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Emotion Reactivity and Its Relation to Daily Affect and Sleep Experiences Among First Year College Students

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EMOTION REACTIVITY AND ITS RELATION TO DAILY AFFECT AND SLEEP EXPERIENCES AMONG FIRST YEAR COLLEGE STUDENTS

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ABSTRACT

Individuals with high emotion reactivity may be at increased likelihood to experience emotions more intensely, frequently, and for longer periods of time than those with low emotion reactivity. This might lead to more extreme fluctuations in their daily experience of emotion. Additionally, those high in emotion reactivity may be at risk for poor sleep. The transition to college has been shown to be a difficult time for some students, and potentially contribute to these emotional fluctuations and shorter sleep duration. However, students high in emotion reactivity might be more likely to experience the negative effects of this transition than those with low emotion reactivity. The present study examined emotion reactivity in the context of day-to-day emotional functioning and sleep duration across the transition to college. First year college students (n=244) completed an initial survey and seven days of daily diary, reporting on their affect and sleep duration. Results demonstrated that those who experienced high levels of emotion reactivity also experienced increased negative affect, and larger day to day variations in negative affect than those who were low in emotion reactivity. Additionally, on days when individuals reported increased sleep duration they also tended to experience greater positive affect the following day. Future research should continue to explore the relation between emotion reactivity and sleep.

CHAPTER ONE

INTRODUCTION

The transition from adolescence to adulthood is a risky period for the development and exacerbation of psychopathology as well as for possible negative changes in health behaviors including sleep. In particular, first year college students find themselves with new independence in unfamiliar environments along with increased social and academic stressors and decreased parental support. In some cases, this may lead to problems in daily functioning including extreme fluctuations in daily affect and sleep, perhaps especially for those with certain individual characteristics or traits. Emotion reactivity has been associated with negative affect (Claes, Smits, & Bijttebier, 2014; Nock, Wedig, Holmberg, & Hooley, 2008) and could be related sleep problems (Baglioni, Spiegelhalder, Lombardo, & Riemann, 2010), but studies have not examined emotion reactivity in relation to daily functioning. Studying individual differences in emotion reactivity may illuminate processes relevant to students' transition to college, and help to identify those who might be susceptible to difficulties during this period. As shown in Figure 1, the current study examines emotion reactivity in a sample of first year college students, and seeks to understand its relation to daily functioning, specifically affect and sleep.

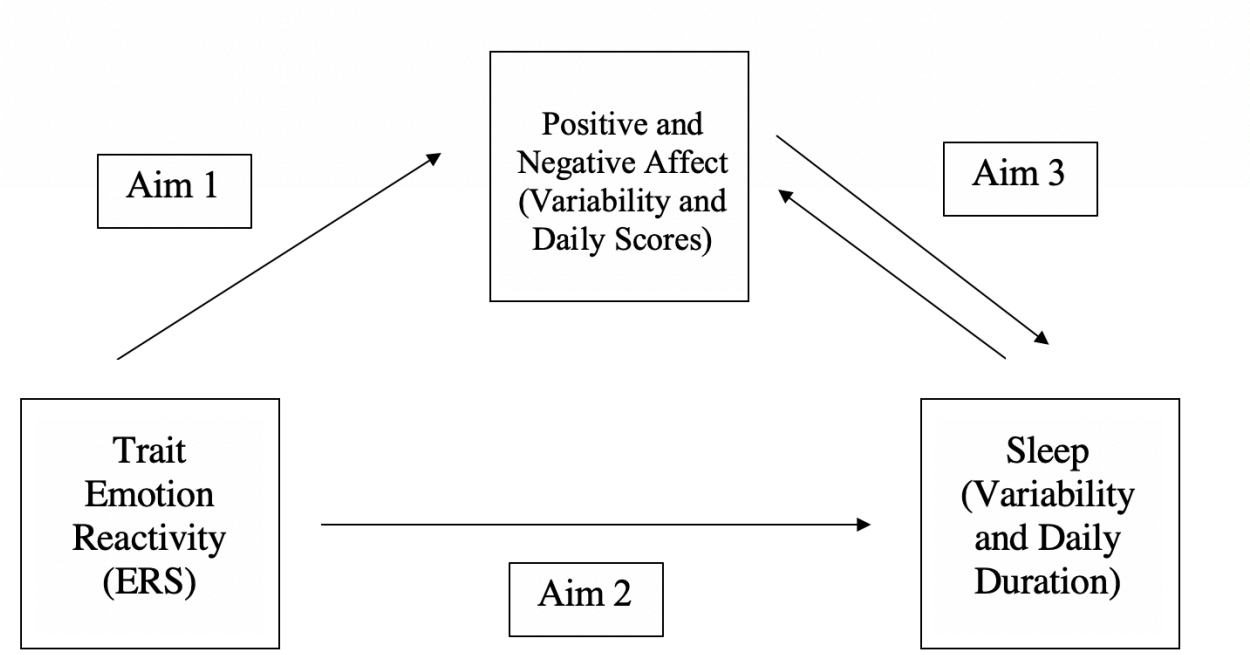

Figure 1. Aims to be Examined in the Present Study

Emotion Reactivity

Emotion reactivity refers to an individual's initial reaction to emotion eliciting stimuli, and this reaction can be experienced experientially, behaviorally, and physiologically (Evans et al., 2016; Gross & Jazaieri, 2014). For example, an individual who is high in emotion reactivity may watch a sad movie, feel very intense sadness immediately, and experience tearfulness, perhaps even for a prolonged period of time even after the movie is over. However, another individual lower in emotion reactivity might see the same movie and not feel sad at all. These individual differences in emotion reactivity could influence how individuals experience their daily lives, and ultimately their overall well-being.

Emotion reactivity has been theorized to be comprised of three components: emotion sensitivity, emotion intensity, and emotion persistence. Specifically, these three components include how frequently an individual experiences emotions in response to stimuli (sensitivity),

how strong or intense those emotions are (intensity), and how long those emotions persist before returning to baseline (persistence) (Davidson, 1998; Nock et al., 2008). Emotion reactivity has been conceptualized in some studies as a trait, or one component of individuals' personality or temperament (Eisenberg, Fabes, Guthrie, & Reiser, 2000; Muris & Ollendick, 2005; Nock et al., 2008; Norberg et al., 2019; Shapero, Abramson, & Alloy, 2016), and as such could influence how an individual lives and experiences their day to day life. Trait levels of emotion reactivity have generally been measured through self-report using measures like the Emotion Reactivity Scale (ERS; Nock et al, 2008), or the Emotional Reactivity and Perseveration Scale (ERPS; Boyes, Carmody, Clarke, and Hasking, 2017). Both of these measures ask participants to consider how they react or respond to emotional stimuli in general, rather than in the specific moment. These measures also assess multiple domains of emotion reactivity (e.g., intensity, duration, sensitivity). Other self-report measures have also been widely used to assess emotion reactivity (e.g., Emotion Intensity Scale: Bachorowski & Braaten, 1994; Affect Intensity Scale: Larsen, Diener, & Emmons, 1986), however these only capture individual components of emotion reactivity (e.g., intensity), rather than capturing all three theorized components of the trait. Emotion reactivity has also been examined through physiological measures including pupillary response (Franzen, Buysse, Dahl, Thompson, & Siegle, 2009), respiratory sinus arrhythmia (Heleniak, King, Monahan, & McLaughlin, 2018), and skin conductance response (Latham et al., 2017) as well as through other self-report measures including Visual Analogue Scales (Norberg et al., 2019) and the Self-Assessment Manikin (Daniela et al., 2010). These physiological and self-report measures have been posited to capture state or trait emotion reactivity, depending on the frequency of measurement and measurement instructions (Zuckerman, 1983). When measuring the trait level of a variable, participants are typically asked

to think about themselves, “in general,” while state measures try to capture the variable in present moment. Trait levels of emotion reactivity are bound to influence state levels of emotion reactivity, and both are likely to influence mood and daily experiences of individuals. Although state measures of emotion reactivity can tell us important information about objective physiological arousal and reaction to stimuli, the subjective self-report experience of trait emotion reactivity can tell us about how an individual perceives their daily experiences more consistently over time.

High levels of emotion reactivity have been linked to negative outcomes. In a cross-sectional study, Nock and colleagues (2008) found that adolescents and young adults recruited from community mental health clinics (ages 12-19) who self-reported high emotion reactivity (via the ERS) were more likely to have a mood, anxiety or eating disorder than those who reported low emotion reactivity. Emotion reactivity also mediated the relation between psychopathology and suicidal thoughts and behaviors in this sample. Another cross-sectional study utilizing the ERS in a sample of Dutch adolescents (ages 14-20) found that those who endorsed high emotion reactivity also endorsed high negative affectivity, poor coping skills, and low effortful control (Claes et al., 2014). A third cross-sectional study of early adolescent girls (ages 11-15) using the ERS found that emotion reactivity was positively associated with depression and anxiety, as well as poor emotion coping, and suicidal ideation (Evans et al., 2016). However, as these studies are all cross-sectional, they cannot tell us about daily experiences in relation to emotion reactivity. More specifically, by examining the ERS in relation to daily affect and sleep, we can learn more about how emotion reactivity may express itself in the everyday lives of college students.

Although high levels of emotion reactivity might be problematic, low levels of emotion reactivity have also been associated with negative outcomes. For example, a meta-analysis of emotion reactivity and Major Depressive Disorder found that those with a depression diagnosis were more likely to be under-reactive (exhibit low emotion reactivity) to both positive and negative stimuli, but particularly positive stimuli (Bylsma, Morris, & Rottenberg, 2008). However, none of the studies in this meta-analysis used the ERS to measure emotion reactivity (as it did not yet exist), and instead measured emotion reactivity through various self-report, behavioral, and physiological measures, without differentiating between state versus trait aspects of emotion reactivity. More research is needed to determine, in particular, how low trait emotion reactivity expresses itself in the daily emotional experiences of those individuals. Additionally, it remains to be understood whether there is an "ideal" amount of emotion reactivity for healthy functioning. One study found that adults who responded with increased reactivity in response to daily pleasant events (as measured by the degree to which they felt certain positive emotions in response to these daily pleasant events) experienced higher levels of flourishing (an optimal state of mental health) than those who did not report this increased positive reactivity to pleasant events (Catalino & Fredrickson, 2011). It could be that a particular balance of reactivity to both positive and negative events is important for healthy functioning. In sum, although evidence suggests that emotion reactivity can influence well-being, there is still much to be understood. In particular, prior studies have not considered how an individual's emotion reactivity expresses itself through daily lived experiences. In other words, do individuals with high emotion reactivity actually report greater variability of affect and health behaviors on a daily basis?

In contrast to this dearth of studies investigating trait emotion reactivity, numerous studies have examined links between emotion regulation, affect, and health behaviors (i.e., Hu et

al., 2014). Researchers have conceptualized emotion reactivity and emotion regulation as two concepts that are related, but distinct from one another (Evans et al., 2016; Gross, 2015; Gross & Jazaieri, 2014; Shapero et al., 2016). Emotion reactivity involves an individual's initial response to a stimulus, while emotion regulation is when an individual then engages in a goal-directed process to influence, implicitly or explicitly, their emotion-generating process, and it can take different forms (Gross & Jazaieri, 2014; Gross, Sheppes, & Urry, 2011; Gross & Thompson, 2007; Gyurak, Gross, & Etkin, 2011). Similar to emotion reactivity, difficulties with emotion regulation have been associated with poor affect (Brans, Koval, Verduyn, Lim, & Kuppens, 2013), poor sleep (Kahn, Sheppes, & Sadeh, 2013), and development and maintenance of psychopathology (Berking, Wirtz, Svaldi, & Hofmann, 2014; Eftekhari, Zoellner, & Vigil, 2009; Eisenberg, Spinrad, & Eggum, 2010; Kovacs, Joormann, & Gotlib, 2008). However, emotion reactivity could influence an individual's use of emotion regulation strategies (Gross, 2002; Nock et al., 2008; Polanco-Roman, Moore, Tsypes, Jacobson, & Miranda, 2018). For example, if someone reacts very intensely towards a negative emotion-evoking stimulus due to their high trait emotion reactivity, they might have difficulty engaging in an emotion regulation strategy and responding to that stimulus appropriately. In one study, difficulty in the expression of one positive emotion (e.g., love) partially mediated the relation between emotion reactivity (as measured by the ERS) and suicidal ideation in a sample of college students (Polanco-Roman et al., 2018), indicating that high emotion reactivity may contribute to difficulties with emotion regulation. Gaining an understanding of individual differences in emotion reactivity and its consequences could help us to improve overall emotion regulation which could ultimately improve affect and sleep, as well as decrease risk for the development or exacerbation of psychopathology.

Affect

Affect refers to everyday emotions experienced by individuals, and can be both positive and negative. High positive affect (PA) has been described as a state of high energy, full concentration, and pleasurable engagement, and includes mood states of happiness and enthusiasm. In contrast, high negative affect (NA) has been described as a general state of distress and unpleasurable engagement and includes mood states of anger, fear, and nervousness (Watson, Clark, & Tellegen, 1988). Initially, PA and NA were thought to exist on opposite ends of one continuum, also known as the bipolar view (Russell, 1980). However, research has supported the idea that PA and NA are related, but distinct from one another (Watson et al., 1988; Watson & Tellegen, 1985). PA and NA can be experienced at the same time (Larsen, McGraw, & Cacioppo, 2001), and research has demonstrated that many brain regions are involved in the experience of both positive and negative affect (Lindquist, Satpute, Wager, Weber, & Barrett, 2015).

Affect plays a role in emotion reactivity, as how long, intensely, and frequently one experiences affect is one facet of the trait. Prior studies have examined affective reactivity (how intensely an individual experiences affect in response to daily stressors) as a measure of emotion reactivity. For example, researchers found that college students who reported increased affective reactivity in response to daily stressors (as measured by daily diary of affect intensity and daily stressor checklists for two weeks) were more likely to report depressive symptoms two months later, than those who reported less affective reactivity in response to stressors (O'Neill, Cohen, Tolpin, & Gunthert, 2004). However, prior research has not examined emotion reactivity as an independent variable in relation to daily fluctuations in affect over time as the present study has

done. In this way, the present study might be able to contribute to understanding how trait levels of emotion reactivity influence state levels of affect intensity.

PA and NA are each associated with different mental and physical health outcomes. For example, low, or blunted, PA has been associated uniquely with depressive symptoms (Bylsma, Taylor-Clift, & Rottenberg, 2011; Crawford & Henry, 2004) while high NA has been associated with (Crawford & Henry, 2004; Watson et al., 1995) and predictive (Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013) of both depression and anxiety. High levels of PA have been shown to be predictive of positive outcomes later in life including increased self-worth, job performance and satisfaction, and fewer relationship problems (Kansky, Allen, & Diener, 2016). PA and NA have also been shown to be predictive of physical health outcomes, particularly that increased PA can improve health outcomes (Pressman & Cohen, 2005; Steptoe, Wardle, & Marmot, 2005). For example, it has been shown that adults who endorsed more happiness (PA) experienced a lower heart rate throughout the day, and a decreased inflammatory response to a mental stress test, both important markers of physical health (Steptoe et al., 2005).

In addition to mean levels of PA and NA, research has also examined variability in affect and its relation to well-being. Variability in effect, that is, fluctuations in the experience of affect over time, has been uniquely associated with mental health and health behaviors when compared with mean levels of affect. For example, one study used Ecological Momentary Assessment (EMA) to compare daily affect in adults with Borderline Personality Disorder to adults with Depression, and found that those participants with Borderline Personality Disorder demonstrated significantly more variability in affect than the Depression group, but did not significantly differ in terms of mean levels of affect (Trull et al., 2008). Another study used experience sampling method (ESM) to look at affect variability and its relation to drinking behaviors in college

students and found that increased affect variability was associated with increased drinking frequency and higher levels of self-reported drinking to cope, while mean levels of NA were not related to either (Gottfredson & Hussong, 2013). Taken together, these studies demonstrate the importance of examining not only mean levels of PA and NA, but also variability in both PA and NA. The present study will examine variability in PA and NA, as well as overall levels in relation to emotion reactivity.

Overall, PA and NA are related, important aspects of health and well-being. Understanding how emotion reactivity relates to daily fluctuations in PA and NA could provide us with a more efficient measure of emotional functioning in college students. Additionally, by examining how these affect fluctuations are related to daily health behaviors over time, we could gain important information about the daily functioning of college students with differing levels of emotion reactivity. Specifically, sleep is one health behavior that has been shown to have a bidirectional relation with daily affect, and might be influenced by emotion reactivity.

Sleep

College students can struggle to maintain a healthy sleep schedule. It is recommended that this age group achieve 7-9 hours of sleep per night (Hirshkowitz et al., 2015), but many have difficulty doing so. In general, research suggests that college students struggle to achieve enough quality sleep, with estimates of poor sleepers as high as 60% (Becker et al., 2018), based on self-report. In one study, college students reported sleeping 6.99 (Becker et al., 2018) hours on average, with less than half, or 36.7% of students obtaining more than seven hours of sleep per night (Becker et al., 2018). In a sample of adolescents one year out of high school, 31% reported obtaining less than seven hours of sleep on weekdays (Perlus, O'Brien, Haynie, & Simons-Morton, 2018). Clinical sleep problems are prevalent, with 13.1% of one sample exceeding

clinical cutoff criteria for insomnia on a self-report measure (Nadorff, Nazem, & Fiske, 2011). Importantly, this lack of sleep can contribute to negative outcomes, and there is evidence of a bidirectional relation between sleep and some psychopathology including depression (Alvaro, Roberts, Harris, & Bruni, 2017).

Not only sleep duration, but also variability in night to night sleep duration might influence well-being. A recent review examined the role of intra-individual variability in sleep duration in health outcomes, and found that increased variability in sleep duration is associated with depression and bipolar symptomatology in young adults (Bei, Wiley, Trinder, & Manber, 2016). Another study found that sleep duration variability, beyond sleep duration, was linked to altered brain development (decreased white matter integrity at one-year follow-up) in adolescents (Telzer, Goldenberg, Fuligni, Lieberman, & Gálvan, 2015). Given the importance of good sleep in maintaining health, and the difficulty that some college students experience in attaining enough consistent, quality sleep, the present study seeks to understand factors associated with poor or healthy sleep (both duration and duration variability) in college students, specifically emotion reactivity and daily affect.

Both emotion reactivity and daily affective experiences could contribute to poor sleep quality. Although research has shown that lack of sleep can increase state emotion reactivity, particularly in response to negative stimuli (Daniela et al., 2010; Franzen et al., 2009), few studies have examined associations between emotion reactivity and sleep outcomes. Emotion reactivity may contribute to poor sleep by mediating the relation between cognitive and autonomic hyperarousal, such that cognitive arousal before bed, leads to increased emotion reactivity which leads to increased autonomic arousal, making it difficult to sleep (Baglioni et al., 2010). It could be that those who are high in trait emotion reactivity are more susceptible to

these effects. In one study, adults were brought into the lab for four consecutive nights. After baseline sleep and emotion measures were taken during the first two nights, participants were instructed to complete a cognitive task. In the experimental condition, the cognitive task was made intentionally difficult and the participants received feedback that they had done poorly on the task, while in the neutral condition the tasks were easier and they did not receive the negative feedback. When compared to the neutral condition, after the experimental condition, participants reported increased NA before bed, and experienced decreased sleep duration and decreased sleep efficiency (Vandekerckhove et al., 2011). However, this study did not include a measure of emotion reactivity, which could tell us more about individual differences in those who had increased difficulty with sleep after experiencing negative affect.

Prior studies have demonstrated relations between sleep and affect. Poor sleep has been associated with decreases in PA (Bower, Bylsma, Morris, & Rottenberg, 2010; McCrae et al., 2008; Rossa, Smith, Allan, & Sullivan, 2014; Simor, Krietsch, Köteles, & McCrae, 2015) and increases in NA (Baglioni et al., 2010; McCrae et al., 2008; Simor et al., 2015). Daily diary studies of sleep and affect provide more nuanced information about the relation between these variables. In one 14-day daily diary study of adults age 60 and over, subjectively measured sleep quality was related to PA and NA such that poor self-reported sleep quality the night before was associated with NA the following day, and good self-reported sleep quality was associated with more PA the following day, but these relations were not found for objective sleep outcomes including actigraphy-measured total wake time after sleep onset (McCrae et al., 2008).

Researchers have also examined the relation between daily affect and sleep in college students over a one week period, and found that higher NA and lower PA during the day were associated with poor sleep quality in a sample of young adults (Simor et al., 2015). Similarly, a

third daily affect and sleep study of female college students, which looked at specific aspects of both PA and NA and their relation to sleep over two weeks, found that NA, specifically sadness, led to worse sleep quality, while increased PA, specifically serenity, led to better sleep quality. Better sleep quality also led to increased PA (e.g., happiness) the following day (Kalmbach, Pillai, Roth, & Drake, 2014). Taken together, these studies point to a bidirectional relation between daily affect and sleep in adults. However, these samples have been restricted to older adults (McCrae et al., 2008), women (Kalmbach et al., 2014), and a small college student sample including all grades (N=87) (Simor et al., 2015). In addition, these studies did not examine the relation between sleep and affect in the context of emotion reactivity, which could play an important role in the daily functioning of first-year college students.

The Current Study

Examining emotion reactivity could help to identify individuals who might be more likely to experience to the development or exacerbation of psychopathology during the college transition. However, few studies have examined the potential implications of high emotion reactivity for other areas relevant to mental health: day to day affect and sleep. As shown in Figure 1 and similar to prior work, the present study conceptualizes emotion reactivity as measured by the ERS as trait-like, and assesses its relation to the daily experiences of affect among first year college students. To address these questions, the ERS was administered once at a baseline assessment, followed by a 7-day daily diary assessing PA, NA, and sleep duration once per day in a sample of first year college students at a private Midwestern university. These daily measures of variables of interest allowed for capture of not only daily levels of PA, NA, and sleep duration across the week, but also variability in these variables from one day to the next. Utilizing daily diaries to assess daily functioning can reduce recall bias that can occur when

asking participants to think back to remember how they felt, or what their schedule was in the past, and allow for better capture day to day fluctuations in measured variables, in an individual's natural environment (Bolger, Davis, & Rafaeli, 2003).

Covariates

As previously mentioned, emotion reactivity has been associated with both depression and anxiety symptoms (Evans et al., 2016; Nock et al., 2008). Additionally, anxiety and depression are both associated with sleep difficulties (American Psychiatric Association, 2013) as well as poor affect (Charles et al., 2013; Crawford & Henry, 2004). Therefore, anxiety and depression symptoms were controlled for in analyses. Research has also identified sex differences in emotion reactivity, with females generally showing increased reactivity compared to males. For example, in one study, researchers found that adolescent girls (age 15) reported more emotional reactivity to daily stressors compared to boys of the same age (Charbonneau, Mezulis, & Hyde, 2009). In a study of first year college students, healthy control females reported increased emotion reactivity (as measured by perceived stressfulness of daily events) compared to healthy control males, though this difference did not carry over to females and males who had experienced past depression (Husky, Mazure, Maciejewski, & Swendsen, 2009). A third study which measured emotion reactivity through the ERS in undergraduate students also found that females reported higher levels of emotion reactivity compared to males (Kleiman, Ammerman, Look, Berman, & McCloskey, 2014). At a neurological level, it has also been demonstrated that women and men have differential emotion reactivity patterns to aversive stimuli specifically that women show higher amygdala activity in response to aversive stimuli compared to men (Domes et al., 2010). Therefore, sex differences in key study variables were examined and sex was included as a covariate as needed.

Aims and Hypotheses

The aims and hypotheses for the present study are as follows:

Aim 1: Examine associations between emotion reactivity and daily fluctuations in positive and negative affect over the course of one week.

Hypothesis 1a: Higher emotion reactivity will be associated with higher daily negative affect and lower daily PA over the course of one week.

Hypothesis 1b: Higher emotion reactivity will be associated with increased variability in positive and negative affect over the course of one week.

Aim 2: Examine associations between emotion reactivity and daily sleep over the course of one week.

Hypothesis 2a: Higher emotion reactivity will be associated with shorter daily sleep duration over the course of one week.

Hypothesis 2b: Higher emotion reactivity will be associated with increased variability in sleep duration over the course of one week.

Aim 3: Examine the bidirectional nature of the relation between daily sleep and daily affect. Specifically, is previous night sleep associated with next day affect, or is does same day affect associated with same night sleep duration?

Hypothesis 3a: Higher negative affect and lower PA during the day will be associated shorter sleep duration that night.

Hypothesis 3b: Higher PA and lower NA during the day will be associated with longer sleep duration that night.

Hypothesis 3c: Shorter sleep duration the night before will be associated with higher NA and lower PA the following day.

Hypothesis 3d: Longer sleep duration the night before will be associated with higher PA and lower NA the following day.

CHAPTER TWO

METHOD

Participants

The initial sample included 271 participants from a private Midwestern university, all college freshmen. These participants were part of a two-year study examining the effects of television food commercials on measures of inhibitory control and executive functioning. Only participants from the second year of data collection were included in the present study, as emotion reactivity was not measured until Year 2. Participants were recruited through an online system that is used to grant experiential learning credits required by introductory psychology courses. Of the 271 initial participants, one participant endorsed their sex as "other" and was excluded from the sample. Participants were also excluded if they did not complete the measure of depressive symptoms (n=14), anxiety symptoms (n=5), or the emotion reactivity scale (n=8), or if they did not have sufficient daily diary data (did not fully complete any day of the daily diary data; n=3). The final analytic sample included 244 participants with an average age of 18.9 years, 86% female, 58% White (see Table 1). The final analytic sample did not significantly differ from the original sample in race and remained primarily female. Participants completed a total of 1,482 daily diary entries across the week. On average, participants completed six daily diaries out of seven possible.

Table 1. Sample Demographics

	n	Percentage
Total sample	244	
Sex		
Female	210	86.1
Male	34	13.9
Race		
White	142	58.2
Asian	52	21.3
Other	18	7.4
Black/African American	17	7.0
Middle Eastern	9	3.7
American Indian or Alaska Native	2	.8
Native Hawaiian or Pacific Islander	2	.8
Hispanic Origin		
No	208	85.2
Yes	36	14.8

Procedure

This study was approved by the university's Institutional Review Board. Participants first completed an initial screening survey which included a consent page and information about the study. This survey took roughly one hour to complete, and included demographic information and a battery of measures selected for the larger study. If participants completed the entire initial survey, they were automatically signed up to complete the daily diary surveys for the remainder of the week, which included questions related daily sleep, eating, and physical activity behaviors, as well as daily mood. The participants were e-mailed a link to the survey each day for seven days, and the survey took approximately 15 minutes to complete. Links to the survey were e-mailed out at 8:00PM each day, and participants were asked to complete the surveys before

12:00PM the following day. Participants were also sent a reminder e-mail at 11:00PM if they and not yet opened or completed the survey. This 8:00PM-12:00PM window was selected in order to allow students to complete the surveys near the end of the day, but before they participated in any late-night social activities. Students were compensated with course credit for their participation. If participants completed all seven days of the daily diary, they were entered into a drawing for a $50 gift card. Ten winners from this group were selected randomly, using a random number generator.

Measures

Demographics

Participants were given a basic demographic questionnaire as part of the battery of measures to complete on the first day of the daily diary study. This questionnaire asked participants to report their sex, age, race/ethnicity, year in school, residence and annual household income.

Emotion Reactivity

The Emotion Reactivity Scale (ERS) is a 21-item self-report measure. Participants are told to think about how they experience emotions, "on a regular basis" in order to capture participants' perceptions of their general emotion reactivity rather than state reactivity in that moment. The measure includes three subscales measuring emotion sensitivity (e.g., "I tend to get emotional very easily"), emotion intensity (e.g., "When I experience emotions, I feel them very strongly/intensely"), and emotion persistence (e.g., "When I am angry/upset, it takes me much longer than most people to calm down."). Items are rated on a 5-point scale from 0 (not at all like me) to 4 (completely like me), and all items are summed to create a total score, with higher scores indicating higher emotion reactivity. The ERS has demonstrated good internal consistency

in an adolescent and young adult sample (ages 12-19 years) (α= .94) (Nock et al., 2008). In the present sample, internal consistency was excellent (α=.95). Participants completed the ERS one time, on day one of the daily diary study.

Affect

The Positive and Negative Affect Scale (PANAS) was administered each day for the entire week of the study. The measure consists of 20 words that describe feelings, 10 positive (e.g., "excited," "proud") and 10 negative (e.g., "scared," "upset"). Participants rate each word on a scale of 1 (very slightly or not at all) to 5 (extremely), indicating how strongly they feel that word in the present moment with higher scores indicating higher levels of either positive or negative affect. Separate scores are calculated for PA and NA, by summing totals for the 10 positive and 10 negative words separately. Internal consistency for both PA and NA scales was good for both PA (α=.92) and NA (α=.89), and comparable to prior studies with college students (Watson et al., 1988). Affect variability was calculated by taking the within-person standard deviation of PA and NA scores across the week separately, as has been done in prior research (Torres & Santiago, 2018).

Sleep

As part of the daily diary, participants were asked questions about their previous night's sleep in each survey. Participants were asked if they went to sleep the previous night (yes or no), what time they went to bed, how long it took them to fall asleep, and how many hours they thought they had been asleep. They were also asked what time they woke up that day, and what time they physically got out of bed. Sleep duration will be calculated using the participant's self-reported sleep duration in minutes. Sleep duration variability was calculated by taking the

within-person standard deviation of daily sleep duration scores across the week for each participant, as has been done in prior research (Palmer, Clementi, Meers, & Alfano, 2018).

Depressive Symptoms

The 10-item Center for Epidemiological Studies Depression Scale (CES-D10) was used to assess for depressive symptoms (Andresen, Malmgren, Carter, & Patrick, 1994). Participants are asked to self-report the frequency of depressive symptoms over the past week through a 0 [rarely or none of the time (less than 1 day)] to 3 [most or all of the time (5 to 7 days)] scale. Sample symptoms include, "I felt depressed," and, "I had trouble keeping my mind on what I was doing." Responses to all items are summed to create a total score. Scores range from 0 to 30, with higher scores indicative of more depressive symptoms over the past week. The CES-D10 has been used in college-aged sample with acceptable internal consistency (α=.78) (Andresen et al., 1994). In the present study, participants completed this measure one time on the first day of the study, and internal consistency was good (α=.84). Participants' total score on this measure will be used to control for depressive symptoms in analyses.

Anxiety Symptoms

The 7-item anxiety subscale of the Depression, Anxiety, and Stress Scale (DASS-21) was used to capture anxiety symptoms in participants. The anxiety subscale of the measure asks participants to rate how much statements applied to themselves over the course of the past week, on a scale from 0 (did not apply to me at all) to 3 (applied to me very much, or most of the time). Sample statements include, "I felt scared without any good reason," and, "I experienced trembling (e.g., in the hands)." Responses to all items are summed to create a total subscale score. The total anxiety subscale score ranges from 0 to 21, with higher scores indicating the experience of more anxiety symptoms. The full measure has been validated in college students

(Antony, Bieling, Cox, Enns, & Swinson, 1998; Kia-Keating et al., 2018), with the anxiety subscale showing good internal consistency (α=.92). In the present sample, internal consistency was shown to be good (α= .80). In the present study, participants completed this measure one time on the first day of the study. Participants' total subscale score on this measure will be used to control for anxiety symptoms in analyses.

Analytic Strategy

Hierarchical Multiple Regressions

Hierarchical multiple regressions were used to analyze the relation between emotion reactivity and PA and NA variability, as well as between emotion reactivity and sleep duration variability. Covariates were entered at step one, followed by variables of interest at step two. All hierarchical multiple regressions were performed in IBM SPSS Statistics 26.

Multi-Level Modeling

Due to the nested nature of this daily diary data (e.g., days nested within college students), multi-level modeling (MLM) was used to examine the relation between key study variables. MLM offers several advantages over other analytic approaches. First, MLM does not require that observations be independent (Raudenbush & Bryk, 2002). Second, MLM is better equipped to handle missing data that can occur in daily diary studies, compared to other longitudinal analyses (e.g., repeated measures ANOVA). Finally, MLM allows for a more nuanced view of the day to day variations of daily diary variables, compared to other analytic approaches which aggregate daily data. Using recommended approaches, within-person variables (e.g., daily ratings of mood) were included at Level-1 of the model, and between-person variables (e.g., emotion reactivity score) at Level-2. In the present study, for all aims, random intercept models were compared to random coefficient models, and final models were selected

based on best model fit. All analyses were conducted using full maximum likelihood estimation in HLM 8 (Raudenbush, Bryk, Cheong, & Congon, 2019). Due to the large sample size, robust standard errors are reported (Raudenbush & Bryk, 2002).

Seven primary models were examined in order to address study aims. The first two models, corresponding to Aim 1, examined the relation between emotion reactivity to daily PA and daily NA, with several covariates including depressive and anxiety symptoms, and sex (for PA). The example below shows the model for the relation between the independent variable of emotion reactivity at Level-2 and dependent variable of daily NA at Level-1:

Level-1 Model

$$NEGATIVE_{ti} = \pi_{0i} + \pi_{1i}*(WVW_{ti}) + e_{ti}$$

Level-2 Model

$$\pi_{0i} = \beta_{00} + \beta_{01}*(DEPRESSI_i) + \beta_{02}*(ANXIETY_i) + \beta_{03}*(ERS_i) + r_{0i}$$
$$\pi_{1i} = \beta_{10} + r_{1i}$$

The third model, corresponding to Aim 2, examined the independent variable of emotion reactivity at Level-2 and its relation to the dependent variable of sleep duration at Level-1. This model can be seen below:

Level-1 Model

$$SLEEPDUR_{ti} = \pi_{0i} + \pi_{1i}*(WVW_{ti}) + e_{ti}$$

Level-2 Model

$$\pi_{0i} = \beta_{00} + \beta_{01}*(DEPRESSI_i) + \beta_{02}*(ANXIETY_i) + \beta_{03}*(ERS_i) + r_{0i}$$
$$\pi_{1i} = \beta_{10} + r_{1i}$$

In the fourth and fifth models, corresponding to Aim 3, the relation between daily affect and same night sleep duration, both at Level-1, with covariates at Levels 1 and 2, was examined. Because of the timing of survey distribution and time window for completion, adjustments were made to the data set prior to examining relations between these variables. First, the survey was e-

mailed out to participants at 8:00PM, but respondents could complete the survey any time up until 12:00PM the following day. In order to ensure that participants' affect was indeed captured before they went to bed, data for these two models were cleaned so that any diary entry that was completed the following morning was counted as missing. Second, as the survey asked participants how long they had slept the night before, the first night of sleep duration (Sunday night, reported on Monday) was deleted, and all days shifted so that daily affect would correspond with the same night sleep duration (rather than with the previous night sleep duration). Due to this data cleaning, these analyses only utilized six days of daily diary data, rather than seven. In these models, PA and NA were group-mean centered (each daily score minus the mean score for the week, so that each score is the individual's difference from their own mean on that day), to understand the relation to sleep duration when an individual experiences more or less positive or negative affect than own average experience. Additionally, each person's overall average PA or NA score was re-introduced in Level-2 of these models to understand the relation between affect and sleep at the between-person level, across the sample. The example below shows the model for the relation between the independent variable of daily NA and the dependent variable of same night sleep duration:

Level-1 Model

$$SLEEPDUR_{ti} = \pi_{0i} + \pi_{1i}*(NEGATIVE_{ti}) + \pi_{2i}*(WVW_{ti}) + e_{ti}$$

Level-2 Model

$$\pi_{0i} = \beta_{00} + \beta_{01}*(NEGATIVE_i) + \beta_{02}*(DEPRESSI_i) + \beta_{03}*(ANXIETY_i) + r_{0i}$$
$$\pi_{1i} = \beta_{10}$$
$$\pi_{2i} = \beta_{20} + r_{2i}$$

The sixth and seventh models, also corresponding to Aim 3, examined the relation between previous night sleep duration and following day affect at Level-1, with covariates at Levels 1 and

2. As with previous temporal analyses of sleep and affect (fourth and fifth models), due to the timing of survey distribution and window for response, adjustments were made to the data set prior to examining relations between these variables. Again, in order to ensure that participants' affect was indeed captured before they went to bed, data were cleaned so that any diary entry that was completed the following morning was counted as missing. In these models, sleep duration was group-mean centered, to understand the relation between sleep and affect when an individual gets more or less sleep than their own average. Individuals' average sleep duration for the week was re-introduced at Level-2 to understand the relation between sleep duration and following day affect at the between-person level, across the sample. The example below shows the model for the relation between the independent variable sleep duration and the dependent variable daily NA:

Level-1 Model

$$NEGATIVE_{ij} = \beta_{0j} + \beta_{1j}*(SLEEPDUR_{ij}) + \beta_{2j}*(WVW_{ij}) + r_{ij}$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(SLEEPAVG_j) + \gamma_{02}*(DEPRESSI_j) + \gamma_{03}*(ANXIETY_j) + u_{0j}$$
$$\beta_{1j} = \gamma_{10}$$
$$\beta_{2j} = \gamma_{20} + u_{2j}$$

CHAPTER THREE

RESULTS

Data Preparation and Preliminary Analyses

Descriptive statistics for key study variables are reported in Table 2. Daily NA values were positively skewed (1.32-1.91). However, due to the use of MLM and reporting of robust standard errors in the present study, no additional steps were taken to correct this skewness (Garson, 2019). Participants reported an average emotion reactivity score of 37.34 out of a possible 84, with higher scores indicating higher levels of emotion reactivity. Participants' average nightly sleep duration was 419.58 minutes (6.99 hours). Weekday sleep averaged 406.76 minutes (6.78 hours) and weekend sleep averaged 458.51 minutes (7.64 hours), a difference of 51.75 minutes. The average depressive symptom score was 10.60 (out of a possible 30) while average anxiety symptom score was 4.30 (out of a possible 21), with higher scores indicating increased depressive and anxiety symptoms. The average PA score was 19.63 while the average NA score was 15.54, both out of a possible score of 50, with higher scores indicating increased PA and NA. Study variables did not significantly differ by race or age. However, PA was significantly lower for females (M=19.26) than males (M=21.89) ($F(1, 242)=4.70$, $p<.05$). Therefore, sex was included as a covariate in analyses with PA as the dependent variable.

Table 2. Correlations, Means, and Standard Deviations of Key Study Variables

	Sex	*Emotion Reactivity*	*Depression Symptoms*	*Anxiety Symptoms*	*Sleep Duration*	*Positive Affect*	*Negative Affect*	*Sleep Duration Variability*	*Positive Affect Variability*	*Negative Affect Variability*
Sex[a]	-	-.084	-.090	-.091	-.057	.138*	.006	.100	-.058	-.038
Emotion Reactivity[a]	-.084	-	.576**	.556**	-.035	-.111	.476**	.112	.047	.427**
Depression Symptoms[a]	-.090	.576**	-	.663**	-.154*	-.352**	.499**	.157*	-.122	.319**
Anxiety Symptoms[a]	-.091	.556**	.663**	-	-.145*	-.119	.464**	.125	.112	.404**
Sleep Duration[b]	-.057	-.035	-.154*	-.145*	-	.085	-.106	-.373**	.007	-.095
Positive Affect[b]	.138*	-.111	-.352**	-.119	.085	-	.055	-.148*	.425**	.063
Negative Affect[b]	.006	.476**	.499**	.464**	-.106	.055	-	.196**	.159**	.629**
Sleep Duration Variability[c]	.100	.112	.157*	.125	-.373**	-.148*	.196**	-	-.029	.176**
Positive Affect Variability[c]	-.058	.047	-.122	.112	.007	.425**	.159**	-.029	-	.280**
Negative Affect Variability[c]	-.038	.427**	.319**	.404**	-.095	.063	.629**	.176**	.280**	-
Mean (SD)	.14(.347)	37.34(20.01)	10.60(5.61)	4.30(3.80)	419.58(71.02)	19.63(6.60)	15.54(5.15)	103.56(53.55)	4.38(2.28)	3.51(2.48)

*= Correlation is significant at the .05 level (2-tailed)
**= Correlation is significant at the .01 level (2-tailed)
[a] = Baseline measure; [b] = Average of 7 daily ratings; [c] = Within-person standard deviation of 7 daily ratings

Variations among key study variables across the days of the week were examined. Repeated measures ANOVAs revealed significant differences across the week in daily PA ($F(1,156)=1398.57$, $p<.001$), negative affect ($F(1,155)=1473.03$, $p<.001$), and sleep duration ($F(1,177)=7945.207$, $p<.001$). Post-hoc tests revealed that PA was significantly higher on Day 1 (Monday) compared to all days except Day 5 (Friday). NA was significantly higher on Days 1, 2, 3, and 4 (Monday through Thursday), than on Days 5, 6, and 7 (Friday through Sunday). Sleep duration was significantly higher on Days 6 and 7 (corresponding with Friday night and Saturday night of sleep) than all other Days (see Figures 2 and 3). Although other explanations (e.g., fatigue with daily diary completion) cannot be ruled out, these variations align with weekday versus weekend levels of mood and sleep duration. Thus, a dummy code variable was created to distinguish between weekdays and weekends (weekdays=0, weekends=1), which was included in all MLM analyses as a covariate at Level-1, in order to control for this effect. For all seven multi-level models, intraclass correlation coefficients (ICCs) were calculated to determine whether or not there was enough within-person variance to proceed with MLM. ICCs are reported in Table 3. All ICCs revealed significant within-person variance indicating that it was appropriate to proceed with MLM.

Hierarchical Multiple Regressions

Three hierarchical multiple regressions were conducted to examine the relations between emotion reactivity and positive and NA variability as well as sleep duration variability (see Tables 4-6). For each regression model, covariates of anxiety symptoms, depressive symptoms, and sex (for PA variability model only) were entered into the first step of the model, followed by emotion reactivity at the second step.

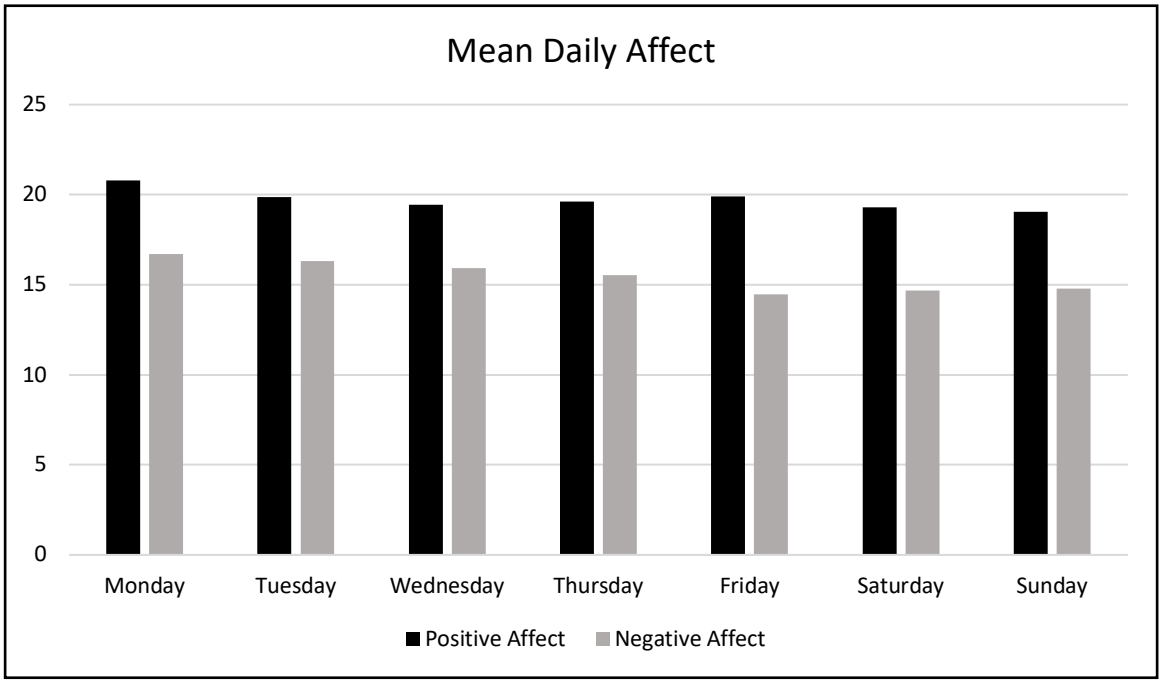

Figure 2. Mean Levels of Daily Affect

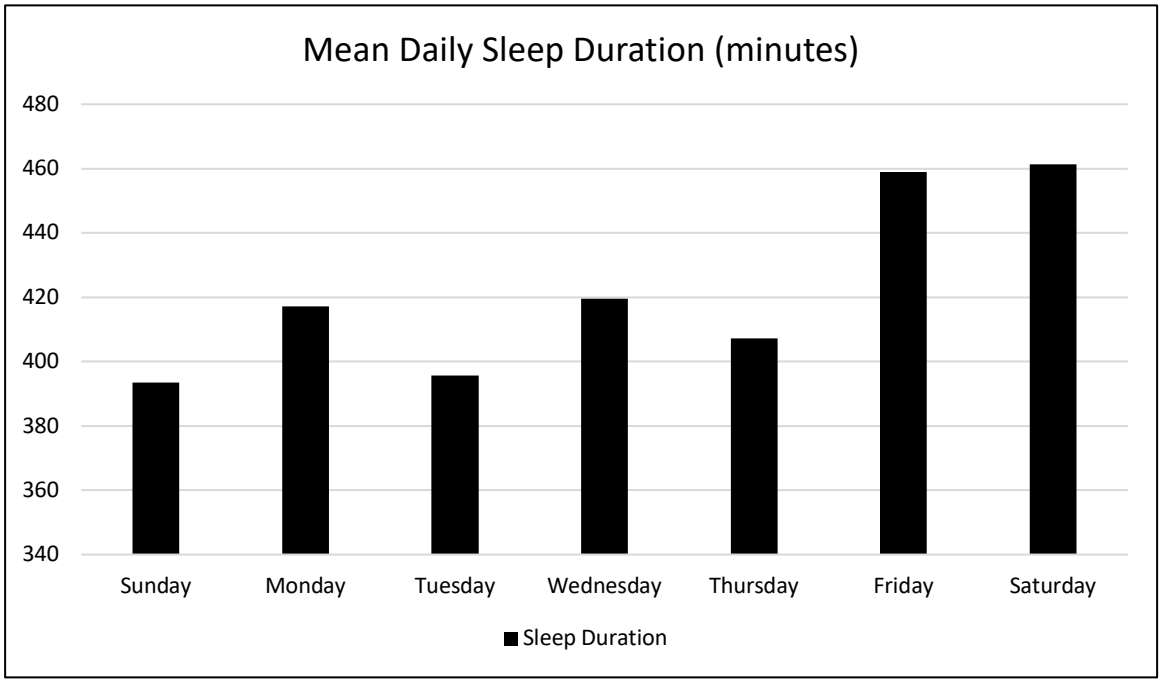

Figure 3. Mean Daily Sleep Duration in Minutes

Table 3. Intraclass Correlations (ICCS)

Model Number	Model	ICC
1	Emotion Reactivity and Positive Affect	0.62
2	Emotion Reactivity and Negative Affect	0.54
3	Emotion Reactivity and Sleep Duration	0.14
4 & 5	Affect and Same Night Sleep Duration	0.08
6	Sleep Duration and Next Day Negative Affect	0.54
7	Sleep Duration and Next Day Positive Affect	0.62

Note. For models four though seven, ICCs were re-calculated as sample was slightly different due to data cleaning.

As shown in Table 4, when covariates were entered into the model at the first step, higher levels of anxiety symptoms were associated with increased NA variability, while depressive symptoms were not associated. When emotion reactivity was added at the second step, higher levels of anxiety symptoms were still significantly associated with increased NA variability, and higher levels of emotion reactivity were also associated with increased NA variability. As shown in Table 5, higher levels of anxiety symptoms, and lower levels of depressive symptoms were associated with increased PA variability at the first and second steps of the model, while emotion reactivity and sex were not associated. As shown in Table 6, no key study variables were significantly associated with sleep duration variability.

Table 4. Hierarchical Multiple Regression Examining Emotion Reactivity and Negative Affect Variability

Negative Affect Variability						
Step	Variable	B	SE B	Standardized B	t	p
1*	Constant	2.135	.314		6.789	.000
	Depressive Symptoms	.045	.035	.102	1.295	.196
	Anxiety Symptoms	.206	.050	.325	4.120	.000
2*	Constant	1.551	.338		4.584	.000
	Depressive Symptoms	-.006	.036	-.013	-.156	.876
	Anxiety Symptoms	.150	.051	.236	2.968	.003
	Emotion Reactivity	.036	.009	.295	3.991	.000
*Step 1: R^2= 0.159, Standard Error: 2.28, F(2, 240): 22.757, p<.001						
*Step 2: R^2= 0.212, Standard Error: 2.21, F(3, 239): 21.425, p<.001						

Table 5. Hierarchical Multiple Regression Examining Emotion Reactivity and Positive Affect Variability

Positive Affect Variability						
Step	Variable	B	SE B	Standardized B	t	p
1*	Constant	5.077	.317		15.996	.000
	Depressive Symptoms	-.146	.034	-.356	-4.341	.000
	Anxiety Symptoms	.217	.049	.366	4.460	.000
	Sex	-.401	.410	-.061	-.978	.329
2*	Constant	4.883	.349		13.976	.000
	Depressive Symptoms	-.163	.036	-.397	-4.534	.000
	Anxiety Symptoms	.199	.050	.335	3.937	.000
	Sex	-.385	.409	-.058	-.939	.349
	Emotion Reactivity	.012	.009	.105	1.321	.188
*Step 1: R^2= 0.093, Standard Error: 2.20, F(3, 237): 8.148, p<.001						
*Step 2: R^2= 0.100, Standard Error: 2.20, F(4, 236): 6.566, p<.001						

Table 6. Hierarchical Multiple Regression Examining Emotion Reactivity and Sleep Duration Variability

Sleep Duration Variability						
Step	Variable	B	SE B	Standardized B	t	p
1	Constant	88.093	7.40		11.91	.000
	Depressive Symptoms	1.426	.822	.149	1.73	.084
	Anxiety Symptoms	-.021	1.19	-.001	-.017	.986
2	Constant	87.233	8.240		10.59	.000
	Depressive Symptoms	1.354	.877	.142	1.54	.124
	Anxiety Symptoms	-.105	1.244	-.008	-.084	.933
	Emotion Reactivity	.053	.222	.020	.239	.811
Step 1: R^2= 0.022, Standard Error: 53.48, F(2, 237): 2.66, p>.05						
Step 2: R^2= 0.022, Standard Error: 53.59, F(3, 236): 1.79, p>.05						

Multi-Level Models

MLM results are reported in Tables 7-13. As shown in Table 7, greater emotion reactivity was associated with higher NA scores over the course of the week, above and beyond the effects of anxiety and depressive symptoms, and weekday versus weekend changes. Higher levels of depressive symptoms were also associated with increased NA, and weekday versus weekend timing was negatively associated with NA, indicating that participants experienced less NA on weekend days. As shown in Table 8, there were no significant associations between emotion reactivity and PA, however, higher levels of anxiety and lower levels of depressive symptoms were significantly associated with increased levels of PA. Weekday versus weekend timing was also significantly negatively associated with PA, indicating that participants experienced less PA on the weekends. As shown in Table 9, weekday versus weekend timing was significantly

positively associated with sleep duration, such that participants slept significantly more on weekend days compared to weekdays. Additionally, increased depressive symptoms were associated with decreased sleep duration.

Table 7. Multi-Level Model Examining Emotion Reactivity and Negative Affect

Dependent Variable: Negative Affect					
Level	Variable	Coefficient (SE)	df	t-ratio	p-value
1	Weekend Vs Weekday	-1.12(0.28)	243	-4.01	<.001
2	Intercept	9.98(0.66)	240	15.03	<0.001
2	Depressive Symptoms	0.23(0.08)	240	2.72	0.007
2	Anxiety Symptoms	0.22(0.14)	240	1.65	0.100
2	Emotion Reactivity	0.06(0.02)	240	4.01	<.001

Table 8. Multi-Level Model Examining Emotion Reactivity and Positive Affect

Dependent Variable: Positive Affect					
Level	Variable	Coefficient (SE)	df	t-ratio	p-value
1	Weekend Vs Weekday	-0.79(0.34)	243	-2.43	0.022
2	Intercept	23.60(1.04)	239	22.75	<0.001
2	Depressive Symptoms	-0.62(0.09)	239	-6.90	<0.001
2	Anxiety Symptoms	0.30(0.12)	239	2.47	0.014
2	Sex	2.19(1.37)	239	1.60	0.110
2	Emotion Reactivity	0.03(0.03)	239	1.23	0.220

Table 9. Multi-Level Model Examining Emotion Reactivity and Sleep Duration

Dependent Variable: Sleep Duration					
Level	Variable	Coefficient (SE)	df	t-ratio	p-value
1	Weekend Vs Weekday	50.96(8.29)	243	6.15	<.001
2	Intercept	424.04(9.81)	240	43.24	<0.001
2	Depressive Symptoms	-1.97(0.96)	240	-2.04	0.042
2	Anxiety Symptoms	-1.64(1.46)	240	-1.13	0.262
2	Emotion Reactivity	0.30(0.25)	240	1.22	0.222

Models examining relations between daily affect and same night sleep duration revealed no significant associations between PA or NA and sleep duration (see Tables 10 and 11). However, in both models, weekday versus weekend was significantly positively associated with same night sleep duration, indicating that participants slept significantly more on weekend days compared to weekdays. In examining the temporal relation of sleep duration and next day affect, longer sleep duration was significantly associated with increased PA the following day (see Table 12). As these analyses were group-mean centered, these results show that when an individual slept more than their own average sleep duration for the week, they experienced more PA the following day. In addition, increased depressive symptoms were associated with decreased PA, while increased anxiety symptoms were associated with increased PA. Weekday versus weekend timing was negatively associated with PA, indicating that participants experienced less PA on weekend days. There was not a significant association between sleep duration and next-day NA (see Table 13). However, increased depressive and anxiety symptoms were significantly associated with increased NA. Weekday versus weekend timing was

significantly negatively associated with NA, indicating that participants experienced less negative affect on weekend days.

Table 10. Multi-Level Model Examining Positive Affect and Same Night Sleep Duration

Dependent Variable: Sleep Duration					
Level	Variable	Coefficient (SE)	df	t-ratio	p-value
1	Weekend Vs Weekday	60.41(12.40)	224	4.87	<.001
1	Daily Positive Affect	0.57(0.93)	482	0.609	0.543
2	Intercept	420.28(22.10)	220	19.02	<0.001
2	Depressive Symptoms	-0.62(1.14)	220	-0.54	0.588
2	Anxiety Symptoms	-2.04(1.39)	220	-1.47	0.144
2	Positive Affect Average	0.78(0.79)	220	1.00	0.320

Table 11. Multi-Level Model Examining Negative Affect and Same Night Sleep Duration

Dependent Variable: Sleep Duration					
Level	Variable	Coefficient (SE)	df	t-ratio	p-value
1	Weekend Vs Weekday	57.77(12.76)	224	4.53	<.001
1	Daily Negative Affect	-2.28(1.42)	482	-1.60	0.110
2	Intercept	450.73(16.44)	221	27.41	<.001
2	Depressive Symptoms	-0.66(1.04)	221	-0.63	0.529
2	Anxiety Symptoms	-1.22(1.41)	221	-0.86	0.390
2	Negative Affect Average	-1.25(1.12)	221	-1.11	0.267

Table 12. Multi-Level Model Examining Sleep Duration and Next Day Positive Affect

Dependent Variable: Positive Affect					
Level	Variable	Coefficient (SE)	df	t-ratio	p-value
1	Weekend Vs Weekday	-1.12(0.38)	-2.95	237	0.004
1	Daily Sleep Duration	0.004(0.001)	2.56	782	0.011
2	Intercept	22.22(2.75)	233	8.08	<.001
2	Depressive Symptoms	-0.57(.09)	233	-6.31	<.001
2	Anxiety Symptoms	0.33(0.12)	233	2.87	0.004
2	Sex	2.67(1.37)	233	1.95	0.052
2	Sleep Duration Average	.005(.006)	233	0.79	0.431

Table 13. Multi-Level Model Examining Sleep Duration and Next Day Negative Affect

Dependent Variable: Negative Affect					
Level	Variable	Coefficient (SE)	df	t-ratio	p-value
1	Weekend Vs Weekday	-0.88(0.33)	237	-2.68	0.008
1	Daily Sleep Duration	-0.00(0.00)	782	-1.20	0.229
2	Intercept	11.10(2.07)	234	5.36	<0.001
2	Depressive Symptoms	0.31(0.09)	234	3.62	<0.001
2	Anxiety Symptoms	0.34(0.14)	234	2.45	0.015
2	Sleep Duration Average	-0.00(0.00)	234	-0.02	0.983

CHAPTER FOUR

DISCUSSION

The purpose of this study was to use daily diary data to examine the relations between emotion reactivity, daily sleep, and daily affect in a sample of first-year college students in order to better understand how individual differences in emotion reactivity play out in the lived experiences (specifically, daily mood and sleep) of students transitioning to college. Prior research has demonstrated a positive association between emotion reactivity and NA and psychopathology (Claes et al., 2014; Evans et al., 2016; Nock et al., 2008), but this research was largely cross-sectional. No prior research has examined a baseline measure of trait emotion reactivity in relation to daily ratings of sleep and emotion across the week. Additionally, this study sought to extend prior research examining the day-to-day relations between sleep and affect by analyzing daily sleep and affect relations in a large sample of first-year college students, in order to better understand how sleep and affect might influence one another in the context of the transition to the college environment.

A key takeaway of this study is that individuals high in emotion reactivity tend to experience more NA during the week. In line with hypotheses, and with prior research (Claes et al., 2014) higher emotion reactivity was significantly associated with increased NA. In addition, higher emotion reactivity was significantly associated with increased NA variability, or greater changes in the experience of negative affect over the course of the week. This aligns with the definition of emotion reactivity in that individuals high in this trait tend to be more sensitive to

emotional experiences as well as experience stronger emotional reactions, leading to frequent, strong emotional responses (Nock et al., 2008) and therefore might be more susceptible to fluctuations in in mood, specifically NA, over the course of the week. These findings might also demonstrate the role of trait emotion reactivity influencing state levels of emotion reactivity, by showing that those with higher levels of emotion reactivity experienced more intense levels of NA on a daily basis, as well as greater fluctuations in daily NA (e.g., NA variability) throughout the week - both aspects of emotion reactivity. However, no associations between emotion reactivity and PA or PA variability were found, although this might be due to the measure that was used in the study. The ERS items seem to be particularly focused on negative mood and events (e.g., "My feelings get hurt easily"; "I am easily agitated"), and therefore might not be able to accurately capture trait levels of positive emotion reactivity, leading to a lack of relations with daily levels and fluctuations of PA over the course of the week. Overall, the ERS might accurately capture trait levels of negative emotion reactivity rather than positive emotion reactivity.

Contrary to expectation, emotion reactivity was unrelated to sleep variables. Prior research has not examined relations between these variables, though there has been some support for a relation between emotion and sleep more broadly, indicating that the experience of positive or negative emotion might influence sleep (e.g., Vandekerckhove et al., 2011; McCrae et al., 2008; Kalmbach et al., 2014; Simor et al., 2015). One explanation is that the present study only measured self-reported sleep duration and sleep duration variability, and did not capture any additional self-reported measures of sleep (e.g., overall sleep quality) or objective measures of sleep (e.g., actigraphy). Other sleep variables, such as subjective sleep quality or objective sleep duration might have a different relation to emotion reactivity than self-reported sleep duration or

sleep duration variability alone. For example, prior studies have found different results in the relation between sleep duration and affect compared to self-reported sleep quality and affect (Kalmbach et al., 2014; McCrae et al., 2008). By including a broader range of sleep variables, both subjective and objective, the present study may have identified other aspects of sleep that may be related to emotion reactivity.

Contrary to expectation, temporal relations between affect and sleep were mixed. First, this study found that longer sleep duration at night was associated with increased PA the following day, pointing to the importance of encouraging young adults to get adequate sleep at night. In the present sample, average sleep duration was 6.99 hours per night, with significant differences between weekday and weekend sleep (6.78 hours during the week versus 7.64 hours on the weekend). Balancing time commitments of academics, work, and social life can be difficult for many college students and might contribute lack of adequate sleep. However, if sleep can contribute to improved positive mood, then students who are having a difficult time transitioning to college might be encouraged to prioritize adequate sleep at night over other commitments. This finding is consistent with prior research which found that better sleep quality at night (but not total sleep duration) was associated with more PA the following day in samples of older adults (McCrae et al., 2008) and young women (Kalmbach et al., 2014). In contrast to prior research, this study found no significant relation between nightly sleep duration and next day NA. A prior study found that on nights when older adults self-reported increased wake time after sleep onset (unwanted wake time while in bed), and on nights in which they self-reported lower sleep quality, they experienced more NA the following day (McCrae et al., 2008). Similar to the relation between emotion reactivity and sleep duration, it might be that sleep duration alone is not associated with next day NA, but other sleep variables (e.g., wake after sleep onset,

and self-reported sleep quality) are. Another explanation is that anxiety and depressive symptoms play a larger role in the relation between sleep duration and NA, as these were both significant in the model in the present study (increased symptoms associated with increased NA). While the prior study did exclude participants with psychiatric diagnoses, they did not control for any subclinical anxiety or depressive symptoms in their sample, as the present study did.

Finally, in examining the opposite temporal relation, PA and NA and same night sleep duration, there were no significant relations. Prior studies have found higher NA and lower PA to be related to poor sleep quality at night (Simor et al., 2015; Kalmbach et al, 2014). However, one study in college students did not control for depressive or anxiety symptoms (Simor et al., 2015) which may help to explain the differences in results. Another study that found a significant relation between affect and sleep duration was conducted only in females (Kalmach et al., 2014). Additionally, as the present study only measured affect at one time point each day (8PM or later, depending on when the participant completed the survey), there may have been a long gap in time between when the participant indicated their affect and when they went to bed, depending on when they filled out the daily diary. This could mean that their affect at bedtime did not match their affect earlier in the evening, which may have influenced results.

Limitations and Future Directions

There were several limitations to this study. First, the sample is majority White (59.3%) and majority female (84.5%), and is comprised solely of first-year college students, limiting the generalizability of the results. Second, the data are all self-report. Though daily diary methods reduce recall bias as participants are able to report at more frequent intervals, self-report data is still subject to error. Prior daily diary studies have included more objective measures like actigraphy (e.g., McCrae et al., 2008), which may yield more accurate estimates of sleep

variables, as participants might struggle to accurately recall bedtimes and wake times. However, subjective sleep duration data are still important as how much people feel they slept may matter more in relation to mood outcomes than how much they actually slept. For example, one study found that only subjective ratings of sleep (quality and wake time after sleep onset) were related to mood such that lower sleep quality and increased wake time after sleep onset were associated with lower PA and higher NA, while objective ratings of sleep were not significantly associated with affect (McCrae et al., 2008). As discussed previously, this study also only captured nightly self-reported sleep duration, and sleep variability (calculated from nightly sleep duration). Other studies have captured not only sleep duration but also measures of sleep quality, which in some cases demonstrated different relations with affect than did sleep duration (Kalmbach et al., 2014; McCrae et al., 2008). Future studies should examine multiple aspects of sleep in relation to emotion reactivity, as this could illuminate specific aspects of sleep that might by influenced by emotion reactivity levels.

In the current study, no association was found between emotion reactivity and PA or PA variability. As discussed previously, this might be due to the general negative focus of the measure of emotion reactivity used in the study. Future research could more specifically examine positive emotion reactivity and its relation to daily affective and sleep experiences by using other measures of emotion reactivity (e.g., the Emotion Reactivity, Intensity, and Perseveration Scale (ERIPS; Ripper, Boyes, Clarke, & Hasking, 2018)) that capture both negative and positive emotion reactivity. Prior research has demonstrated positive outcomes in individuals who show increased reactivity to positive events (Catalino & Fredrickson, 2011). Similarly, the process of savoring, which involves regulating the intensity and duration of positive feelings after experiencing a positive event has been shown to be a mechanism through which people

experience positive emotion after positive events (Jose, Lim, & Bryant, 2012), contributing to well-being. Using measures that capture both positive and negative emotion reactivity could be useful in better understanding trait emotion reactivity and its influence on overall well-being.

This study also did not measure or consider the environment in which these students were living and functioning, which may influence the relations between emotion reactivity and affect and sleep. It might be that students who are in more stressful environments (e.g., experienced financial stressors, must hold a job, participate in athletics, challenging academic course load, have a difficult roommate situation etc.) are more susceptible to the negative effects of high emotion reactivity compared to those who are in a more stable or positive environment. Research has found that some children who are more sensitive or reactive ("orchids") are potentially more vulnerable to negative outcomes, and might avoid these negative outcomes if they are placed in a positive environment with needed supports (see Kennedy, 2013 for a discussion). Future research should examine how context might shape outcomes in those with higher levels of emotion reactivity.

The timing of the distribution of the survey and allowable window of time for daily diary completion was another limitation of the present study. Sending out the survey at night at 8:00PM and allowing participants to have until the following afternoon to complete may have induced recall bias into the data, in that a fair amount of time passed between when participants woke up and reporting of sleep duration. Additionally, there was a long gap between when participants woke up, and when they reported their affect, somewhat weakening those results, as many other experiences impacting mood may have occurred throughout the day, and mood may have been changed independent of sleep duration. Future research examining the relation

between sleep and mood using methods with increased rates of mood reporting such as ecological momentary assessment (EMA) will be useful to better understand this relationship.

Similarly, due to the time-dependent nature of the analyses and the timing of the survey completion window, daily diary responses of those who completed their diary the following day were required to be eliminated, reducing sample size for those analyses. The study length of seven days may not have been long enough to capture an accurate picture of participants' daily experiences of mood and sleep. Prior daily diary studies have used two weeks (e.g., Kalmbach et al., 2014) for data collection. Finally, while the incentive for study participation (levels of class credit contingent upon varying amounts of completion of daily diary entries with gift card raffle for completing all seven days) was effective overall at keeping completion rates up (average completion=6 daily diaries), there was an artifact where a high number of participants (n=244) completed the first day of the diary, followed by a drop-off over the course of the week (n=199 on Friday, n=196 on Saturday), then increased completion on the final day of the study (n=220 on Sunday). Future studies might include additional incentive and reminders to keep participation consistent throughout the study.

Conclusion

The transition to college is a time when young adults experience a significant amount of change in their routines and environment leading to fluctuations in mood and disruptions in sleep schedules, which could contribute to longer-term consequences including the exacerbation and development of psychopathology. Identifying those who might be at higher risk for exacerbation or development of psychopathology as they transition to college is important. High levels of emotion reactivity have been associated with negative outcomes (Claes et al., 2014; Evans et al., 2016; Nock et al., 2008), and this study further demonstrates an association between high levels

of emotion reactivity and increased NA and NA variability, beyond the effects of anxiety or depressive symptoms. In light of these findings, universities might consider early intervention for students with high levels of emotion reactivity, possibly making sure they are aware of mental health resources available on campus. Additionally, this study underscores the importance of sleep duration during the transition to college, finding that college students who get more sleep than usual also experience more PA. Future research should continue to examine relations between emotion reactivity, affect, and sleep using rigorous methods (e.g., EMA) and measures (e.g., actigraphy) in order to better understand these relations and contribute to possible interventions.

APPENDIX A

DEMOGRAPHICS

1. Birthdate _____

2. Gender _____

3. Are you of Hispanic, Latino, or of Spanish origin?
    a. Yes
    b. No

4. How would you describe yourself? (select all that apply)
    a. White
    b. Black or African American
    c. American Indian or Alaska Native
    d. Asian or Indian
    e. Native Hawaiian or Other Pacific Islander
    f. Other (please specifcy)

5. Year in school?

    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior
    e. Other. Please specify: _____

6. Where do you live?
    a. Residential hall on campus
    b. Off campus apartment
    c. With parent(s)/legal guardian in Chicago area.
    d. Other. Please specify: _____

7. Which describes your annual household income?
    a. Less than $25,000
    b. $25,000 - $50,000
    c. $50,000 - $75,000
    d. $75,000 - $100,000
    e. Above $100,000

APPENDIX B

EMOTION REACTIVITY SCALE

This questionnaire asks different questions about how you experience emotions on a regular basis. When you are asked about being 'emotional,' this may refer to being angry, sad, excited, or some other emotion. Please rate the following statements:
(Each item is rated on a 0 to 4 scale (0 =not at all like me and 4 =completely like me))

1. When something happens that upsets me, it's all I can think about it for a long time.
2. My feelings get hurt easily.
3. When I experience emotions, I feel them very strongly/intensely.
4. When I'm emotionally upset, my whole body gets physically upset as well.
5. I tend to get very emotional very easily.
6. I experience emotions very strongly.
7. I often feel extremely anxious.
8. When I feel emotional, it's hard for me to imagine feeling any other way.
9. Even the littlest things make me emotional.
10. If I have a disagreement with someone, it takes a long time for me to get over it.
11. When I am angry/upset, it takes me much longer than most people to calm down.
12. I get angry at people very easily.
13. I am often bothered by things that other people don't react to.
14. I am easily agitated.
15. My emotions go from neutral to extreme in an instant.
16. When something bad happens, my mood changes very quickly. People tell me I have a very short fuse.
17. People tell me that my emotions are often too intense for the situation.
18. I am a very sensitive person.
19. My moods are very strong and powerful.
20. I often get so upset it's hard for me to think straight.
21. Other people tell me I'm overreacting

APPENDIX C

POSITIVE AND NEGATIVE AFFECT SCALE (PANAS)

For the following questions, indicate to what extent you feel this way right now, that is, at the present moment.

1 = Very slightly or not at all 2 = A little 3 = Moderately 4 = Quite a bit 5 = Extremely

Interested	_____	Alert	_____
Distressed	_____	Upset	_____
Excited	_____	Inspired	_____
Strong	_____	Nervous	_____
Guilty	_____	Determined	_____
Scared	_____	Attentive	_____
Hostile	_____	Jittery	_____
Enthusiastic	_____	Active	_____
Proud	_____	Afraid	_____
Irritable	_____	Ashamed	_____

APPENDIX D

SLEEP DURATION AND TIMING

The following questions refer to <u>specific day of the week (e.g. Sunday night)</u>

1. Did you go to sleep last night? (referring to [Sunday] night)? (YES / NO)
   (IF NO, skip to alcohol)
   (IF YES)
   a. What time did you go to sleep last night? _ _: _ _ AM/PM
   b. How long did it take you go to sleep last night? ___ min/hr
   c. How many hours of sleep did you get last night? ____ hr
   d. What time did you wake up today? _ _: _ _ AM/PM
   e. What time did you physically get out of bed (referring to [Monday] morning): _ _: _ _ AM/PM

APPENDIX E

CENTER FOR EPIDEMIOLOGICAL STUDIES DEPRESSION SCALE

Below is a list of some of the ways you may have felt or behaved. Please indicate how often you have felt this way during the past week.

Rarely or none of the time (less than 1 day)	**Some or a little of the time** (1-2 days)	**Occasionally or a moderate amount of time** (3-4 days)	**All of the time** (5-7 days)

1. I was bothered by things that usually don't bother me.
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

2. I had trouble keeping my mind on what I was doing
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

3. I felt depressed.
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

4. I felt that everything I did was an effort.
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

5. I felt hopeful about the future.
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

6. I felt fearful.
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

7. My sleep was restless.
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

8. I was happy.
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

9. I felt lonely.
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

10. I could not "get going."
    a. Rarely or none of the time
    b. Some or little of the time
    c. Occasionally or a moderate amount of time
    d. All of the time

APPENDIX F

DEPRESSION, ANXIETY, AND STRESS SCALE

Please read each statement and circle a number 0, 1, 2, or 3 that indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement.

1. I was aware of dryness of my mouth
    0. Did not apply to me at all
    1. Applied to me to some degree, or some of the time
    2. Applied to me a considerable degree, or a good part of the time
    3. Applied to me very much, or most of the time

2. I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion)
    0. Did not apply to me at all
    1. Applied to me to some degree, or some of the time
    2. Applied to me a considerable degree, or a good part of the time
    3. Applied to me very much, or most of the time

3. I felt scared without any good reason
    0. Did not apply to me at all
    1. Applied to me to some degree, or some of the time
    2. Applied to me a considerable degree, or a good part of the time
    3. Applied to me very much, or most of the time

4. I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)
    0. Did not apply to me at all
    1. Applied to me to some degree, or some of the time
    2. Applied to me a considerable degree, or a good part of the time
    3. Applied to me very much, or most of the time

5. I felt I was close to panic
    0. Did not apply to me at all
    1. Applied to me to some degree, or some of the time
    2. Applied to me a considerable degree, or a good part of the time
    3. Applied to me very much, or most of the time

6. I was worried about situations in which I might panic and make a fool of myself
    0. Did not apply to me at all
    1. Applied to me to some degree, or some of the time
    2. Applied to me a considerable degree, or a good part of the time
    3. Applied to me very much, or most of the time

7. I experienced trembling (e.g., in the hands)
    0. Did not apply to me at all
    1. Applied to me to some degree, or some of the time
    2. Applied to me a considerable degree, or a good part of the time
    3. Applied to me very much, or most of the time

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