highly negative daily moods, subjectively report less refreshing sleep and poorer sleep quality on the PSQI (Song et al., 2015). Among young adults, negative mood, rumination, and negative emotion (i.e., depression, anxiety, and anger) are significantly associated with poorly rated subjective sleep quality, increased sleep onset latency, and sleep disturbance as measured with the PSQI (Stewart, Rand, Hawkins, & Stines, 2011; Thomsen, Mehlsen, Christensen, & Zachariae, 2003). Also, throughout young and middle-adulthood, emotionally distressing negative events have been linked to changes in individual sleep architecture (e.g., increased sleep fragmentation, lower sleep efficiency and total sleep time, and increased awakenings) as measured through Polysomnography (Talamini, Bringmann, de Boer, & Hofman, 2013; Vandekerckhove et al., 2011).

Overall, both positive and negative affect show independent associations with sleep outcomes. However the two should also be considered in combination when connected to sleep, as older and middle-aged adults who report higher positive affect *and* lower negative affect tend to report better subjective sleep (McCrae et al., 2008; Norlander, Johansson, & Bood, 2005). As positive affect and negative affect are two separate constructs, and the absence of negative affect does not necessarily mean the presence of positive affect, and vice-versa (Diener & Emmons, 1985; Watson & Tellegen, 1985), it is important to consider the simultaneous contributions of both in order to create a better understanding of an individual's overall affective state. A novel approach to characterizing the association between positive affect and negative affect is the positivity ratio.

Positivity ratio. The positivity ratio is the proportion of positive affect to negative affect. Importantly, the positivity ratio has implications for mental health, as it is a predictor of subjective wellbeing (Diehl, Hay, & Berg, 2011). Specifically, in order for an individual to sustain better mental health, a higher ratio of positive to negative affect is beneficial (Diehl et al., 2011; Fredrickson, 2013; Meeks, Van Haitsma, Kostiwa, & Murrell, 2012). Much debate still exists in the literature as to whether or not an "optimal positivity ratio" for better wellbeing exists (Brown, Sokal, & Friedman, 2013; Fredrickson and Losada, 2005). However, as of late, researchers accept that a critical minimum positivity ratio is not backed by evidence (Brown et al., 2013).

Age differences in the positivity ratio have been identified in existing literature, with older adults reporting the highest mean positivity ratios compared to younger and middle-aged adults (Diehl et al., 2011). Given that higher positivity ratios have been associated with older age, examining age differences in affect is warranted.

Effects of Age

Affective changes across the lifespan. Emotional wellbeing is shown to improve throughout the lifespan (Carstensen et al., 2011). In fact, older age is associated with increased stability of emotions, better emotional control, and less time spent in highly negative states (Carstensen et al., 2011; Hay & Diehl, 2011; Lawton, Kleban, Rajagopal, & Dean, 1992). Specifically, when compared to younger adults, older individuals experience less day-to-day negative affect, and a small increase in positive affect (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000). Conversely, younger adults report more negative emotional experiences (Gross et al., 1997). Arousal has also been shown to differ by age, but there is a lack of consensus in the literature about how exactly older and younger adults experience high versus low arousal affect. For example, older age has been linked to reduced high arousal affect (e.g., “feeling excited or upset”), and increased low arousal affect (e.g., “feeling relaxed or depressed”), such that older adults would be less likely to experience highly arousing emotions (Pinquart, 2001). More recently, older age was associated with levels of high arousal positive affect similar to younger adults, but lower levels of high arousal negative affect (Kessler and Staudinger, 2009).

How is it that in the face of negative issues and stressors sometimes associated with old age (e.g., declining health, bereavement of friends and family, role-shifting, etc.) that older adults are able to be less negative and retain better emotional wellbeing (Carstensen et al., 2011)? The Socioemotional Selectivity Theory (SST) and the Strength and Vulnerability Integration (SAVI) model provide a conceptual rationale to explain age differences in emotional experiences.

Socioemotional Selectivity Theory (SST). According to the SST, an individual's temporal perspective impacts goals (Carstensen & Mikels, 2005). When time is seen as unlimited, individuals make preparations for the future. However, when time is seen as fixed, individuals focus on areas of life that are more meaningful to them. Thus, as individuals age and begin to perceive their time as limited, the SST theorizes that they will focus more on the quality of their social relationships and work to enhance important relationships. A perspective of less time also allows the individual to appreciate and focus on the positives in life (Carstensen, Isaacowitz, & Charles, 1999). For example, when setting emotional goals, individuals have the opportunity to focus their attention and memory toward information significant for their goals; this information could be either positive or negative. Within the frame of age, older adults favor emotionally gratifying and positive information (Carstensen & Mikels, 2005), while younger adults focus more on negative information (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). The term "positivity effect" was created to describe this phenomenon of a shift from focusing on negative material in youth to remembering positive material in middle to older age (Carstensen & Mikels, 2005).

Strength And Vulnerability Integration (SAVI). The SAVI model of emotion regulation in adulthood complements the SST by addressing how older adults emotionally regulate when faced with negative stimuli. As mentioned above, in comparison to younger and middle-aged adults, older adults can limit their actual experience of negative emotions and enhance the experience of emotionally positive events (Charles, 2010). However, when older adults are unable to avoid the experience of an emotionally negative event, SAVI states that the physiological vulnerabilities of older adults can reduce their emotion regulation abilities. In fact, if an older adult is unable to avoid a highly arousing emotional event, it is more difficult for them to return to homeostasis than their younger counterpart following the emotional event. Given the consequence of highly arousing emotions for older adults, they may try to limit their exposure to highly arousing experiences, so as to avoid the physiologically arousing component.

Sleep and age. In addition to examining age differences in affective experiences, age is also important to consider when examining sleep, which also changes across the lifespan. Contrary to popular belief, changes in sleep have been shown to start earlier in adulthood (Vitiello, 2007), with the largest portion of changes in sleep patterns, as measured by PSG and actigraphy, occurring between early adulthood and 60 years of age (Ohayon, Carskadon, Guilleminault, & Vitiello, 2004). In particular, the percentage of slow-wave sleep, sleep efficiency, total sleep time, and the percentage of REM sleep decline throughout adulthood. After the age of 60, only sleep efficiency continues to decrease significantly.

When specifically examining the sleep of older adults, in comparison to the sleep of younger and middle-aged adults, older adult's sleep can be characterized as "lighter" (Crowley, 2011), with more time spent in the lighter stages of sleep. Spending more time in the lighter stages of sleep may explain why older adults report more nightly awakenings and less restorative sleep (Vaz Fragoso & Gill, 2007). In fact, up to 50% of older adults have reported difficulty staying asleep (Neikrug & Ancoli-Israel, 2010). Importantly, when examining the age and sleep association, it is important to be cognizant of how much changes in sleep are due to age *per se*, versus other factors associated with aging.

The Senescent Sleep Model provides a theoretical framework for understanding normal and pathological changes in sleep with age (Vaz Fragoso & Gill, 2007). The model purports that normal and usual aging predispose, precipitate, and perpetuate the sleep complaints that are often found among older adults. Specifically, the normal changes in sleep associated with aging (e.g., decreased slow wave sleep, sleep spindles, and REM sleep) can predispose older adults for sleep issues by making them vulnerable to adverse outcomes. These normal changes alone, however, are insufficient to produce sleep disorders. Precipitating factors associated with usual aging (e.g., declining health and physical function) *can* be classified as causal in the aging and adverse sleep outcomes relationship. The effects of predisposing and precipitating factors are enhanced through psychosocial means by perpetuating factors that can be a consequence of aging (e.g., social isolation, caregiving, social losses, poor sleep hygiene, etc.). Overall, the combination of medical, psychiatric, and social changes associated with aging can limit an older adult's ability to obtain proper sleep (Vaz Fragoso & Gill, 2007; Vitiello, 2007). Fortunately, many of the factors that influence sleep disturbance in older adults can be diagnosed and treated (Vaz Fragoso & Gill, 2007).

The Current Study

Overall, the current study examined to what extent an individual's positivity ratio predicts sleep outcomes, while exploring potential age differences in this association. This study adds to the currently limited information on the associations between positive and negative affect and sleep. An innovation of the present study includes combining positive affect and negative affect into a positivity ratio to predict sleep outcomes. Additionally, this study examined subjective and objective sleep outcomes simultaneously in the same sample.

Specific Aims and Hypotheses

Overall, the proposed study examined sleep across age groups in a healthy sample, while assessing for age differences in how an individual's positivity ratio, and affective valence and arousal are associated with sleep.

Aim 1. To examine to what extent affect predicts both subjective and objective sleep outcomes.

Aim 1.1. To examine how an individual's positivity ratio predicts subjective and objective sleep outcomes. Higher trait positive affect has been linked to better objectively and subjectively measured sleep (Fredman et al., 2013; Ong et al., 2013). Based on these findings, I hypothesized the following:

Hypothesis 1.1. Higher positivity ratios will be associated with better objective and subjective sleep outcomes.

Aim 1.2. To examine how the arousal dimension of the positivity ratio is associated with subjective and objective sleep. Based on existing literature that shows arousal to predict worse sleep outcomes (Lichstein & Rosenthal, 1980; Morin et al., 2003), I hypothesized the following:

Hypothesis 1.2. The high arousal positivity ratio will predict worse subjective and objective sleep compared to the low arousal positivity ratio.

Aim 2. To examine to what extent affect varies by age.

Aim 2.1. To examine how the positivity ratio varies as a function of age. Given that previous research shows positive affect and wellbeing to increase with age (Carstensen et al., 2000; Carstensen et al., 2011; Gross et al., 1997; Mroczek & Kolarz, 1998), and the amount of time older adults spend in highly negative states is less compared with younger counterparts (Hay & Diehl, 2011), I hypothesized the following:

Hypothesis 2.1. As age increases, the amount of positive affect in relation to negative affect will increase, leading to higher positivity ratios. Thus, older ages will be associated with higher positivity ratios than younger ages.

Aim 2.2. To explore how the high and low arousal positivity ratios vary as a function of age. Based on a review of the literature by Pinquart (2001), which found increases in age to be associated with reductions in high arousal affect, I hypothesized the following:

Hypothesis 2.2. The high arousal positivity ratio will decrease as age increases and there will not be a significant relationship between the low arousal positivity ratio and age.

Aim 3. To examine age differences in the association between the positivity ratio and sleep outcomes.

Aim 3.1. To examine to what extent age moderates the association between the positivity ratio and subjective and objective sleep outcomes.

Hypothesis 3.1. Given age differences in affect (e.g., older adults reporting better affect) and sleep (e.g., increasing age has been associated with poorer sleep), it is difficult to predict the nature of the moderation. However, exploring a potential age moderation could increase our understanding of how age may affect the association between the positivity ratio and sleep outcomes. As a result, Aim 3.1 was exploratory.

Aim 3.2. To examine to what extent age moderates the associations between: (1) the high arousal positivity ratio and sleep, and (2) the low arousal positivity ratio and sleep. High arousal has been shown to negatively impact sleep outcomes (Lichstein & Rosenthal, 1980; Morin et al., 2003). Given that SAVI suggests it is more difficult for older adults to return to baseline after a highly arousing emotional experience than their younger counterparts, and that older adults may be more vulnerable to highly arousing emotions, I hypothesized the following:

Hypothesis 3.2.1. High arousal positivity ratio will predict worse sleep outcomes for older adults in comparison to their younger counterparts for both subjective and objective sleep outcomes.

Hypothesis 3.2.2. Low arousal positivity ratio will not predict a significant difference in subjective and objective sleep outcomes across age groups.

Method

Participants. This project involved an archival analysis of data from the Midlife in the United States-II study (MIDUS-II). Participants were recruited nationally as a part of the MIDUS-II study of health and wellbeing, a longitudinal follow-up study to MIDUS, sponsored by the National Institute on Aging. The final samples used for the present study consisted of 364 adults, aged 34 to 83 years of age (*M* = 54.40, *SD* = 11.72), for the actigraphy sample and 388 adults, aged 34 to 83 years of age (*M* = 53.96, *SD* = 11.68) for the daily sleep diary sample, both of which were obtained only at the University of Wisconsin-Madison site. Additionally, 1172 adults, aged 34 to 84 years of age (*M* = 54.52, *SD* = 11.71) participated in Project 1 and responded to the Pittsburgh Sleep Quality Index. Demographic data is available in Table 1.

Procedure. In MIDUS-II, participants completed a phone interview and two self-administered questionnaires (SAQs), measuring several psychological constructs (e.g., positive affect, negative affect, personality), demographic variables, and mental and physical health. Additionally, subsets of participants completed one or more of four separate projects (e.g., daily diary study, cognitive functioning, biomarkers, and neuroscience projects). The current study used data from participants who were involved in Project 1 (the aforementioned phone and self-administered questionnaire) and Project 4. Actigraphy and daily sleep diary data were collected in Project 4 at the University of Wisconsin-Madison site only, which constitutes a subset of participants.

Measures

Affect.

Positive affect. Positive affect was measured using the positive affect scale in MIDUS-II (α = .92), which is comprised of 10 items, four from the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) and six items that were created for MIDUS-II. The affect items specific to MIDUS-II were selected from established affective assessment scales (Bradburn, 1969; Fazio, 1977; Kessler et al., 1994; MacMillan, 1957; Radloff, 1977; Taylor, 1953), all of which are valid measurement instruments (Mroczek & Kolarz, 1998). Participants rate the MIDUS-II affect items on a scale of one to five (i.e., 1 = all of the time, 2 = most of the time, 3 = some of the time, 4 = a little of the time, and 5 = none of the time) regarding how much of the time they felt "cheerful, in good spirits, extremely happy, calm and peaceful, satisfied, and full of life" over the past 30 days. The PANAS items (i.e., enthusiastic, attentive, proud, and active) are also rated on the same scale for the past 30 days. Higher scores are indicative of higher positive affect.

Negative affect. Negative affect was measured using the negative affect scale in MIDUS-II, which is comprised of 11 items, five items from the PANAS (Watson et al., 1988) and six items that were created for MIDUS-II. The affect items specific to MIDUS-II were selected from established affective assessment scales (Bradburn, 1969; Fazio, 1977; Kessler et al., 1994; MacMillan, 1957; Radloff, 1977; Taylor, 1953), all of which are valid measurement instruments (Mroczek & Kolarz, 1998). Participants responded to the MIDUS-II negative affect items using the same response anchors as in the positive affect scale to prompts such as feeling "so sad nothing could cheer you up, nervous, restless or fidgety, hopeless, that everything was an effort, and worthless" over the past 30 days. The PANAS portion of the negative affect scale is rated over the past 30 days on the same scale to determine how often participants felt: "afraid, jittery, irritable, ashamed, and upset." Higher scores are indicative of higher negative affect.

For the present study, 10 negative affect items were needed to compare to the 10 positive affect items, as the number of negative affect and positive affect items must be equal to calculate the positivity ratio. Given that MIDUS-II provides 11 items for the negative affect scale, one item needed to be removed. To retain the PANAS items in both scales, one item was removed from the 6-item negative affect scale that is unique to MIDUS-II. Comparison of all the negative affect items (from both the PANAS and the items unique to MIDUS-II), revealed two items that are very similar: "restless or fidgety" and "jittery". As such, the PANAS item, "jittery", was retained and "restless or fidgety" was removed. Following the removal of this item, internal consistency was calculated for the remaining 10-items and showed that the 10-item negative affect scale has high internal reliability ($\alpha = .91$).

Positivity ratio. Affect in the present study was measured by accounting for the dual contributions of both positive affect and negative affect by creating a positivity ratio for each individual (Fredrickson & Losada, 2005; Diehl et al., 2011). First, each participant's positive affect and negative affect scores were summed across all 10 positive affect and 10 negative affect items. Given that individuals have been shown to process positive affect and negative affect differently, different thresholds for positive affect and negative affect were required (Cacioppo & Berntson, 1999; Cacioppo & Gardner, 1999; Ito & Cacioppo, 2005). Specifically, the negativity bias states that when presented with negative stimuli, individuals will have stronger reactions than if they were presented with positive stimuli of the same magnitude

(Cacioppo & Berntson, 1999; Cacioppo & Gardner, 1999; Ito & Cacioppo, 2005). However, the positivity offset theory indicates that even when an individual is receiving little or no input from stimuli, regardless of if the stimuli is positive or negative, the individual will still report experiencing at least some positive affect (Cacioppo, Gardner, & Berntson, 1999).

When calculating positivity ratios for each individual, participant positive affect ratings that are ≥3 were included to account for the positivity offset. Participant negative affect ratings that are ≥2 were included to offset the negativity bias. These thresholds are in line with previous standards established by Diehl and colleagues (2011). Consequently, the positivity ratio was created from 10 positive affect and 10 negative affect items, with each positive affect item ≥3 and each negative affect item ≥2 contributing one point to the overall positivity ratio score.

The final positivity ratio for each participant was calculated by dividing the sum of their positive affect score by the sum of their negative affect score (Diehl et al., 2011; Fredrickson & Losada, 2005). Higher ratios indicate the presence of more trait positive affect in comparison to negative affect. For the sample participant (Table 2), the amount of all positive affect scores ≥3 is 7, and the amount of all negative affect scores ≥2 in 6. To calculate the individual's positivity ratio, we divided the number of positive affect items included by the number of negative affect items included in the final score: 7/6 = 1.17.

Table 2

Valence and arousal positivity ratios. Based on the Circumplex Model of Affect (Russell, 1980), affective experiences can be divided into four quadrants: (1) high arousal and high valence; (2) high arousal and low valence; (3) low arousal and high valence; and (4) low arousal and low valence (Figure 1). For the purpose of my thesis, in addition to creating an overall affect positivity ratio, I sought to create two positivity ratios based on the arousal dimension: (1) the high arousal positivity ratio and (2) the low arousal positivity ratio. Both high and low arousal positivity ratios would be calculated in the same fashion as the overall positivity ratio. Since I would be comparing high arousal positive affect to high arousal negative affect, I would split the items into two groups based upon which quadrants they occupy in the Circumplex Model of Affect (i.e., high arousal affect: top left and right quadrants; low arousal affect: bottom left and right quadrants). Given that several of the MIDUS-II positive affect and negative affect items are not directly represented on the original Circumplex Model of Affect (Russell, 1980), I conducted an exploratory factor analysis (EFA) for all items (Table 12), to determine which factors (high arousal, low arousal, or perhaps neither) the items would map onto.

Sleep. In order to capture the multifaceted nature of sleep disturbance, I used data acquired from both subjective and objective measures of sleep. Specifically, global perceptions of sleep quality were assessed using the PSQI, daily perceptions of specific sleep parameters were assessed using a daily sleep diary, and objective assessments of sleep were provided by actigraphy. Table 3 summarizes the sleep variables used in the analyses for this study.

Pittsburgh Sleep Quality Index (PSQI). The PSQI (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) measures sleep quality subjectively by asking participants to answer questions based on their sleep habits over the past month. Participants are asked to reply based on their sleep experience for the majority of days and nights. Overall, the PSQI contains 19 self-rated items, which measure seven sleep components. The measure also contains 5 items that are rated by the participant's bed partner/roommate. The seven sleep components include: (1) subjective sleep quality, (2) sleep latency, (3) sleep duration, (4) habitual sleep efficiency, (5) sleep disturbance, (6) use of sleeping medications, and (7) daytime dysfunction. The seven sleep component scores have been shown to be internally consistent ($\alpha = 0.83$; Buysse et al., 1988). The PSQI also provides a global sleep score (GSS), which sums the data from the seven components and provides an overall rating of an individual's sleep. The global sleep score is reverse scored, so that higher scores are indicative of poorer sleep. A global sleep score greater than 5 has been shown to differentiate poor sleepers from good sleepers ($\alpha = 0.75$, $p < .001$; Buysse et al., 1988). The PSQI overall, and the global sleep score independently, have both been shown valid. Specifically, the PSQI has the ability to differentiate between groups that vary in sleep disturbance (e.g., patients with sleep disorders, patients with depression, and controls; Buysse et al., 1988), and the global sleep score is considered the most valid of the PSQI variables (Buysse et al., 1988). The global sleep score was used for the present study, as it provides an overall 'global' assessment of sleep that complements the information about specific sleep outcomes provided by sleep diaries and actigraphy.

Daily sleep diary. The daily sleep diary is a self-report measure, consisting of questions that participants answer for seven days. Sleep diaries provide a repeated assessment of sleep behavior, which can incorporate variability across weekdays and weekends (Carney et al., 2012). The questions are completed within 10 minutes of awakening, and assess: (1) whether the individual used sleep medications or supplements to help with sleep; (2) time they went to bed, (3) amount of time it took the individual to fall asleep; (4) how difficult it was for the individual to fall asleep; (5) number of nighttime awakenings; (6) what time the individual woke up for the day and did not go back to sleep; (7) what time the individual got out of bed for the day; and (8) a rating of the individual's overall sleep quality. Using the daily sleep diary that is a part of MIDUS-II, we included the following variables in final analyses: sleep onset latency (SOL) and self report of sleep quality (SRSQ).

Actigraphy. Actigraphic data was collected using the ACTIWATCH®-64, a wrist-worn activity logger that has a built-in motion sensor, a piezoelectric accelerometer (Montgomery-Downs, Insana, & Bond, 2012). Actigraphy detects and records motion and uses an established algorithm to analyze individual activity patterns to determine wake and sleep periods. The activity loggers were set to detect the number of movements in 30-second intervals (epochs) and programmed to start data collection at 7:00 am the day after the participant was given the logger. The participants wore the ACTIWATCH®-64 from the day data collection began until one week later. Daily sleep diaries were used in conjunction with actigraphy data to set the intervals during which the participant reported going to sleep and waking up.

Actigraphy is commonly used in research and clinical settings as an objective assessment of sleep that participants can wear within the home, across multiple nights. Actigraphy is shown to be reliable and valid in distinguishing between sleep and wakeful states (Sadeh, Alster, Urbach, & Lavie, 1989; Sadeh, Hauri, Kripke, & Lavie, 1995). Actigraphy has also been shown valid for measuring sleep and wakefulness states in comparison with Polysomnographic recordings (Sadeh et al.,1995). However, it is recommended that actigraphy be paired with daily sleep diaries, as patients with disrupted sleep (e.g., individuals with insomnia) may spend time lying awake in bed, which is misidentified as sleep (Ancoli-Israel et al., 2015). The following actigraphic variables were used in final analyses: wake after sleep onset (WASO), sleep onset latency (SOL), total sleep time (TST), and sleep efficiency (SE).

Designs & Analyses

SPSS version 23 was used to perform all analyses. All assumptions for regression analyses were checked prior to beginning the analyses. Power calculations using G*Power (Faul, Erdfelder, Buchner, & Albert-Georg, 2009) suggested that for a hierarchical multiple regression analysis with 4 predictors, a sample size of at least 395 participants is needed to predict an R^2 of at least 0.02 at an alpha level of 0.05, with a power of 0.80. As a result, my study was adequately powered.

Several covariates were entered into the analyses given their known associations with sleep. Specifically, I controlled for age (Ohayon et al., 2004), gender (Reyner & Horne, 1995), and self-evaluated physical health (McCrae et al., 2008). Also, given the multiple sleep variables for both the sleep diary and actigraphy measures, and the lack of a precedent linking the positivity ratio to specific sleep variables, I first ran preliminary correlations with the positivity ratio predicting all sleep outcome variables. Significant sleep variables were used as outcomes in the regression analyses.

For the aim one analyses, hierarchical linear regressions were performed with the covariates entered in the first step and the positivity ratio entered in the second step. Subjective and objective sleep outcomes were entered as the dependent variable for each regression using the variables identified by preliminary correlations. To determine the presence of valence and arousal dimensions in the positive affect and negative affect variables, an Exploratory Factor Analysis was conducted to see which factors, if any, the variables would load onto.

For the aim two analyses, hierarchical linear regressions were performed again, controlling for gender and health in step one and adding age as a continuous variable in step two, predicting the positivity ratio.

For aim three, Hayes' SPSS PROCESS macro was used to test for age as a moderator in the positivity ratio and sleep outcomes relationships. PROCESS automatically generates the proportion of variance in the sleep outcome variable (Y) that can be uniquely attributed to the moderation of the positivity ratio's effect (X) by age (M). PROCESS also provides a regression coefficient (b_3) that quantifies the extent to which the effect of X on Y is altered by changes in M by one unit (Hayes, 2013). If b_3 is statistically different from zero, the null hypothesis will be rejected and it can be inferred that age does in fact partially moderate the association between the positivity ratio and sleep outcomes.

Results

Meeting Regression-Based Assumptions

The assumption of linearity was met. Outliers were removed so that data met the assumptions of univariate and multivariate normality. Square root transformations were applied to the positivity ratio and the actigraphic sleep onset latency and wake after sleep onset variables. Log transformations were applied to the sleep diary wake after sleep onset and sleep onset latency variables. Transformed data was used in all analyses except for the ANOVA analysis of the positivity ratio. Additionally, normally distributed errors were checked and met.

Preliminary Correlations

Preliminary correlations (Table 4) revealed the positivity ratio to be positively correlated with sleep efficiency (actigraphy), r (396) = .23, $p < .001$ and total sleep time (actigraphy), r (396) = .16, $p < .01$. The positivity ratio was also negatively correlated with the following variables: sleep onset latency (daily sleep diary), r (400) = -.12, $p < .05$, self reported sleep quality (daily sleep diary), r (423) = -.25, $p < .001$, the global sleep score, r (1170) = -.30, $p < .001$, sleep onset latency (actigraphy), r (396) = -.20, $p < .001$, and wake after sleep onset, r (396) = -.12, $p < .05$. The positivity ratio was not significantly correlated with the actigraphy variable wake after sleep onset, r (395) = .07, $p = .180$. As a result, the following variables were included in final analyses of all aims: sleep onset latency (daily sleep diary), self reported sleep quality (daily sleep diary), sleep efficiency (actigraphy), sleep onset latency (actigraphy), wake after sleep onset (actigraphy), total sleep time (actigraphy), and the global sleep score (Table 3).

Affect Predicting Subjective and Objective Sleep Outcomes

To investigate how the positivity ratio predicts sleep, when controlling for age, gender, and self-evaluated physical health, a series of hierarchical linear regressions were computed.

Global sleep score. Covariates significantly predicted the global sleep score, $F(3, 995) = 40.93$, $p < .001$, $R^2 = .110$ (Table 5). When the positivity ratio was added to the model, it significantly improved the prediction, $\Delta R^2 = .039$, $p < .001$, and the model significantly predicted the global sleep score, $F(4, 994) = 43.54$, $p < .001$, $R^2 = .149$. Overall, greater positivity ratio scores predicted lower global sleep scores (i.e., better sleep), $\beta = -.937$, $t\ (997) = -6.77$, $p < .001$.

Self-reported sleep quality as measured by daily sleep diary. Self-reported sleep quality was significantly predicted by covariates (Table 7), $F(3, 298) = 9.95$, $p < .001$, $R^2 = .091$. The prediction was significantly improved by the addition of the positivity ratio to the model, $\Delta R^2 = .033$, $p = .001$, and the model significantly predicted self-reported sleep quality, $F(4, 297) = 10.54$, $p < .001$, $R^2 = .124$. Overall, self-reported sleep quality was significantly predicted by the positivity ratio, so that positivity ratio scores predicted lower self-reported sleep quality scores (i.e., which is indicative of better sleep quality given the reverse scoring of the scale), $\beta = -.187$, $t\ (300) = -3.36$, $p = .001$.

Sleep onset latency as measured by daily sleep diary. Covariates significantly predicted participant sleep onset latency (Table 6), $F(3, 284) = 4.37$, $p = .005$, $R^2 = .044$. When the positivity ratio was added to the model, it did not significantly improve the overall model, $\Delta R^2 = .001$, $p = .664$, and did not significantly predict participant sleep onset latency, $\beta = -.013$, t

(286) = -.434, p = .664. However, the overall model still significantly predicted sleep onset latency, $F(4, 283) = 3.32$, $p = .011$, $R^2 = .045$.

Sleep efficiency as measured by actigraphy. Sleep efficiency was significantly predicted by covariates (Table 8), $F(3, 292) = 16.94$, $p < .001$, $R^2 = .148$. The addition of the positivity ratio to the model did not significantly improve the prediction, $\Delta R^2 = .000$, $p = .685$. Overall, the final model predicted sleep efficiency as measured by actigraphy, $F(4, 291) = 12.71$, $p < .001$, $R^2 = .149$, but the positivity ratio did not significantly predict sleep efficiency, β = .270, t (294) = .406, $p = .685$.

Sleep onset latency as measured by actigraphy. Covariates significantly predicted sleep onset latency (Table 9), $F(3, 292) = 10.98$, $p < .001$, $R^2 = .101$. However, adding the positivity ratio to the model did not significantly improve the prediction, $\Delta R^2 = .004$, $p = .255$. The final model significantly predicted sleep onset latency as measured by actigraphy, $F(4, 291) = 8.57$, $p < .001$, $R^2 = .105$. However, sleep onset latency was not significantly predicted by the positivity ratio, β = -.180, t (294) = -1.140, $p = .255$.

Total sleep time as measured by actigraphy. Total sleep time was significantly predicted by covariates (Table 10), $F(3, 292) = 9.57$, $p < .001$, $R^2 = .090$. The addition of the positivity ratio did not significantly improve the model, $\Delta R^2 = .002$, $p = .478$. However, the final model still significantly predicted total sleep time as measured by actigraphy, $F(4, 291) = 7.29$, $p < .001$, $R^2 = .091$. Additionally, the positivity ratio did not significantly predict total sleep time, β = 3.47, t (294) = .711, $p = .478$.

Wake after sleep onset as measured by actigraphy. Covariates significantly predicted wake after sleep onset (Table 11), $F(3, 292) = 6.80$, $p < .001$, $R^2 = .065$. When the positivity ratio was added to the model, the prediction was not significantly improved, $\Delta R^2 = .002$, $p = .429$. The final model revealed a significant prediction of wake after sleep onset as measured by actigraphy, $F(4, 291) = 5.250$, $p < .001$, $R^2 = .067$. Also, the positivity ratio was not a significant predictor of wake after sleep onset, $\beta = .091$, t (294) = .793, $p = .429$.

High and Low Arousal Positivity Ratios Predicting Sleep

Before examining how the two dimensions of the positivity ratio based on valence and arousal are associated with subjective and objective sleep outcomes, an exploratory factor analysis was performed to determine which variables of the MIDUS-II PANAS corresponded to the high and low arousal positivity ratios.

Exploratory Factor Analysis. Data were subjected to factor analysis using Principal Axis Factoring and orthogonal Varimax rotation. The Kaiser-Meyer-Olkin measure (KMO) was .94, showing that the data could be subjected to an EFA. Bartlett's test of sphericity confirmed that patterned relationships exist within the items, x^2 (190) = 17551.92, $p < .001$. With an eigenvalue cut-off of 1.0, the data revealed two factors, which was confirmed by the scree plot. These two factors explained a cumulative variance of 60.86%. Table 12 contains the factor loadings present after rotation with .4 as the significant factor criterion. Given that the factor loadings revealed only two factors (positive affect and negative affect) instead of four (positive affect high and low arousal and negative affect high and low arousal), we can conclude that the MIDUS-II PANAS factors cannot be broken down into high arousal and low arousal positivity ratios. Thus, Aims 1.2, 2.2, and 3.2 could not be examined.

Age Predicting the Positivity Ratio

To investigate the association between age and the positivity ratio, when controlling for gender and self-evaluated physical health, a hierarchical linear regression was conducted (Table 13). Covariates significantly predicted positivity ratio scores, $F(2, 1051) = 47.18$, $p < .001$, R^2 =

.082. When age was added to the model, it significantly improved the prediction, $\Delta R^2 = .066$, $p <$ .001, and the model significantly predicted positivity ratio scores, $F(3, 1050) = 60.87$, $p < .001$, $R^2 = .148$. Overall, increasing age predicted higher positivity ratios, β = .017, t (1052) = 9.00, $p <$ .001.

Additional follow-up analyses were run to further explore the relationship between the positivity ratio and age (Table 16). A one-way analysis of variance (ANOVA) was calculated on participants' positivity ratio scores to determine differences by age group. The analysis was significant, $F(2, 1252) = 36.65$, $p < .001$, indicating a significant variation among positivity ratio scores for participants age 39 and below (younger adults), age 40 to 64 (middle-aged adults), and age 65 and above (older adults). Comparisons indicate the younger adult and middle-aged adult positivity ratio scores were significantly different (Table 16), β = -.848, $p = .013$. Additionally, both younger and middle-aged adult positivity ratio scores significantly differed from older adult scores, β = 2.475, $p < .001$ and β = 1.628, $p < .001$, respectively. Overall, positivity ratios significantly increased with age.

Age Differences in the Positivity Ratio and Sleep Associations

Age was investigated as a moderator of the significant positivity ratio and sleep outcome associations, to determine if these associations are conditional upon age. Self-evaluated physical health and gender were included as covariates in all moderation analyses. In the positivity ratio and self-reported sleep quality association (Table 15), age was not a significant moderator, β = -.003, t(300) = -.625, p = .532, indicating that the relationship between the positivity ratio and self-reported sleep quality does not vary by age. Additionally, age was not a significant moderator for the positivity ratio and global sleep score association (Table 14), β = .014, t(997) = 1.272, p = .204, indicating that this relationship does not change based upon age.

Discussion

Positivity Ratio and Sleep Relationship

Overall, the positivity ratio was associated with better sleep outcomes on the PSQI global sleep score and daily sleep diary self-reported sleep quality measure, both of which are subjective measures. The positivity ratio was not significantly associated with the remaining subjective and objective measures. Prior studies have shown discrepancies between objective and subjective sleep data for younger (sleep onset latency, wake after sleep onset, total sleep time; Baker, Maloney, & Driver, 1999; Lauderdale, Knutson, Yan, Liu, & Rathouz, 2008), younger and middle-aged (sleep efficiency; Jackowska, Dockray, Hendrickx, & Steptoe, 2011), and older adults (total sleep time; Van Den Berg et al., 2008). This study found discrepancies between subjective and objective sleep reports within a lifespan sample, congruent with prior research performed with separate age samples. Additionally, only two of three subjective sleep measures were significantly predicted by the positivity ratio (i.e., the global sleep score and self-reported sleep quality were both significant, while sleep onset latency measured by daily sleep diaries was not). A possible explanation for the difference in subjective sleep findings is that the global sleep score and self-reported sleep quality measures are more qualitative, while sleep onset latency is a more quantitative measure, asking participants to remember a specific number of minutes. The qualitative measures may have been affected by the individual's affect or mood. Perhaps there is a connection between subjectively rated affect and subjectively rated sleep that the objective data misses. In fact, positive affect and life satisfaction have been shown to predict higher self-rated health in populations across adulthood (Siahpush, Spittal, & Singh, 2008). It is possible this effect extends to self-rated sleep measures, as higher levels of positive affect prior to sleep have been associated with better subjectively reported sleep quality (Gray and Watson, 2002; Stewart, Rand, Hawkins, and Stines, 2011). Perhaps if someone feels particularly happy when they fall asleep, they may wake up and subjectively report feeling more rested due to the increased positive affect, despite having poor sleep efficiency as measured through objective means. In contrast, objective measures of sleep, like actigraphy, are less influenced by affect. Though, this area needs to be researched further.

Overall, while sleep has been shown to predict affect (Baglioni et al., 2010; Bower et al., 2010; Totterdell et al., 1994), the present study examined the role of affect in predicting sleep. Specifically, a higher ratio of positive to negative affect, or a higher positivity ratio, predicted better overall global sleep efficiency and self-rated sleep efficiency. This finding is a unique addition to the literature as it assesses positive and negative affect *together* instead of *individually*. While we know sleep to be predicted by positive affect and negative affect assessed separately, the interaction between positive and negative affect in the prediction of sleep has not been examined. Previous literature links higher positivity ratios to better subjective wellbeing (Diehl, Hay, & Berg, 2011) and better mental health (Diehl et al., 2011; Fredrickson, 2013; Meeks et al., 2012), and this study extends the positive aspects of the positivity ratio to subjectively rated sleep quality.

Perhaps higher positivity ratios predict better sleep given that (a) positive affect is already linked to better sleep quality independently (Fredman et al., 2013; Ong et al., 2013; Song et al., 2015) and (b) lower levels of negative affect are beneficial in comparison to higher levels, which have been associated with poor sleep quality and disturbance (Stewart et al., 2011; Thomsen et al., 2003). Our sample's mean negative affect (M = 3.95, SD = 2.86) indicates that overall, some negative affect was present in the positivity ratio. The mean positive affect was much higher (M = 8.18, SD = 3.79), indicating higher levels of positive affect in comparison to negative affect within our sample. Overall, the mean positivity ratio was well above one (*M* = 3.25, *SD* = 3.19) indicating overall higher positive affect in ratio to negative affect across the sample. Notably, even with some negative affect present in the ratio, the positivity ratio still predicts better sleep outcomes. Perhaps positive affect is serving as a protective mechanism against the negative affect, which is similar to positive affect serving as a protective factor against stress and other psychosocial factors to predict better sleep (Ong et al., 2015). However, positive affect's role as a protective mechanism may be limited given that as negative affect continued to increase in relation to positive affect, the positivity ratio became smaller and predicted worse sleep. It is important that researchers explore the combination of positive and negative affect in predicting sleep outcomes because positive affect and negative affect do not work in isolation. The present results suggest that an individual with high positive affect *and* high negative affect will have poorer sleep than a counterpart with high positive affect and lower negative affect. If positive affect were studied in isolation, research would suggest that both individuals would have good sleep. However, by using the positivity ratio, we are privy to the full picture, which shows a differential association with sleep.

Age, Positivity Ratio, and Sleep

Previous research shows emotional wellbeing to improve with age, as outlined by the Socioemotional Selectivity Theory (Carstensen et al., 2011). Older adults report less negative affect and slight increases in positive affect in comparison to their younger counterparts (Carstensen et al., 2000). The current findings support these age differences, as the positivity ratio was found to increase with age. Follow-up analyses revealed that the mean positivity ratio for older adults (*M* = 4.62, *SD* = 3.78) was significantly higher than middle-aged (*M* = 2.99, *SD* = 3.00) and younger adult (*M* = 2.14, *SD* = 2.11) positivity ratio scores. The higher the positivity ratio, the greater the amount of positive affect to negative affect, showing that older adults within our sample indeed reported higher levels of positive affect in ratio to their negative affect levels when compared to younger participants, which corroborates prior research (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Gross et al., 1997).

Moderation of Positivity Ratio and Sleep Outcome Associations by Age

Additionally, this study sought to explore a possible moderation of the association between the positivity ratio and significant sleep outcomes by age. A possible explanation for the lack of age differences in this association is that there truly is not a moderation among the positivity ratio and global sleep score (the only significant regression association), signifying that the relationship between the positivity ratio and global sleep did not vary by age. Although affect levels differ between age groups, it seems whether affect is low or high, it is equally predictive of worse or better sleep for the different age groups. Affect is predictive of self-rated health across the lifespan (Siahpush, Spittal, & Singh, 2008) and we see the same predictive effect here with sleep. This result informs potential clinical implications, as the positivity ratio appears to be an equally good predictor of better global sleep across all age groups.

Limitations

Several limitations of the study arise from using the already established MIDUS-II dataset. For example, the dataset is racially homogeneous, which limits the generalizability of results, especially given the increasing heterogeneity of the American population. Another limitation is the time lapse in data collection between Project 1 and Project 4. Overall, the mean elapsed time between the completion of affect measures in Project 1 and sleep measures in Project 4 for the sample was 25.60 months (*SD* = 15.14). However, given that MIDUS-II affect measures are measuring trait, rather than state affect, a time lapse of this size is less detrimental than if we were measuring state affect. Additionally, a time delay between measures can have benefits, as common method biases are reduced (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Specifically, the potential common method bias produced by measuring predictor and criterion variables at the same time point is reduced, which could create artifactual covariance unrelated to construct content (Podsakoff et al., 2003).

Also, the sample within our study presented with global sleep scores above five (M = 6.23, SD = 3.68), which is indicative of poorer sleep, which may not completely represent the general population, as only 7.5% to 30% of the general population has been classified as having insomnia (Singareddy et al., 2012). However, given that sleep complaints have been on the rise in recent decades (Pandey & Phillips, 2015), and our participants are a community sample, the impaired sleep score over five may in fact be representative of the new general population global sleep score. More research is needed to examine this trend.

A final limitation of this study is the inability to screen the sample for sleep disorders (e.g., sleep apnea), or control for their use of medications (e.g., hypnotic medication and sleep aids). It should be noted that the PSQI global sleep score asks how often an individual has taken medication in the past month to help them sleep. However, the type of medication used, which could influence sleep outcomes, was not provided.

Implications and Future Directions

Overall, this study expands understanding of the associations between affect and sleep across the lifespan, through the lens of the novel gauge of positive affect and negative affect relative to one another - the positivity ratio. Instead of separating the two, the combination of positive and negative affect shows that they work in unison to predict sleep outcomes, which is a new approach in the field of affect and sleep research. Additionally, this study examines the positivity ratio's association with sleep outcomes in the presence of age effects, at an imperative time for aging in America.

There are both theoretical and clinical implications of this study. Theoretically, this study supports the findings that the positivity ratio improves with age and shows a link between the positivity ratio and positive subjective sleep outcomes throughout the lifespan. Clinically, this research can be applied in work with clients suffering from poor sleep. Importantly, emphasizing the focus of emotional regulation and cognitive components, as in CBTi, for sleep interventions instead of just focusing on behavioral modification may be helpful. More research is needed to examine the unique contribution of increasing the affective positivity ratio as a component of sleep treatment approaches.

Future research may consider exploring emotional arousal in the form of high arousal and low arousal positivity ratio variables and their relation to sleep outcomes. A new measure may need to be created to further assess the dimensions of valence and arousal in both positive and negative affect in order to be able to conduct this research. An additional examination of emotional arousal in relation to sleep across the lifespan is warranted given arousal is hypothesized to predict worse sleep for older adults in comparison to younger ages (Benloucif et al., 2004). An overall expansion on this topic will help to inform both theory and clinical work in a time when the population is aging and worsening sleep is being reported (Colby & Ortman, 2014; Pandey & Phillips, 2015).

Conclusion

Findings from the current study link higher positivity ratios to better subjectively rated sleep in the form of the global sleep score and daily sleep diary self-rated sleep quality, which corroborates previous literature associating higher trait positive affect with better sleep. This study expands upon existing literature by focusing on the association between a ratio of positive and negative affect to sleep outcomes, showing that a higher ratio of positive to negative affect is predictive of better global sleep and self-rated sleep quality. An attempt was made to separate the positivity ratio into valence and arousal dimensions and further assess how the two dimensions relate to subjective and objective sleep. However, exploratory factor analysis revealed only two factors (positive affect and negative affect) were present among the variables, which prevented the creation and examination of high and low arousal positivity ratios in relation to sleep outcomes.

Additionally, previous research links an increase in positive affect and wellbeing to increased age. Results from this study also show a positive trend in affect with increased age, in the form of an increase in positivity ratio scores with age. Specifically, as age increases, the amount of positive to negative affect present in an individual increases as well. Follow-up revealed the positivity ratio of older adults to be significantly higher than both middle-aged and young adults, which is consistent with prior research on affect and aging. This study also explored a possible moderation of the association between the positivity ratio and sleep outcomes by age. Results revealed no moderation of the positivity ratio and sleep associations, signifying that the association between the positivity ratio and sleep does not vary by age. This result informs potential clinical implications, as the positivity ratio appears to be an equally good predictor of better sleep across all adult age groups.

Follow-up analyses helped to further expand upon the information given by our sample. Results revealed the positivity ratio of older adults was significantly higher than both middle-aged and young adults, which is consistent with prior research on affect and aging.

Overall, this study shows the importance of also considering affect in behavioral sleep interventions, as affect is a predictor of sleep outcomes. Specifically, more research is necessary to examine both positive and negative affect in interventions, as both positive and negative affect were simultaneously predictive of sleep outcomes within this study.

References

Ancoli-Israel, S., Martin, J. L., Blackwell, T., Buenaver, L., Liu, L., Meltzer, L. J., ... & Taylor, D. J. (2015). The SBSM guide to actigraphy monitoring: Clinical and research applications. *Behavioral Sleep Medicine*, *13*, S4-S38.

Ancoli-Israel, S., Poceta, J. S., Stepnowsky, C., Martin, J., & Gehrman, P. (1997). Identification and treatment of sleep problems in the elderly. *Sleep Medicine Reviews*, *1*(1), 3-17.

Babson, K. A., & Feldner, M. T. (2015). Sleep and affect: An integrative synthesis and future directions. In K. A. Babson & M. T. Feldner (Eds.), *Sleep and Affect: Assessment, Theory, and Clinical Implications* (464-477). Academic Press.

Baglioni, C., Spiegelhalder, K., Lombardo, C., & Riemann, D. (2010). Sleep and emotions: a focus on insomnia. *Sleep Medicine Reviews*, *14*(4), 227-238.

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.

Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology*, *5*(4), 323-370.

Benloucif, S., Orbeta, L., Ortiz, R., Janssen, I., Finkel, S. I., Bleiberg, J., & Zee, P. C. (2004). Morning or evening activity improves neuropsychological performance and subjective sleep quality in older adults. *Sleep*, *27*(8), 1542-1551.

Bower, B., Bylsma, L. M., Morris, B. H., & Rottenberg, J. (2010). Poor reported sleep quality predicts low positive affect in daily life among healthy and mood-disordered persons. *Journal of Sleep Research*, *19*(2), 323-332.

Bradburn, N. M. (1969). *The structure of psychological well-being.* Chicago: Aldine.

Brown, N. J., Sokal, A. D., & Friedman, H. L. (2013). The complex dynamics of wishful thinking: The critical positivity ratio.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2), 193-213.

Cacioppo, J. T., & Berntson, G. G. (1999). The affect system architecture and operating characteristics. *Current Directions in Psychological Science*, *8*(5), 133-137.

Cacioppo, J. T., & Gardner, W. L. (1999). Emotion. *Annual Review of Psychology*, *50*(1), 191-214.

Cacioppo, J.T., Gardner, W.L., & Berntson, G.G. (1999). The affect system has parallel and integrative processing components: Form follows function. *Journal of Personality and Social Psychology, 76*, 839–855.

Carney, C. E., Buysse, D. J., Ancoli-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012). The consensus sleep diary: standardizing prospective sleep self-monitoring. *Sleep*, *35*(2), 287-302.

Carstensen, L. L., Isaacowitz D., & Charles, S. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist, 54*(3), 165-181.

Carstensen, L. L., & Mikels, J. A. (2005). At the intersection of emotion and cognition aging and the positivity effect. *Current Directions in Psychological Science*, *14*(3), 117-121.

Carstensen, L. L., Pasupathi, M., Mayr, U., & Nesselroade, J. R. (2000). Emotional experience in everyday life across the adult life span. *Journal of Personality and Social Psychology*, *79*(4), 644-655.

Carstensen, L. L., Turan, B., Scheibe, S., Ram, N., Ersner-Hershfield, H., Samanez-Larkin, G. R., ... & Nesselroade, J. R. (2011). Emotional experience improves with age: evidence based on over 10 years of experience sampling. *Psychology and Aging*, *26*(1), 21-33.

Charles, S. T. (2010). Strength and vulnerability integration: a model of emotional well-being across adulthood. *Psychological Bulletin*, *136*(6), 1068-1091.

Chen, H. C., Lin, C. M., Lee, M. B., & Chou, P. (2011). The relationship between pre-sleep arousal and spontaneous arousals from sleep in subjects referred for diagnostic polysomnograms. *Journal of the Chinese Medical Association*, *74*(2), 81-86.

Colby, S. L., & Ortman, J. M. (2014). The baby boom cohort in the United States: 2012 to 2060. *Current Population Reports. US Census Bureau, Washington, DC: P25-1141*.

Crowley, K. (2011). Sleep and sleep disorders in older adults. *Neuropsychology Review*, *21*(1), 41-53.

Diehl, M., Hay, E. L., & Berg, K. M. (2011). The ratio between positive and negative affect and flourishing mental health across adulthood. *Aging & Mental Health*, *15*(7), 882-893.

Diener, E., & Emmons, R. A. (1985). The independence of positive and negative affect. *Journal of Personality and Social Psychology, 47*(5), 1105-1117.

Espie, C. A., Lindsay, W. R., & Espie, L. C. (1989). Use of the Sleep Assessment Device (Kelley and Lichstein, 1980) to validate insomniacs' self-report of sleep pattern. *Journal of Psychopathology and Behavioral Assessment*, *11*(1), 71-79.

Fairholme, C. P., & Manber, R. (2015). Sleep, emotions, and emotion regulation: An overview. In K. A. Babson & M. T. Feldner (Eds.), *Sleep and Affect: Assessment, Theory, and Clinical Implications* (464-477). Academic Press.

Faul, F., Erdfelder, E., Buchner, A., & Albert-Georg, L. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149-1160.

Fazio, A. (1977). A concurrent validational study of the NCHS General Well-Being Schedule. In *Vital and Health Statistics Publications* (Series 2, No. 73). Washington, DC: U.S. Government Printing Office.

Folkman, S. (2008). The case for positive emotions in the stress process. *Anxiety, Stress, and Coping*, *21*(1), 3-14.

Fredman, L., Gordon, S. A., Heeren, T., & Stuver, S. O. (2013). Positive affect is associated with fewer sleep problems in older caregivers but not noncaregivers. *The Gerontologist*, *54*(4), 559-569.

Fredrickson, B. L. (2013). Updated thinking on positivity ratios. *American Psychologist, 68*(9), 814-822.

Fredrickson, B. L., Cohn, M. A., Coffey, K. A., Pek, J., & Finkel, S. M. (2008). Open hearts build lives: positive emotions, induced through loving-kindness meditation, build consequential personal resources. *Journal of Personality and Social Psychology*, *95*(5), 1045-1062.

Fredrickson, B. L., & Losada, M. F. (2005). Positive affect and the complex dynamics of human flourishing. *American Psychologist*, *60*(7), 678-686.

Gelso, C. J., & Fretz, B. R. (1992). *Counseling Psychology*. Fort Worth, TX: Harcourt Brace Jovanovich.

Gray, E. K., & Watson, D. (2002). General and specific traits of personality and their relation to sleep and academic performance. *Journal of Personality, 70*(2), 177-206.

Gross, J. J., Carstensen, L. L., Pasupathi, M., Tsai, J., Götestam Skorpen, C., & Hsu, A. Y.

(1997). Emotion and aging: experience, expression, and control. *Psychology and Aging*, *12*(4), 590-599.

Hay, E. L., & Diehl, M. (2011). Emotion complexity and emotion regulation across adulthood. *European Journal of Ageing*, *8*(3), 157-168.

Hayes, A. F. (2013). *An introduction to mediation, moderation, and conditional process analysis*. New York: The Guilford Press.

Ito, T., & Cacioppo, J. (2005). Variations on a human universal: Individual differences in positivity offset and negativity bias. *Cognition & Emotion*, *19*(1), 1-26.

Jackowska, M., Dockray, S., Hendrickx, H., & Steptoe, A. (2011). Psychosocial factors and sleep efficiency: discrepancies between subjective and objective evaluations of sleep. *Psychosomatic Medicine*, *73*(9), 810-816.

Kessler, E. M., & Staudinger, U. M. (2009). Affective experience in adulthood and old age: The role of affective arousal and perceived affect regulation. *Psychology and Aging*, *24*(2), 349-362.

Kessler, R. C , McGonagle, K. A., Zhao, S., Nelson, C. B., Hughes, M., Eshleman, S., Wittchen, H. U., & Kendler, K. S. (1994). Lifetime and 12-month prevalence of DSM-H-R psychiatric disorders in the United States. *Archives of General Psychiatry, 51,* 8-19.

Lauderdale, D. S., Knutson, K. L., Yan, L. L., Liu, K., & Rathouz, P. J. (2008). Self-reported and measured sleep duration: how similar are they?. *Epidemiology (Cambridge, Mass.)*, *19*(6), 838-845.

Lawton, M. P., Kleban, M. H., Rajagopal, D., & Dean, J. (1992). Dimensions of affective experience in three age groups. *Psychology and Aging*, *7*(2), 171-184.

Lichstein, K. L., & Rosenthal, T. L. (1980). Insomniacs' perceptions of cognitive versus somatic determinants of sleep disturbance. *Journal of Abnormal Psychology*, *89*(1), 105-107.

MacMillan, A. M. (1957). The Health Opinion Survey: Techniques for estimating prevalence of psychoneurotic and related types of disorder in communities. *Psychological Reports, 3,* 325-339.

McCrae C. S., Wilson, N. M., Lichstein, K. L., Durrence, H. H., Taylor, D. J., Riedel, B. W., & Bush, A. J. (2008) Self-reported sleep, demographics, health, and daytime functioning in young old and old old community-dwelling seniors. *Behavioral Sleep Medicine, 6*, 106-126.

Means, M. K., Edinger, J. D., Glenn, D. M., & Fins, A. I. (2003). Accuracy of sleep perceptions among insomnia sufferers and normal sleepers. *Sleep Medicine*, *4*(4), 285-296.

Meeks, S., Van Haitsma, K., Kostiwa, I., & Murrell, S. A. (2012). Positivity and well-being among community-residing elders and nursing home residents: what is the optimal affect balance?. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *67*(4), 460-467.

Montgomery-Downs, H. E., Insana, S. P., & Bond, J. A. (2012). Movement toward a novel activity monitoring device. *Sleep and Breathing*, *16*(3), 913-917.

Morin, C. M., Rodrigue, S., & Ivers, H. (2003). Role of stress, arousal, and coping skills in primary insomnia. *Psychosomatic Medicine*, *65*(2), 259-267.

Mroczek, D. K., & Kolarz, C. M. (1998). The effect of age on positive and negative affect: a developmental perspective on happiness. *Journal of Personality and Social Psychology*, *75*(5), 1333-1349.

Neikrug, A. B., & Ancoli-Israel, S. (2010). Sleep disorders in the older adult–a mini-review. *Gerontology*, *56*(2), 181-189.

Nicassio, P. M., Mendlowitz, D. R., Fussell, J. J., & Petras, L. (1985). The phenomenology of the pre-sleep state: the development of the pre-sleep arousal scale. *Behaviour Research and Therapy*, *23*(3), 263-271.

Norlander, T., Johansson, Å., & Bood, S. Å. (2005). The affective personality: Its relation to quality of sleep, well-being and stress. *Social Behavior and Personality: An International Journal*, *33*(7), 709-722.

Ohayon, M. M., Carskadon, M. A., Guilleminault, C., & Vitiello, M. V. (2004). Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep*, *27*(7), 1255-1274.

Ong, A. D., Bastarache, E. D., & Steptoe, A. (2015). Positive affect as resilience and vulnerability in sleep. In K. A. Babson & M. T. Feldner (Eds.), *Sleep and Affect: Assessment, Theory, and Clinical Implications* (464-477). Academic Press.

Ong, A. D., Exner-Cortens, D., Riffin, C., Steptoe, A., Zautra, A., & Almeida, D. M. (2013). Linking stable and dynamic features of positive affect to sleep. *Annals of Behavioral Medicine*, *46*(1), 52-61.

Pandey, S., & Phillips, B. A. (2015). Why is the prevalence of insomnia skyrocketing? And what can be done about it?. *Sleep Medicine, 16*(5), 555-556.

Pinquart, M. (2001). Correlates of subjective health in older adults: a meta-analysis. *Psychology and Aging*, *16*(3), 414-426.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879-903.

Radloff, L. S. (1977). The CES-D scales: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1,* 385-405.

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

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*(6), 1161-1178.

Russell, J. A. (1989). Measures of emotion. In R. Plutchik, & H, Kellerman (Eds.), *The measurement of emotions. Emotion: Theory, research, and experience, Vol. 4* (83-111). San Diego, CA: Academic Press.

Sadeh, A., Alster, J., Urbach, D., & Lavie, P. (1989). Actigraphically based automatic bedtime sleep-wake scoring: validity and clinical applications. *Journal of Ambulatory Monitoring*, *2*(3), 209-216.

Sadeh, A., Hauri, P. J., Kripke, D. F., & Lavie, P. (1995). The role of actigraphy in the evaluation of sleep disorders. *Sleep*, *18*(4), 288-302.

Sateia, M. J., Doghramji, K., Hauri, P. J., & Morin, C. M. (1999). Evaluation of chronic insomnia. *Sleep, 23*(2), 1-66.

Shoji, K. D., McCrae, C. S., & Dautovich, N. D. (2013). Age differences in the role of cognitive versus somatic arousal in sleep outcomes. *Behavioral Sleep Medicine*, *12*(4), 257-271.

Shoji, K. D., Tighe, C. A., Dautovich, N. D., & McCrae, C. S. (2015). Beyond mean values: Quantifying intraindividual variability in pre-sleep arousal and sleep in younger and older community-dwelling adults. *Sleep Science*, *8*(1), 24-30.

Siahpush, M., Spittal, M., & Singh, G. K. (2008). Happiness and life satisfaction prospectively predict self-rated health, physical health, and the presence of limiting, long-term health conditions. *American Journal of Health Promotion*, *23*(1), 18-26.

Singareddy, R., Vgontzas, A. N., Fernandez-Mendoza, J., Liao, D., Calhoun, S., Shaffer, M. L., & Bixler, E. O. (2012). Risk factors for incident chronic insomnia: a general population prospective study. *Sleep Medicine*, *13*(4), 346-353.

Song, S., Graham-Engeland, J. E., Mogle, J., & Martire, L. M. (2015). The effects of daily mood and couple interactions on the sleep quality of older adults with chronic pain. *Journal of Behavioral Medicine*, *38*(6), 944-955.

Steptoe, A., O'Donnell, K., Marmot, M., & Wardle, J. (2008). Positive affect, psychological well-being, and good sleep. *Journal of Psychosomatic Research*, *64*(4), 409-415.

Stewart, J. C., Rand, K. L., Hawkins, M. A., & Stines, J. A. (2011). Associations of the shared and unique aspects of positive and negative emotional factors with sleep quality. *Personality and Individual Differences*, *50*(5), 609-614.

Talamini, L. M., Bringmann, L. F., de Boer, M., & Hofman, W. F. (2013). Sleeping worries away or worrying away sleep? Physiological evidence on sleep-emotion interactions.

Taylor, J. A. (1953). A personality scale of manifest anxiety. *Journal of Abnormal and Social Psychology, 48,* 285-290.

Thomsen, D. K., Mehlsen, M. Y., Christensen, S., & Zachariae, R. (2003). Rumination—relationship with negative mood and sleep quality. *Personality and Individual Differences*, *34*(7), 1293-1301.

Totterdell, P., Reynolds, S., Parkinson, B., & Briner, R. B. (1994). Associations of sleep with everyday mood, minor symptoms and social interaction experience. *Sleep: Journal of Sleep Research & Sleep Medicine, 17,* 466-475.

Tsuno, N., Besset, A., & Ritchie, K. (2005). Sleep and depression. *Journal of Clinical*

Psychiatry, *66*(10), 1254-1269.

Vandekerckhove, M., Weiss, R., Schotte, C., Exadaktylos, V., Haex, B., Verbraecken, J., & Cluydts, R. (2011). The role of presleep negative emotion in sleep physiology. *Psychophysiology*, *48*(12), 1738-1744.

Van Den Berg, J. F., Van Rooij, F. J., Vos, H., Tulen, J. H., Hofman, A., Miedema, H. M., ... & Tiemeier, H. (2008). Disagreement between subjective and actigraphic measures of sleep duration in a population-based study of elderly persons. *Journal of Sleep Research*, *17*(3), 295-302.

Vaz Fragoso, C. A., & Gill, T. M. (2007). Sleep complaints in community-living older persons: a multifactorial geriatric syndrome. *Journal of the American Geriatrics Society*, *55*(11), 1853-1866.

Vitiello, M. V. (2007). Growing old should not mean sleeping poorly: recognizing and properly treating sleep disorders in older adults. *Journal of the American Geriatrics Society*, *55*(11), 1882-1883.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063-1070.

Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin*, *98*(2), 219-235.

Table 1

Participant Demographics

	Actigraphy Sample	GSS Sample	Daily Sleep Diary Sample
Variable		Statistic	
N	364	1172	388
M (*SD*) age (years)	54.40 (*11.72*)	54.52 (*11.71*)	53.96 (*11.68*)
Age range	34 – 83	34 - 84	34 - 83
Gender, % female	59.8%	56.8%	60.4%
Race, %			
White	94.9%	92.8%	95.0%
African American	1.4%	2.6%	1.3%
Native American or Alaska Native	1.4%	1.3%	1.3%
Asian	0.7%	0.3%	0.7%
Other	1.7%	2.8%	1.7%
Marital Status, %			
Currently Married	65.8%	62.7%	63.8%
Separated	3.3%	2.8%	3.1%
Divorced	13.3%	16.6%	13.4%
Widowed	8.3%	7.2%	8.7%
Never Married	6.7%	6.1%	7.9%
Living with someone	2.5%	4.7%	3.1%
Self Rated Health			
Excellent	18.9%	19.8%	18.9%
Very Good	43.9%	41.8%	44.7%
Good	28.4%	28.8%	27.8%
Fair	7.4%	7.8%	7.3%
Poor	1.4%	1.7%	1.3%
M (*SD*) Positivity Ratio	3.04 (*3.04)*	3.26 (*3.19)*	2.95 (*2.98*)
M (*SD*) Global Sleep Score	6.24 (*3.65*)	6.23 (3.69)	6.31 (*3.72*)
Actigraphy			
M (*SD*) Sleep Efficiency	79.85 (*10.30*)	--	--
M (*SD*) SOL (min)	30.25 (*31.27*)	--	--
M (*SD*) WASO (min)	47.99 (*23.23*)	--	--
M (*SD*) TST (min)	371.77 (*65.07)*	--	--
Daily Sleep Diary			
M (*SD*) Self Rated Sleep Quality[a]	--	--	2.40 (*0.76*)
M (*SD*) SOL (min)	--	--	34.41 *(174.12)*
M (*SD*) WASO (# times)	--	--	2.07 *(2.13)*

Note. [a] denotes reverse-coded scales.
Note. SOL = sleep onset latency, WASO = wake after sleep onset, TST = total sleep time

Table 2

Sample Participant Positive Affect and Negative Affect Scores

Positive Affect Items (1 – 10)	**Included/Not Included in Sum**	**Negative Affect Items (1 – 10)**	**Included/Not Included in Sum**
5	Included	1	Not Included
4	Included	2	Included
1	Not Included	3	Included
1	Not Included	2	Included
3	Included	5	Included
2	Not Included	1	Not Included
5	Included	4	Included
5	Included	1	Not Included
4	Included	1	Not Included
3	Included	3	Included
Sum = 29		**Sum = 19**	

Table 3

Summary Table of Sleep Variables for Analyses

Actigraphy (Objective)	**Daily Sleep Diary (Subjective)**	**PSQI (Subjective)**
1. Wake After Sleep Onset (WASO) 2. Sleep Onset Latency (SOL) 3. Total Sleep Time (TST) 4. Sleep Efficiency (SE)	1. Sleep Onset Latency (SOL) 2. Self Report of Sleep Quality (SRSQ)	1. Global Sleep Score (GSS)

Table 4

Preliminary Correlation Results

Measure	1	2	3	4	5	6	7	8	9
1. Positivity Ratio	—								
2. SOL *(D)*	-.12*	—							
3. WASO *(D)*	.07	.25***	—						
4. Sleep Efficiency *(A)*	.23***	-.12*	.02	—					
5. SOL *(A)*	-.20***	.14**	-.09	-.77***	—				
6. WASO *(A)*	-.12*	.16**	.25***	-.62***	.32***	—			
7. SRSQ *(D)*	-.25***	.39***	.27***	-.13*	.05	.19***	—		
8. TST *(A)*	.16**	.03	.22***	.63***	-.39***	-.09	-.06	—	
9. GSS	-.30***	.44***	.18***	-.26***	.19***	.26***	.52***	-.11*	—

Note. *(A)* denotes actigraphy, while *(D)* denotes daily sleep diary data.
Note. SOL = sleep onset latency, WASO = wake after sleep onset, SRSQ = self-reported sleep quality, TST = total sleep time, GSS = global sleep score
* *p* < .05, ***p* < 01, *** *p* < .001

Table 5

Regression Analysis: Predicting Global Sleep Score From Covariates and Positivity Ratio

Step 1	R^2= .110			Step 2	ΔR^2 = .039		
	B	SE *B*	β		*B*	SE *B*	β
Age	-.01	.01	-.04	Age	.01	.01	.02
Gender***	.99	.21	.14	Gender***	.90	.20	.13
Physical Health***	1.11	.11	.30	Physical Health***	.89	.11	.24
				Positivity Ratio***	-.94	.14	-.21

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

Table 6

Regression Analysis: Predicting Daily Sleep Diary Sleep Onset Latency From Covariates and Positivity Ratio

Step 1	R^2= .044			Step 2	ΔR^2 = .001		
	B	SE *B*	β		*B*	SE *B*	β
Age*	.00	.00	.14	Age*	.00	.00	.15
Gender*	.09	.04	.13	Gender*	.09	.04	.13
Physical Health	.04	.02	.10	Physical Health	.03	.02	.09
				Positivity Ratio	-.01	.03	-.03

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

Table 7

Regression Analysis: Predicting Self-Reported Sleep Quality From Covariates and Positivity Ratio

Step 1	R^2= .091			Step 2	ΔR^2 = .033		
	B	SE *B*	β		*B*	SE *B*	β
Age	-.01	.00	-.08	Age	-.00	.00	-.03
Gender	-.04	.08	-.03	Gender	-.04	.08	-.03
Physical Health***	.24	.04	.30	Physical Health***	.18	.05	.23
				Positivity Ratio**	-.19	.06	-.20

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

Table 8

Regression Analysis: Predicting Sleep Efficiency (actigraphy) From Covariates and Positivity Ratio

Step 1	R^2= .148			Step 2	ΔR^2 = .000		
	B	SE *B*	β		*B*	SE *B*	β
Age	-.03	.04	-.04	Age	-.04	.04	-.05
Gender***	5.30	.93	.31	Gender***	5.29	.93	.31
Physical Health***	-1.92	.52	-.20	Physical Health**	-1.85	.55	-.20
				Positivity Ratio	.27	.66	.02

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

Table 9

Regression Analysis: Predicting Sleep Onset Latency (actigraphy) From Covariates and Positivity Ratio

Step 1	R^2= .101			Step 2	ΔR^2 = .004		
	B	SE *B*	β		*B*	SE *B*	β
Age	.01	.01	.08	Age	.02	.01	.10
Gender***	-.90	.22	-.23	Gender***	-.90	.22	-.23
Physical Health**	.40	.12	.18	Physical Health**	.35	.13	.16
				Positivity Ratio	-.18	.16	-.07

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

Table 10

Regression Analysis: Predicting Total Sleep Time (actigraphy) From Covariates and Positivity Ratio

Step 1	R^2= .090			Step 2	ΔR^2 = .002		
	B	SE *B*	β		*B*	SE *B*	β
Age	.20	.28	.04	Age	.14	.30	.03
Gender***	35.75	6.86	.29	Gender***	35.67	6.86	.29
Physical Health	-4.25	3.79	-.06	Physical Health	-3.24	4.05	-.05
				Positivity Ratio	3.47	4.88	.04

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

Table 11

Regression Analysis: Predicting Wake After Sleep Onset (actigraphy) From Covariates and Positivity Ratio

Step 1	R^2= .065			Step 2	ΔR^2 = .002		
	B	SE *B*	β		*B*	SE *B*	β
Age	.01	.01	.06	Age	.01	.01	.05
Gender**	-.51	.16	-.18	Gender**	-.51	.16	-.18
Physical Health**	.23	.09	.15	Physical Health**	.26	.10	.17
				Positivity Ratio	.09	.12	.05

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

Table 12

Factor Loadings for the Exploratory Factor Analysis

	Factor 1	Factor 2
In good spirits	.916	
Cheerful	.902	
Attentive	.873	
Enthusiastic	.858	
Active	.841	
Satisfied	.833	
Calm and peaceful	.832	
Proud	.808	
Full of life	.786	
Extremely happy	.665	
Sad		.697
Hopeless		.678
Everything is an effort		.663
Ashamed		.633
Jittery		.596
Afraid		.593
Irritable	.354	.579
Worthless		.575
Upset	.364	.558
Restless		.546

Table 13

Regression Analysis: Predicting the Positivity Ratio From Covariates and Age

Step 1	R^2= .287			Step 2	Δ R^2 = .385		
	B	SE *B*	β		*B*	SE *B*	β
Gender**	-.14	.10	-.09	Gender*	-.11	.05	-.07
Physical Health***	-.23	.03	-.28	Physical Health***	-.24	.02	-.29
				Age***	.02	.00	.26

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

Table 14

Positivity Ratio Predicting GSS Moderated by Age

Parameter	*B*	SE *B*	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	5.273	1.292	4.080	.000	2.737	7.809
Age	-.021	.022	-.956	.339	-.064	.022
Positivity Ratio	-1.740	.646	-2.693	.007	-3.007	-.472
Positivity Ratio x Age	.014	.011	1.272	.204	-.008	.036
Gender	.915	.205	4.475	.000	.514	1.317
Physical Health	.885	.114	7.781	.000	.662	1.108

Table 15

Positivity Ratio Predicting Self-Reported Sleep Quality Moderated by Age

Parameter	*B*	SE *B*	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	2.129	.513	4.150	.000	1.120	3.139
Age	.004	.009	.398	.691	-.014	.021
Positivity Ratio	-.026	.265	-.096	.923	-.546	.495
Positivity Ratio x Age	-.003	.005	-.625	.532	-.012	.006
Gender	-.045	.078	-.580	.562	-.199	.109
Physical Health	.182	.046	3.924	.000	.091	.273

Table 16

ANOVA Descriptive Statistics: Positivity Ratio

Variable: Positivity Ratio	Mean	Standard Deviation	N
Older Adults	4.62	3.78	265
Middle-aged Adults	2.99	3.00	865
Young Adults	2.14	2.11	125
Total	3.25	3.19	1255

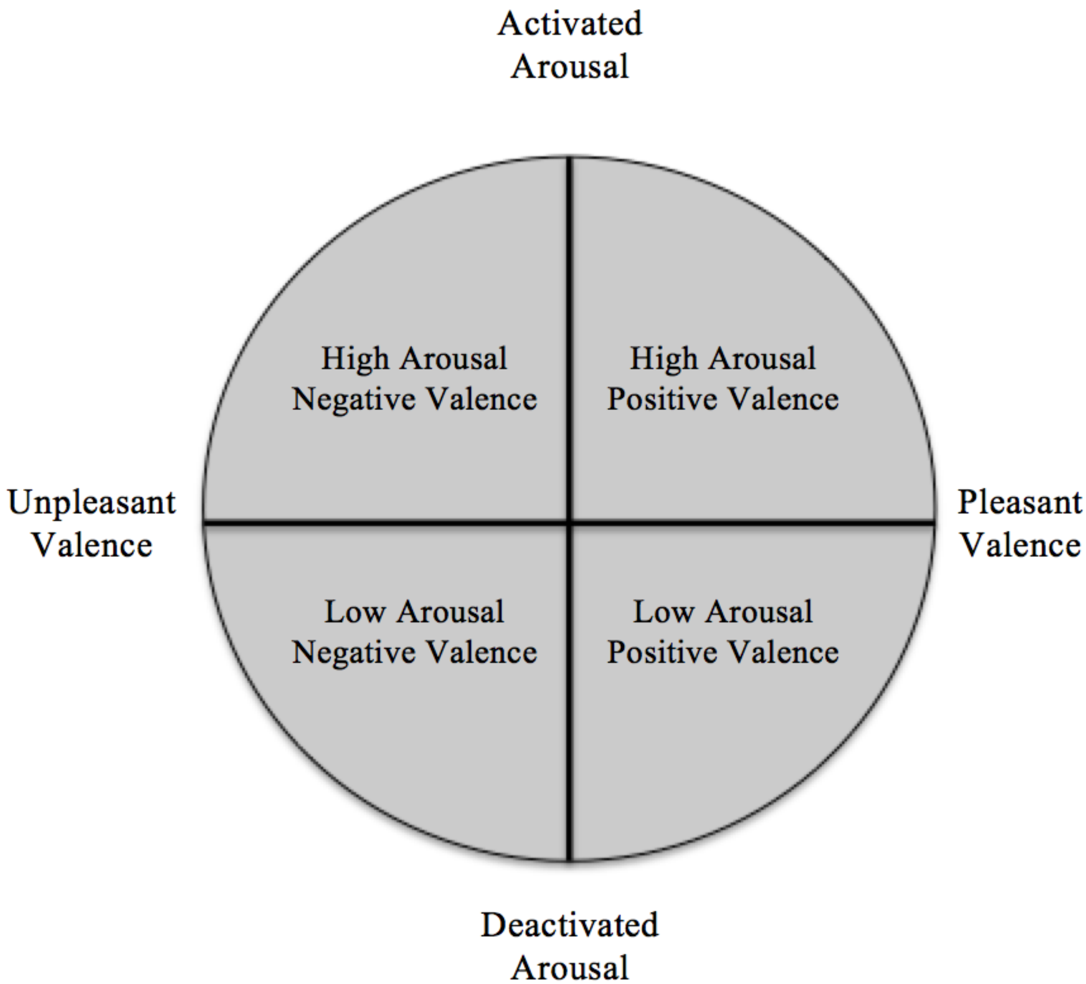

Figure 1. Circumplex Model of Affect. This figure illustrates the four quadrants of affective experiences.

Vita

Janna Lynn Imel was born on July 28, 1992 in Ashland, Kentucky. She graduated from Greenup County High School, Greenup, Kentucky, in 2010. She received her Bachelor of Arts in Psychology and a Certificate in Peace, Justice, and Conflict Transformation, from the University of Louisville, Louisville, KY in 2014. Ms. Imel is currently a third-year student in Virginia Commonwealth University's Counseling Psychology Ph.D. Program.