A Poor Night's Sleep Predicts Next-Day Social Events Among Individuals With Chronic Pain via Fluctuations in Affects

by

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ABSTRACT

Experiencing poor, unrefreshing sleep is a common occurrence for individuals with chronic pain. Sleep disturbance predicts not only greater pain and disability, but also heightened negative affect and reduced positive affect in individuals with chronic pain. Such fluctuations in affect have been linked with more negative and fewer positive social events. For those with chronic pain, negative social relations can exacerbate pain, whereas positive social interactions can help decrease disability. Thus, exploring the sleep–social functioning process in chronic pain may be one way to improve daily functioning and quality of life. The current study examined positive and negative affect as two parallel mediators of the within-day relations between sleep quality and positive and negative social events in individuals with chronic pain. For 21 days, electronic daily diary reports were collected from 220 individuals with fibromyalgia, a condition characterized by widespread chronic pain. Within-person relations among reports of last night's sleep quality, afternoon affects and pain, and evening social events were estimated via multilevel structural equation modeling. Findings showed that positive affect mediated both the sleep quality–positive social events and sleep quality–negative social events relations. That is, greater than usual sleep disturbance last night predicted afternoon reports of lower than usual positive affect. Low positive affect, in turn, predicted evening reports of fewer than usual positive social events and more than usual negative social events that day, controlling for the effects of afternoon pain. In addition, negative affect mediated the sleep quality–negative social events link. That is, greater than usual sleep disturbance last night predicted afternoon reports of higher than usual negative affect, which, in turn, predicted evening reports of more than usual negative

social events that day, controlling for the effects of afternoon pain. Of the three significant mediated paths, the sleep quality–positive affect–positive social events path was the strongest in magnitude. Thus, a night of poor sleep can have an impact on social events the next day in those with chronic pain by dysregulating affect. Further, findings highlight the key role of positive affect in the sleep–social functioning process and potential socio-affective benefits of sleep interventions in chronic pain.

DEDICATION

I will love you forever

For today, for tomorrow, for always

My dream, my reality, my end

One lifetime with you is not enough

To my husband, my best friend.

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TABLE OF CONTENTS

CHAPTER Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER 1

INTRODUCTION

Attaining adequate sleep is essential for maintaining health, well-being, and survival. Whereas experiencing a single night of good sleep quality can lead to better function the next day, experiencing continuous nights of good sleep quality over extended periods of time can help protect against the development and worsening of physical and mental health illnesses (e.g., Haack & Mullington, 2005; Zhang, Lam, Li, Li, & Wing, 2012). Nevertheless, obtaining adequate sleep remains a struggle for many individuals. In fact, an estimated 35% of adults in the United States experience "poor" or "only fair" sleep quality (National Sleep Foundation [NSF], 2014), putting them at risk for worse health. The increased risk of health problems tied to poor sleep may be especially relevant for individuals with chronic pain. Chronic pain is the most common chronic illness (Centers for Disease Control and Prevention [CDC], 2009). For individuals with chronic pain, sleep problems exacerbate pain and mood disturbance, leading to greater physical disability (e.g., Naughton, Ashworth, & Skevington, 2007). The implications of poor sleep for social function among those with chronic pain, however, are less studied. Not only is positive social functioning important for maintaining daily functioning, but it also helps individuals cope with the burden of their pain (Zautra, Hamilton, & Yocum, 2000). Therefore, the current study examined the within-day relation between sleep quality and social functioning among individuals with chronic pain, and evaluated the extent to which fluctuations in positive and negative affect mediate that relation, independent of pain.

CHAPTER 2

SLEEP DISTURBANCE

Sleep problems can be acute or chronic in nature. Existing evidence suggests that both acute and chronic sleep disturbance is related to an increased risk of developing a number of health conditions, including obesity, diabetes, hypertension, cardiovascular disease, and mood disorders (Colten & Altevogt, 2006). Further, the fatigue associated with daytime sleepiness is linked with reduced productivity and a heightened likelihood of motor vehicle and other accidents (Colten & Altevogt, 2006; Daley et al., 2009). In an effort to generate awareness among health care professionals and the general public of the risks of poor sleep, the United States Department of Health and Human Services identified sleep research and dissemination as a high priority target for improving health, wellness, productivity, and safety among the population (Healthy People, 2020, 2014). Therefore, the need to understand the links between poor sleep and health is pressing, especially within high risk groups like those with chronic pain. Before elaborating on the effects of poor sleep in chronic pain, it is useful to understand how sleep impacts functioning in healthy individuals.

Physiological Health

Sleep disturbance impacts daily and longer-term physiological processes among individuals who are healthy. Research findings show that even partial sleep deprivation (i.e., 4 hours of sleep at night for one night) can postpone the recovery of the hypothalamic-pituitary-adrenal (HPA) axis from circadian activation in the early morning and lead to increased cortisol levels that evening (Leproult, Copinschi, Buxton, & Van

Cauter, 1997). Of note, the HPA axis plays a central role in an individual's ability to efficiently respond to and recover from daily stressors (Dickerson & Kemeny, 2004). Experiencing dysregulation between the body's internal clock system (i.e., circadian activation) and the HPA axis over the longer-term contributes to the development of immune and metabolic health conditions (Nicolaides, Charmandari, Chrousos, & Kino, 2014). Further, a night of complete sleep deprivation (i.e., no sleep) reduces parasympathetic activity, elevates sympathetic activity and evening cortisol levels, and enhances the cortisol response following a stressor the next day (Spiegel, Leproult, & Van Cauter, 1999; Minkel et al., 2014). Such physiological changes following sleep disturbance indicate that poor sleep itself is a stressor and it interferes with the body's ability to effectively manage additional stressors. Experiencing prolonged sleep disturbance, on the other hand, can maintain disruptions in physiological processes, creating an allostatic load on the body that is known to result from chronic stress exposure (McEwen, 2006; Lange, Dimitrov, & Born, 2010; Franzen et al., 2011).

The consequences of poor sleep also extend to other metabolic and endocrine functions. Collectively, both animal and human studies have shown that sleep deprivation fuels physiological changes that increase the risk of developing diabetes and obesity. In a sample of rats, for instance, both moderate and severe levels of sleep deprivation disrupted glucose homeostasis and body weight control (Barf, Meerlo, & Scheurink, 2010). In studies of healthy adults, sleep disturbance at night has been shown to reduce glucose tolerance and energy expenditures during the next day (Spiegel et al., 1999; Benedict et al., 2011). Of note, the changes in metabolic and endocrine function that result from sleep disturbance are similar to those observed in normal aging populations;

this suggests that sleep problems may increase the risk of developing medical conditions related to aging at younger than expected ages (Spiegel et al., 1999).

In summary, sleep deprivation poses significant physiological consequences for healthy individuals. A single night of sleep disturbance is able to impair physiological function the next day and interfere with one's ability to cope with stressors. When disturbances in sleep are sustained over time, the resulting changes in physiological processes can impair long term health.

Psychosocial Health

Affective function. Collectively, findings suggest that poor sleep alters the affective experience of healthy individuals by reducing positive affect and heightening negative affect. Observational findings derived from daily diary studies have shown that experiencing poor sleep quality at night is associated with lower positive affect and greater negative affect the next day in both healthy younger adults (Haack & Mullington, 2005; Bower, Bylsma, Morris, & Rottenberg, 2010) and healthy older adults (McCrae et al., 2008). Experimental investigations have yielded a similar pattern of findings. For instance, in an experimental study of healthy individuals, sleep loss resulting from forced awakenings throughout the night for three consecutive nights significantly reduced positive affect, even after controlling for elevations in negative affect (Finan, Quartana, & Smith, 2015). Other experimental studies in healthy individuals have shown that restricting sleep at night worsens mood during the day as demonstrated by reports of elevated negative affect (Baum et al., 2013, Minkel et al., 2012). Of note, a review paper examining the longer term implications of ongoing sleep problems suggests that the

affective disturbances resulting from poor sleep can lead to depression and/or anxiety symptoms over time (Baglioni, Spiegelhalder, Lombardo, & Riemann, 2010).

Beyond affecting affect levels, sleep disturbance may also create a state of heightened affective reactivity. In experimental studies with healthy individuals, neuroimaging has been used to examine reactions to emotional stimuli after sleep deprivation. Findings showed that following sleep deprivation, the amygdala becomes especially reactive to *negative* (e.g., fearful facial expressions) but not positive (e.g., happy facial expressions) stimuli and the functional connectivity between the amygdala and prefrontal regions becomes reduced (Chuah et al., 2010; Motomura et al., 2013; Rosales-Lagarde et al., 2012). Further, a cross-sectional study demonstrated that for healthy individuals who experience poor versus good sleep quality, the increased amygdala reactivity to negative stimuli is associated with self-reports of higher perceived stress and depressive symptoms (Prather, Bogdan, & Hariri, 2013). The alterations in affective reactivity associated with sleep disturbance are also evident in daily life. For instance, in a study of medical residents with inconsistent sleep schedules, a combination of actigraphy and daily diary reports demonstrated that poor sleep exacerbated negative affect following unpleasant events and reduced positive affect following pleasant events (Zohar, Tzischinsky, Epstein, & Lavie, 2005).

Sleep quality impacts the ability not just to regulate, but also to recognize affective social cues. In one experimental study, for instance, healthy participants were asked to identify positive, negative, neutral, and ambivalent facial expressions that were created by varying eyebrow and lip positions on cartoon drawings (Pallesen et al., 2004). Findings showed that participants who were sleep deprived for one night demonstrated a

decrease in their overall accuracy to recognize facial expressions and an increase in their reaction time to all facial expressions compared to participants who were not sleep deprived. Similarly, sleep deprived participants have shown a marked deficit in their capacity to accurately recognize *angry* and *happy* facial expressions but not *sad* expressions (van der Helm, Gujar, & Walker, 2010). These deficits following limited sleep deprivation disappeared after a night of sleep recovery.

In summary, poor sleep is related to affect in healthy individuals (See Table 1 for a summary of sleep–affect studies conducted with healthy individuals). Findings from experimental studies show that individuals who are sleep deprived have greater negative affect and reduced positive affect during the day, and they are more likely to react affectively to negative events. Sleep deprived individuals are also less accurate in recognizing affective social cues, which may negatively impact their social relations. Findings from studies with daily diaries suggest that a night of greater than usual sleep disturbance is followed by elevated negative affect and reduced positive affect the next day in healthy individuals. Literature on daily diary data is especially relevant for the current study, which examined the implications of poor sleep quality at night on positive and negative affect the next day in individuals with chronic pain.

Social function. Given the evidence linking sleep disturbance with an impaired ability to recognize social cues, it is not surprising that sleep is important for social functioning as well. Some research demonstrates that individuals with troubled relationships and/or low support from relationships experience problems with sleep (Ailshire & Burgard, 2012; Kent, Uchino, Cribbet, Bowen, & Smith, 2015). For instance, in both undergraduate and older adult samples, those who identified themselves as feeling

lonely reported poorer sleep quality than did non-lonely individuals (Cacioppo et al., 2002). This is especially problematic for older adults, a group at risk of developing insomnia, because insomnia makes it more difficult to maintain social connections and to form new ones (Crowley, 2011; Nicholson, 2012).

Research examining the sleep–social function relation has also demonstrated that poor sleepers experience more conflict in relationships and good sleepers experience less conflict and better psychological well-being (Hamilton, Nelson, Stevens, & Kitzman, 2007; Carney, Edinger, Meyer, Lindman, & Istre, 2006). In a daily diary study of healthy couples, individuals experiencing sleep disturbance at night reported more conflict in their romantic relationship the next day (Gordon & Chen, 2014); these individuals were also less empathic when discussing the conflict with their partner. Findings also suggest that people who are sleep deprived behave more aggressively in their relationships and are less likely to behave in ways that would mitigate conflict in their relationships (i.e., they are more likely to blame others and less likely to accept blame; Kahn-Greene, Lipizzi, Conrad, Kamimori, & Killgore, 2006).

Affect-social functioning relations. One mechanism hypothesized to connect sleep to social functioning is affect. A review examining the relations among sleep, emotion, and social interactions notes that the emotional expressivity and recognition that becomes impaired follow sleep deprivation is especially harmful for social interactions (Beattie, Kyle, Espie, & Biello, 2015). Further, studies in healthy individuals suggest that affective health also impacts social relations. In fact, a study using daily diary reports of healthy individuals, found positive correlations between positive affect and positive social interactions, and between negative affect and negative social interactions (Vittengl

& Holt, 1998). In an experimental study, healthy participants were randomly assigned to an intervention designed to increase positive affect (i.e., loving kindness practice) or to a wait-list control (Kok et al., 2013). Participants who received the intervention relative to the control condition experienced higher levels of positive affect, which predicted subsequent increases in their perceptions of social connectedness.

In sum, existing research demonstrates that the consequences of sleep disturbance extend to physiological and psychosocial processes in healthy individuals. The greatest impact, however, appears to be on day-to-day functioning. Even one night of poor sleep limits a person's reserve capacity, or the ability to effectively cope and utilize one's resources, making it more difficult to manage stressors, regulate affect, and maintain the quality of one's social relationships the next day. For individuals with chronic pain, the impact of sleep disturbance on daily function can be even more profound, because sleep disturbance is common in this group and it adds to the burden of pain and other symptoms.

CHAPTER 3

CHRONIC PAIN

Chronic pain is a condition characterized by pain that persists for more than 12 weeks or beyond the healing time expected for an injury or illness (American Society of Anesthesiologists Task Force on Chronic Pain Management, 2010). Chronic pain is the most common chronic illness and the leading cause of disability in the United States (CDC, 2009). In fact, recent estimates indicate that 30% of individuals in the United States suffer from chronic pain, with approximately half of them experiencing pain on a daily basis (Johannes, Kim Le, Zhou, Johnston, & Dworkin, 2010). Managing chronic pain is complex for both individuals and health care providers because its source and presentation are quite variable. For instance, chronic pain can develop from a physical injury that leads to tissue damage or it can result from aging and related medical conditions, such as arthritis or low back pain (Loeser & Melzack, 1999; Gagliese & Melzack, 1997). Further, it is possible that pain symptoms gradually develop, persist, and worsen without a visible or identifiable cause, which poses even greater challenges for the individual suffering from this phenomenon and the interventionists trying to treat them. Regardless of the cause of chronic pain, it often leads to distress and impairment. Importantly, similar to the effects of sleep disturbance, the effects of chronic pain also extend to the psychosocial health outcomes (i.e., affective health and quality of social relations) that impact day-to-day functioning.

Affective Function

Affective disturbances are especially prevalent among individuals with chronic pain. Negative affect in particular is experienced alongside the stress of ongoing pain. For instance, depression and anxiety are common co-morbidities of individuals with chronic pain. Among those with chronic pain, approximately 22% experience depression and 35% experience an anxiety disorder; these rates are twice those of individuals without chronic pain (McWilliams, Cox, & Enns, 2003). Not only does this negative affect exacerbate pain levels, but it also decreases pain tolerance (e.g., Tang et al., 2008). Further, individuals with chronic pain experience notable deficits in levels of positive affect (e.g., Zautra et al., 2005). This impairment interferes with individuals' ability to cope with their pain and other stressors, as positive affect has been shown to mitigate the deleterious consequences of aversive experiences (Zautra, Johnson, & Davis, 2005). For example, in a daily diary study of individuals with chronic pain, positive affect weakened the relation between daily pain flares and same-day increases in negative affect (Zautra, Smith, Affleck, & Tennen, 2001).

Social Function

Chronic pain also disrupts social functioning. Similar to positive affect, positive social engagement is a source of resilience in chronic pain (Sturgeon & Zautra, 2010). Social relations often provide support and resources during adverse situations (Cacioppo, Reis, & Zautra, 2011). Individuals with chronic pain, however, are less engaged in social relations and less able to maintain them over time than are healthy individuals (Zautra et al., 2000). Further, the experience of pain contributes to interpersonal conflict in social

relations for individuals with chronic pain (Faucett & Levine, 1991). Perceptions of poorer social support, in turn, predict greater negative affect, pain, and long-term disability (Davis, Zautra, & Reich, 2001; Feldman, Downey, & Schaffer-Neitz, 1999; Evers, Kraaimaat, Geenen, Jacobs, & Bijlsma, 2003). Of note, an intervention study designed to increase positive social engagement in individuals with chronic pain demonstrated that in addition to greater social engagement, these individuals experienced reduced disease activity and better quality of life and coping abilities (Zautra et al., 2000). Findings from this study suggest that individuals with chronic pain who are able to maintain positive social relations despite the experience of pain, have better health outcomes.

Like sleep disturbance, chronic pain disrupts two important domains of psychosocial health: affective and social functioning. Given that both poor sleep and chronic pain can be considered stressors, what are the implications for psychosocial health for individuals with concurrent sleep disturbance and pain?

CHAPTER 4

SLEEP AND CHRONIC PAIN

Sleep plays a prominent role in chronic pain adaptation. It is noteworthy that more than half of individuals with chronic pain experience problems with sleep (NSF, 2015). Disturbances in sleep, as a result, exacerbate pain, worsen mood, and impair coping abilities. Although existing research points to a bidirectional relation between sleep quality and pain, the evidence suggests that sleep quality is a more robust predictor of pain than is pain of sleep quality (Finan, Goodin, & Smith, 2013), which points to the substantial impact of sleep on pain management. Research findings also demonstrate that individuals with chronic pain experience poor affective health and social relations, both of which are important domains of psychosocial function that influence the ability to cope with pain. Based on findings from studies with healthy individuals, poor sleep has the potential to impair these areas of function in individuals with chronic pain, leading to even worse health. Therefore, identifying the implications of sleep disturbance for affective and social functioning in individuals with chronic pain is one step in the process of identifying ways to improve day-to-day function and quality of life.

Affective Function

Among individuals with chronic pain, sleep disturbance is followed by elevated negative affect and diminished positive affect. Studies using daily diary reports have found that a night of poor sleep predicts increases in negative affect and reductions in positive affect the next day in individuals with chronic pain (Gerhart et al., 2017; Hamilton, Affleck, Tennen, Karlson, & Luxton, 2008; Kothari, Davis, Yeung, & Tennen,

2015). Daily diary data also show that the reduced positive affect following a night of poor sleep leads to higher levels of perceived disability that next day (Kothari et al., 2015). Findings from this diary study highlight the potential importance of sustaining or boosting positive affect following a night of poor sleep for maintaining daytime function in individuals with chronic pain (Kothari et al., 2015).

Cross-sectional studies demonstrate similar findings in individuals with chronic pain. In a recent study of children and adolescents with chronic pain, poor sleep was associated with higher negative and reduced positive affect, both of which were associated with greater disability (Evans, Djilas, Seidman, Zeltzer, & Tsao, 2017). Cross-sectional findings also show that poor sleep is related to elevated negative affect and/or symptoms of depression, which in turn are related to higher levels of pain (O'Brien et al., 2010; Parmelee, Tighe, & Dautovich, 2015) and pain-related disability in individuals with chronic pain (Naughton et al., 2007).

In sum, similar to studies with individuals who are healthy, studies with individuals who have chronic pain also demonstrate that poor sleep impairs affect by elevating negative affect and dampening positive affect (See Table 1 for a summary of sleep–affect studies conducted with individuals with chronic pain). Both daily diary and cross-sectional studies demonstrate that these disturbances in affect can lead to even greater disability in individuals with chronic pain. A next step forward in this area of research is to understand not only the affective but also the social consequences following a night of sleep disturbance in those with chronic pain.

Social Function

The literature examining the effects of sleep disturbance on social functioning in chronic pain is limited, despite findings demonstrating that poor sleep is linked with impaired social functioning in healthy individuals and social functioning is impaired in chronic pain groups (e.g., Gordon & Chen, 2014; Zautra et al., 2000). In fact, the single cross-sectional study that has examined the sleep–social functioning link found that poor sleep quality was associated with poor social functioning in individuals with chronic pain (Theadom, Cropley, & Humphrey, 2007). Additional research has explored the relation between sleep quality and social relationships in aging women (Friedman et al., 2005). Not only is the prevalence of chronic pain higher in women than men, but it can also increase with age (Patel, Guralnik, Dansie, & Turk, 2013). Findings from this study showed that women with higher levels of interleukin-6 experience poorer sleep quality and worse social relations. Of note, high levels of interleukin-6 contribute to the inflammation observed in some chronic pain conditions (e.g., rheumatoid arthritis; Hirano et al., 1988). Further, women with poor sleep but good social relations and women with poor social relations but good sleep had interleukin-6 levels that were similar to women with both good sleep and good social relations. This suggests that sleep and social functioning are related and that improving either may help manage pain.

Although limited, existing evidence suggests that poor sleep quality is associated with impaired social function in those with chronic pain. To date, daily diary reports have not been used to explore whether the effects of a night of greater than usual sleep disturbance extend to social function the next day in individuals with chronic pain.

Understanding the within-day impact of sleep disturbance is especially relevant for identifying ways to improve daily pain management.

Affect-Social Functioning Relations

Within the chronic pain literature, much of the existing research has focused on the effects of social events on affect as opposed to the effects of affect on social events. Findings from this research domain show that experiencing more negative social interactions is associated with greater negative mood and/or symptoms of depression (e.g., Zautra, Burleson, Matt, Roth, & Burrows, 1994; Feldman et al., 1999). Experiencing positive social interactions, however, can mitigate this relation. For instance, in a daily diary study consisting of individuals with chronic pain, negative social events were less strongly associated with negative affect on days when positive social events were higher than usual (Finan et al., 2010). In addition, on days when individuals with chronic pain are more engaged in their social goals, they experience greater positive affect (Affleck et al., 1998).

Research examining the impact of affect on social events is much more limited. One study used daily diary reports to assess for the social effects of feeling lonely in individuals with chronic pain; findings showed that when individuals felt lonely, they reported both more negative and fewer positive social events (Wolf & Davis, 2014). Therefore, negative affect may impact exposure to not only negative but also to positive social events in individuals with chronic pain. Whether positive affect predicts subsequent reports of positive social events has not been studied among those with chronic pain, but findings gleaned from samples of healthy individuals (e.g., Vittengl &

Holt, 1998) point to the likelihood that positive affect will predict more positive social events in those with chronic pain as well. The link between positive affect and negative social events has not been explored and may be an important avenue for research examining the effects of affect on social function.

CHAPTER 5

THE PROPOSED STUDY

Disturbances in sleep can be harmful for day-to-day function in healthy individuals, but perhaps even more so for those with chronic illness. Further, given the high prevalence of sleep disturbance in individuals with chronic pain, its impact can be especially debilitating for these individuals. In fact, research has documented the negative consequences of sleep disturbance for multiple domains of health in those with chronic pain, particularly affective health. An area of research that has received little attention, however, is on the effects of sleep on social functioning. This is surprising given that sleep disturbance is a common correlate of chronic pain and that positive social engagement is a key source of resilience that is linked with better health outcomes in individuals with chronic pain.

Among individuals with chronic pain, high levels of negative affect and low levels of positive affect are common and often exacerbated following disturbances in sleep (e.g., O'Brien et al., 2010; Evans et al., 2017). Although limited, findings also suggest that changes in affect can be harmful for social functioning (e.g., Beattie et al., 2015). Thus, a potential mechanism linking sleep quality to social functioning is the fluctuations in positive and negative affect.

The proposed study was designed to examine the within-day process through which sleep disturbance predicts positive and negative social events in individuals with chronic pain (See Figure 1a). Focusing on the within-day level is important because it offers a snapshot into the daily life of an individual with chronic pain, demonstrating how events unfold after waking from a night of poor sleep. This study has two specific aims:

1) to determine whether last night's sleep disturbance predicts next day's level of positive and negative social engagement; and 2) to determine whether sleep-related fluctuations in positive and negative affect serve as parallel mediators of the sleep–social functioning relations. An additional exploratory aim is to evaluate whether today's social events carry over to predict tomorrow morning's sleep quality, based on evidence suggesting that those with poor social relations experience worse sleep (e.g., Ailshire & Burgard, 2012; Kent et al., 2015; See Figure 1b).

To address the study aims, data were drawn from an existing data set that includes daily diary reports completed by individuals with pain due to fibromyalgia (FM). FM is a chronic illness characterized by widespread pain and nonrestorative sleep – sleep that is unrefreshing and of poor quality, though the duration of it may appear normal (Moldofsky, 2008). In addition, the prevalence of sleep problems in FM is significantly greater than that of other chronic pain groups. For instance, in a study comparing sleep problems in FM, rheumatoid arthritis, and the general population, 63% of individuals with FM, 30% of individuals with rheumatoid arthritis, and 24% of the general population reported that their sleep was *not* restful enough (Belt, Kronholm, & Kauppi, 2009). It is also noteworthy that individuals with FM experience difficulties in regulating affect. Specifically, studies have shown that individuals with FM in particular demonstrate significant deficits in levels of positive affect (Zautra et al., 2005). Further, social functioning may be especially problematic in FM relative to other chronic pain conditions. Because their pain condition is not visible to others and has no clear pathophysiology, individuals with FM may experience a sense of social stigma, perceiving that others assume their pain is feigned or exaggerated (Davis et al., 2001;

Åsbring & Närvänen, 2002; Kool & Geenen, 2012). As a result, pain-related stigma can lead to loneliness and social withdrawal in individuals with FM. Therefore, focusing on the FM group is especially relevant when studying the sleep–social functioning processes in chronic pain.

Hypotheses

Proposed model. To examine the roles of positive and negative affect in the relations between sleep and positive and negative social events, the current study drew on within-day electronic diary reports collected across 21 days from individuals with FM. For the proposed model, the following hypotheses were tested (See Figure 1a):

1. Early-morning reports of greater than usual sleep disturbance last night will predict afternoon reports of:
    a. Higher than usual negative affect;
    b. Lower than usual positive affect.
2. Afternoon reports of higher than usual negative affect will predict evening reports of:
    a. Higher than usual negative social events, controlling for afternoon pain;
    b. Lower than usual positive social events, controlling for afternoon pain.
3. Afternoon reports of lower than usual positive affect will predict evening reports of:
    a. Lower than usual positive social events, controlling for afternoon pain.

4. Negative affect will significantly mediate the relation between sleep quality and positive social events and the relation between sleep quality and negative social events. Positive affect will significantly mediate the relation between sleep quality and positive social events.

Additional hypothesis. In addition to the model hypotheses, the current study assessed the effects of today's social events on sleep quality reported tomorrow morning (See Figure 1b):

5. Evening reports of more than usual negative social events and fewer than usual positive social events will predict next-day early-morning reports of poor sleep quality last night.

CHAPTER 6

METHOD

Participants

Participants were recruited from the Phoenix, Arizona metropolitan area as part of a larger intervention study assessing psychological treatments for FM. Methods of recruitment included print and online versions of advertisements, physician referrals, and FM support groups. To be eligible for participation, individuals were required to meet the following criteria: 1) be between the ages of 18 and 72 years; 2) speak English; 3) report pain lasting three or more months in at least four quadrants of the body, or in two quadrants of the body with significant sleep disturbance and fatigue; and 4) pass the manual tender point examination that is consistent with American College of Rheumatology's diagnostic criteria for FM (Wolfe et al., 1990). Participants were excluded from the study if they: 1) were involved in litigation related to their pain; 2) were participating in a psychosocial treatment for pain or mood disturbance; and/or 3) had comorbid medical or psychological conditions that could interfere with their involvement in the study.

Procedure

Screening. Interested respondents were first screened by phone to determine their eligibility for the study. Those who screened eligible underwent the manual tender point examination, which was performed by a trained nurse. During this exam, a dolorimeter was used to administer 4 kilograms of pressure to 18 tender point and 3 control point sites on the body. To be eligible, participants were required to have reported pain on at least 11

of the 18 tender point sites, which confirms presence of the widespread musculoskeletal pain and tenderness that is characteristic of FM (Wolfe et al., 1990).

Study participation. Once enrolled into the study, participants completed the informed consent form along with an initial packet of questionnaires that assessed their pain and physical and psychosocial health. Afterwards, trained research staff members conducted phone interviews to measure history of depression, trauma, and other significant life events. Participants then completed a series of pre-intervention assessments: 1) a laboratory session that measured startle responses and pain tolerance; 2) a 21-day daily diary measuring physical, psychological and social events; and 3) questionnaires assessing the level of current symptoms along with physical and emotional functioning. Participants were then randomized into one of the three 7-week treatment conditions. Lastly, participants completed post-treatment and 6- and 12-month follow-up assessments. The current study drew data from participants diagnosed with FM who completed the pre-intervention 21-day daily diary.

Daily diary assessment. Before beginning the *pre*-intervention diary, a research staff member met with participants to provide them with a cell phone and detailed instructions on how to complete the diary. During the 21-day diary, an automated phone system called each participant on their phone four times per day and delivered audio recorded questions. Participants were asked to indicate their responses using the phone keypad input function. The four daily time points were: 1) in the early-morning, 20 minutes following a wake up time specified by the participant (this was consistent across the 21 days); 2) in the late-morning at 11:00 am; 3) in the afternoon at 3:30 pm; and 4) in the evening at 7:00 pm. If a call was missed, participants were instructed to call into the

system within three hours of the call to complete study questions. Research staff members regularly monitored call activity and contacted participants if they missed multiple calls to address any barriers to completion. Participants were compensated $2/day for completing diaries with a bonus of $1/day for a 50% or greater completion rate. For the current study, sleep quality assessed at Time 1, pain and positive and negative affect assessed at Time 3, and positive and negative social events assessed at Time 4 were used in the model testing. For the exploratory model analyses (described below), pain assessed at Time 2 and interpersonal stress and joy assessed at Time 3 were also included.

Main Model Measures

All measures for the current study are included in Appendix A, Study Measures.

Sleep quality. Early-morning ratings of sleep last night were assessed using items drawn from the Pittsburgh Sleep Quality Index (PSQI), which has been shown to have strong internal consistency, diagnostic validity, and test-retest reliability (Buysse, Reynolds, Monk, Berman, & Kupfer, 1991). Items were modified so that they assessed prior night's sleep rather than past month's sleep. Participants indicated whether they experienced trouble staying asleep and the total number of hours and minutes they actually slept during the prior night. Participants also responded to an additional item derived from the PSQI; "What was the overall quality of your sleep last night?" (0 = "extremely poor sleep" to 100 = "extremely good sleep"). Finally, they responded to an item developed for the current study assessing the restorative capacity of sleep; "How refreshed did you feel after waking this morning?" (0 = "not at all refreshed" to 100 =

"extremely refreshed"). The two latter items were used to measure participants' overall quality of sleep at night. These two items were rescaled from a 0 to 100 scale to a 0 to 5 scale by dividing each score by 20. By rescaling these items, the scaling became comparable to other variables in the model. The within-person correlation for the two items was $r = 0.70$. A composite of sleep quality was formed by averaging the responses to the two rescaled items on each day.

Affect. Afternoon ratings of affect were assessed using items selected from the Positive and Negative Affect Schedule-Expanded Form (PANAS-X; Watson & Clark, 1994). Positive affect was measured using two items drawn from the Joviality subscale (i.e., cheerful, energetic) and one item drawn from Serenity subscale (i.e., calm). Negative affect was measured using one item drawn from the Hostility subscale (i.e., angry) and two items drawn from the Sadness subscale (i.e., sad, lonely). Participants were asked to rate the extent to which they felt each affect during the preceding 2- to 3-hour period using the scale 1 = "not at all" to 5 = "completely." The within-person reliability for the three positive affect items was $\alpha = 0.55$ and for the three negative affect items was $\alpha = 0.62$. A composite for positive affect and a composite for negative affect was formed by averaging the responses to the three items on each day.

Social events. Evening ratings of positive and negative social events were assessed using the Inventory of Small Life Events (ISLE) for older adults (Zautra, Finch, Reich, & Guamaccia, 1991). To measure a wider range of social events with their spouse/partner, study investigators supplemented the original 10 ISLE items (6 desirable events, 4 undesirable events) with 4 additional items (i.e., 4 undesirable events) that assessed for interpersonal rejection (e.g., spouse or partner ignored participant, spouse or

partner was too busy to talk or go out). Thus, participants were asked to respond "yes" or "no" to 6 desirable events and 8 undesirable events that might have occurred with their spouse or partner that day. An example of a desirable event is, "You had a long conversation with your spouse or partner" and an example of an undesirable event is, "Your spouse or partner ignored you." Participants also responded to 10 desirable events and 5 undesirable events with family members. An example of a desirable event is, "You helped a family member" and an example of an undesirable event is, "You had an argument with a family member." Lastly, participants responded to 6 desirable events and 5 undesirable events with friends or acquaintances. An example of a desirable event is, "You went to a party or other social gathering" and an example of an undesirable event is, "You had a conflict with a friend or acquaintance." Participants were instructed to count the number of positive/desirable events and number of negative/undesirable events that occurred in each category. For the total number of positive social events that occurred on a day, a sum of the desirable events with spouse or partner, family members, and friends or acquaintances was computed. For the total number of negative social events that occurred on a day, a sum of the undesirable events with spouse or partner, family members, and friends or acquaintances was computed. Each day's scores could range from 0 to 22 for positive events and 0 to 18 for negative events.

Control variable.

***Pain*.** Afternoon ratings of pain were assessed using the standard 1-item measure of pain intensity: "What was your overall level of pain?" (Jensen, Karoly, & Braver, 1986). Participants responded to this item to rate their level of pain during the preceding 2- to 3-hour period using a scale of 0 = "no pain" to 100 = "pain as bad as it can be." Item

responses were rescaled from a 0 to 100 scale to a 0 to 5 scale by dividing each score by 20.

Additional Measures Used in Exploratory Analyses

In addition to the main model measures (i.e., early-morning sleep quality, afternoon positive and negative affect, evening positive and negative social events, and afternoon pain), two control variables were used in the exploratory model analyses:

Pain. Late-morning ratings of pain were assessed and rescaled using the standard 1-item measure of pain intensity described above for afternoon pain (Jensen et al., 1986).

Interpersonal stress and joy. Afternoon ratings of interpersonal stress and joy were assessed by asking participants to rate how stressful or enjoyable their relations were with: 1) a spouse or partner; 2) family members (not including spouse or partner); and 3) friends or acquaintances, during the preceding 2- to 3-hour period. Participants were asked to respond to each item using a scale of 1 = “not at all” to 5 = “completely.” A composite for interpersonal stress and a composite for interpersonal joy was formed by selecting the highest value from the three items on each day.

CHAPTER 7

DATA ANALYTIC PLAN

Modeling Strategy

For the main study model (see Figures 1 and 2) and for all exploratory models, multilevel structural equation modeling (MSEM; Preacher, Zyphur, & Zhang, 2010) was performed using M*plus* version 7 statistical software (Muthén & Muthén, 2013). MSEM is appropriate given that study data are organized at two distinct levels: level 1, days (*within-person*) which is nested within level 2, individuals (*between-person*). In addition, MSEM allows for the analysis of more complex multilevel models, such as those with multiple mediators and outcome variables (Preacher et al., 2010).

An M*plus* multilevel model partitions each measured variable into a within-person (level 1) latent score and a between-person (level 2) latent score (Muthén & Muthén, 2013). The two latent variables generate orthogonal variance components at the within- and between-person levels and, as a result, account for random effects in clustered data (Muthén & Asparouhov, 2008). Traditionally, centering is achieved in multilevel modeling by deviating raw scores of measured variables from the cluster means of those variables (Raudenbush & Bryk, 2002). In MSEM, however, "implicit model-based group mean centering" is used, where latent scores are deviated from latent cluster means of level 1 predictors (Preacher et al., 2010). This method also prevents biases in parameter estimates, which can result from clustering in data when estimating relations among variables at the within- and between-person levels.

Though results at the within- and between-person levels are presented, the study hypotheses focused on the within-person level (i.e., level 1) to identify the mechanisms

linking sleep quality last night to social events experienced the next day (See Figure 1a). The within-person level accounts for covariation within a person throughout a day to examine, for instance, deviations from a person's usual early-morning sleep quality to deviations from that person's usual afternoon positive affect. On the other hand, findings at the between-person level (i.e., level 2) are cross-sectional since each study variable is measured by calculating a mean of the 21-day diary.

Mediation

The study model and exploratory models were assessed using the guidelines provided by Preacher and colleagues (2010). That is, all paths were specified to have random intercepts and fixed slopes, except for the c'_1 and c'_2 paths which had random intercepts and random slopes (i.e., the paths connecting sleep quality to positive and negative social events). The study model had two parallel mediators, afternoon positive affect and negative affect, and four mediated paths (See Figure 1a). One example of a mediated path is the path connecting a_1 to $b_{1.1}$, which examines positive affect as a mediator of the relation between sleep quality and positive social events (See Table 2 for a list of all mediated paths). The R*Mediation* program was used to determine whether each mediated path was significant (Tofighi & MacKinnon, 2011). This program calculates the asymmetric confidence interval of a mediated effect using coefficient estimates of the *a* and *b* paths, their standard errors, and the correlation between the *a* and *b* paths. If the 95% confidence interval does not include zero, the mediated effect is assumed to be significant. Of note, the method used by R*Mediation* has been shown to provide better control of Type I error rates and statistical power compared to other

methods of calculating mediated effects, such as the Sobel Test (MacKinnon, Lockwood, &Williams, 2004).

Missing Data

Because participants in the current study were asked to complete study measures 4 times per day for 21 consecutive days, a burdensome assessment, there were missing data. Missing data can lead to unbalanced cluster sizes in multilevel data. Therefore, the Full Information Maximum Likelihood estimator using an accelerated expectation maximum algorithm procedure was applied when running the model in M*plus*. This method is robust not only to missing data, but also to different cluster sizes and non-normal distributions (Muthén & Asparouhov, 2008; Preacher et al., 2010).

CHAPTER 8

RESULTS

Sample Characteristics

The sample characteristics are presented in Table 3. The mean age of the participants was 51 years (Range: 19 to 72 years) and the majority were female and Caucasian. Just over half of the participants were married or partnered, had completed some level of college education, and were working full- or part-time. The annual family household income of the sample was between $39,999 and $49,999.

Participants reported experiencing a range of comorbid health conditions (See Table 3). More than half of the sample experienced stomach and/or abdominal issues (e.g., irritable bowel syndrome, ulcers) and headaches, including migraines. A large portion of the sample had received treatment to address psychological concerns. Further, a third of the sample reported experiencing endocrine-related health issues and a third reported chronic fatigue. Participants also experienced other health issues, such as sleep disorders, arthritis, and hypertension. In addition, the majority of the sample was taking medication, including tricyclic antidepressants, anticholinergics, and opiates.

Overall, the sample experienced difficulties with sleep. Across the diary assessment, participants provided average reports of sleep quality ($M = 2.69$, $SD = 1.33$) and feeling refreshed upon awakening ($M = 2.17$, $SD = 1.29$) on scales that could range from 0 to 5. Participants also experienced some difficulty with staying asleep at night ($M = 2.45$, $SD = 1.11$). On average, participants slept 6 hours and 37 minutes at night ($SD = 1.93$) across the diary assessment.

Data Completion

Across diary days, time points, and participants, on more than 90% of the days, participants completed at least one of the diary time points on a day. Regarding the study variables, 81% of early-morning sleep quality reports, 79% of afternoon pain reports, 78% of afternoon positive and negative affect reports, and 71% of evening positive and negative social event reports were completed across days and participants during the diary period. Across study variables and time points, participants completed an average of between 15 and 18 days of diary reports (See Table 4 for the data completion rates of specific study variables).

Descriptive Statistics and Correlations Among Study Measures

See Table 5 for the descriptive statistics of study variables aggregated across all assessments. During the 21-day diary, participants reported experiencing moderate levels of sleep disturbance last night and pain and positive affect in the afternoon. Low levels of negative affect in the afternoon were reported across the diary. Further, participants reported experiencing a higher number of positive social events than negative social events during the diary assessment period. The intraclass correlations of study measures ranged from 0.30 to 0.57, which indicates within-person variation and suggests that multilevel data analysis was appropriate for the current study design.

Differences in study variables between partnered and non-partnered participants are depicted in Table 6. Overall, partnered participants reported significantly better sleep quality, greater afternoon positive affect, less afternoon negative affect and pain, and

more positive and negative social events than non-partnered participants across the diary period.

Table 7 presents the pooled within-person correlations and the between-person correlations among all study variables. At the within-person level, most variables were significantly related to one another. However, both early-morning sleep quality and afternoon pain were not significantly related to evening positive or negative social events at the within-person level. Further, study variables were related to one another in the expected direction; however, a positive relation was found between evening positive social events and negative social events at the within-person level. At the between-person level, most variables were again significantly related to one another and in the expected direction. Early-morning sleep quality and afternoon pain both were not significantly related to evening negative social events at the between-person level.

Multilevel Structural Equation Model Findings

Proposed model. The relations among early-morning sleep quality, afternoon positive and negative affect, afternoon pain, and evening positive and negative social events were examined in a single multilevel structural equation model (MSEM) with two mediators and four mediated paths (See Figure 1a and Table 2 for the proposed model of all mediators and mediated paths). The model fit indices suggested good model fit overall ($RMSEA$ = 0.016; CFI = 0.998; $SRMR_{within}$ = 0.007; $SRMR_{between}$ = 0.033).

Within-person level findings. At the within-person level, positive affect significantly mediated two paths: 1) the relation between sleep quality and positive social events; and 2) the relation between sleep quality and negative social events (See Figure

2a and Table 8a). Specifically, early-morning reports of greater than usual sleep disturbance last night predicted afternoon reports of lower than usual positive affect (a_1 path; $p < 0.001$). Low positive affect, in turn, predicted both evening reports of lower than usual positive social events that day ($b_{1.1}$ path; $p < 0.001$), and evening reports of greater than usual negative social events that day ($b_{1.2}$ path; $p < 0.05$), controlling for the effects of afternoon pain. The asymmetric confidence interval of both the sleep quality–positive affect–positive social events path [0.025, 0.063] and the sleep quality–positive affect–negative social events path [-0.020, -0.001] indicated that positive affect is a significant mediator.

Negative affect, the second mediator, significantly mediated the sleep quality–negative social events link at the within-person level (See Figure 2a and Table 8a). Early-morning reports of greater than usual sleep disturbance last night predicted afternoon reports of greater than usual negative affect (a_2 path; $p < 0.01$). High negative affect, in turn, predicted evening reports of greater than usual negative social events that day, controlling for the effects of afternoon pain ($b_{2.2}$, $p < 0.001$). The asymmetric confidence interval supported the mediating role of negative affect in the sleep quality–negative social events link [-0.035, -0.008]. Afternoon reports of negative affect did *not* predict evening reports of positive social events that day, controlling for the effects of afternoon pain ($b_{2.1}$, $p > 0.05$). Thus, negative affect did *not* mediate the sleep quality–positive social events relation.

As an additional step, to examine whether today's social events carried over to affect sleep, the effects of today's positive and negative social events on tonight's sleep quality (reported tomorrow morning) were examined in a separate model (See Figure 1b).

Findings showed that neither today's positive ($p > 0.05$) nor negative social events ($p > 0.05$) predicted tonight's sleep quality, controlling for the effects of last night's sleep quality (See Figure 2b).

Overall, the relations between early-morning reports of last night's sleep quality and evening reports of today's social events were mediated by afternoon affect. Positive, but not negative, affect mediated the relation between sleep quality and positive social events. Both positive and negative affect mediated the relation between sleep quality and negative social events. Sleep quality was not directly related to positive social events (c'_1 path, $p > 0.05$) or negative social events (c'_2 path, $p > 0.05$), which points to complete mediation by positive and negative affect. Further, the strength of the three mediated paths was tested via contrasts. The sleep quality–positive affect–positive social events path proved to be stronger in magnitude ($p < 0.001$) than both the sleep quality–positive affect–negative social events and sleep quality–negative affect–negative social events paths. Lastly, the number of positive and/or negative social events today did not predict next-day early-morning reports of sleep quality last night.

Between-person level findings. At the between-person level, one of the four modeled mediated paths was significant: sleep quality–positive affect–positive social events (See Table 7b). Across the diary assessment, participants who, on average, provided early-morning reports of poor sleep last night, provided afternoon reports of reduced positive affect (a_1 path; $p < 0.001$). Low positive affect in the afternoon was associated with evening reports of low positive social events, controlling for average afternoon pain ($b_{1.1}$ path; $p < 0.05$). The asymmetric confidence interval indicated the mediating role of positive affect in the sleep quality–positive social events relation at the

between-person level [0.054, 0.0469]. Because sleep quality was not directly related to positive social events (c'_1 path, $p > 0.05$), positive affect accounted for complete mediation.

Exploratory analyses. Additional models were evaluated to explore several key questions: 1) do the patterns of findings hold for both partnered and non-partnered participants?; 2) does including diary day as a control variable for evening reports of social events alter the main study findings?; 3) does controlling for the covariation between late-morning pain and both afternoon positive and negative affect alter the main study findings?; 4) does controlling for the covariation between afternoon interpersonal stress and joy and both evening positive and negative social events alter the main study findings?; and 5) does a model that includes late-morning pain and both afternoon interpersonal stress and joy as covariates alter the main study findings? Because the primary focus of the exploratory analyses was on the within-person level findings, only the within-person level findings from these exploratory models are described. Tables including model results include reports of both the within- and between-person tests of mediation, however.

Examining differences between partnered and non-partnered participants. To explore whether being in an intimate relationship may affect the relation between sleep and social functioning, the proposed model was examined separately for partnered participants and non-partnered participants. The model with partnered participants ($RMSEA = 0.022$; $CFI = 0.996$; $SRMR_{within} = 0.013$) and the model with non-partnered participants ($RMSEA = 0.012$; $CFI = 0.999$; $SRMR_{within} = 0.003$) both yielded good model fit indices.

Partnered participants. At the within-person level, there were no differences in findings between the proposed model including the total sample ($N = 220$) and the model with partnered participants only ($N = 127$; See Figure 3 and Table 9a). That is, afternoon reports of positive affect mediated the relation between early-morning reports of sleep disturbance last night and evening reports of positive social events and negative social events, controlling for the effects of afternoon pain. In addition, afternoon reports of negative affect mediated the relation between early-morning reports of sleep disturbance last night and evening reports of negative social events, controlling for the effects of afternoon pain. The asymmetric confidence intervals supported the two mediating roles of positive affect one mediating role of negative affect in the relations between sleep quality and social events. Sleep quality was not directly related to positive or negative social events (c'_1 and c'_2 paths, $p > 0.05$), which indicates complete mediation by positive and negative affect. Further, of the three mediated paths, the sleep quality–positive affect–positive social events path was the strongest in magnitude ($p < 0.001$). Evening reports of today's positive and/or negative social events did not predict tonight's sleep quality reported tomorrow in the early-morning, controlling for last night's sleep quality ($p > 0.05$).

Non-partnered participants. Findings from the model with non-partnered participants ($N = 93$) partly replicated those in the total sample. In particular, they supported the mediating role of afternoon positive affect in the sleep quality–positive social events relation and the mediating role of afternoon negative affect in the sleep quality–negative social events relation at the within-person level (See Figure 4 and Table 10a). Unlike the proposed model and model with partnered individuals, the model with

non-partnered individuals did *not* find positive affect to be a mediator of the relation between sleep quality and negative social events (i.e., sleep quality was predictive of positive affect, but positive affect was not predictive of negative social events). The asymmetric confidence intervals are consistent with two mediated paths: sleep quality–positive affect–positive social events; sleep quality–negative affect–negative social events. Also, sleep quality was not related to positive or negative social events (c'_1 and c'_2 paths, $p > 0.05$), which indicates complete mediation by positive and negative affect. The sleep quality–positive affect–positive social events path remained the strongest in magnitude ($p < 0.05$). Further, today's positive and/or negative social events did not predict sleep quality reported the next morning, controlling for today morning's sleep quality, for non-partnered participants ($p > 0.05$).

Controlling for the effects of diary day on both evening positive and negative social events. Diary day was significantly related to evening reports of both positive and negative social events at the within-person level. That is, as the diary days progressed, participants reported lower than their usual level of positive ($p < 0.01$) and negative social events ($p < 0.001$). Therefore, a model that controlled for the effects of diary day on positive and negative social events was examined (See Figure 5). Overall, this model yielded good fit indices ($RMSEA = 0.025$; $CFI = 0.976$; $SRMR_{within} = 0.018$).

After controlling for the effects of day on evening reports of both positive and negative social events, the within-person level model findings remained the same as those of the proposed model (See Figure 5 and Table 11a). Specifically, the following mediated paths were found and supported by their confidence intervals: 1) sleep quality–positive affect–positive social events; 2) sleep quality–positive affect–negative social events; and

3) sleep quality–negative affect–negative social events. Further, the sleep quality–positive affect–positive social events path was the strongest in magnitude ($p < 0.001$). Positive and negative affect completely mediated the relations between sleep quality and positive and negative social events (c'_1 and c'_2 paths, $p > 0.05$).

Controlling for the effects of late-morning pain on both afternoon positive and negative affect. The effects of late-morning pain on afternoon positive and negative affect were controlled in the proposed study model to understand whether the mediating roles of afternoon positive and negative affect were influenced by prior pain that day (See Figure 6). This model yielded good fit indices ($RMSEA = 0.050$; $CFI = 0.977$; $SRMR_{within} = 0.023$).

At the within-person level, the proposed model findings did not change after controlling for the effects of late-morning pain on both afternoon positive and negative affect (See Figure 6 and Table 12a). Controlling for late-morning pain, afternoon reports of positive affect continued to mediate the relation between early-morning reports of sleep quality last night and evening reports of positive and negative social events. Further, afternoon reports of negative affect, controlling for late-morning pain, mediated the sleep quality–negative social events relation. The asymmetric confidence intervals supported the two mediating roles of positive affect and one mediating role of negative affect. Also, the sleep quality–positive affect–positive social events path remained the strongest in the magnitude ($p < 0.001$). Positive and negative affect accounted for complete mediation (c'_1 and c'_2 paths, $p > 0.05$).

Controlling for the effects of afternoon interpersonal stress and joy on both evening positive and negative social events. The proposed model was examined after

controlling for the effects of afternoon interpersonal stress and interpersonal joy on both evening positive and negative social events (See Figure 7). The purpose of this exploratory analysis was to account for any effect caused by afternoon levels of stress or joy related to relationships on the overall number of positive and/or negative social events experienced on a day. The model fit indices indicated poor fit overall (*RMSEA* = 0.115; *CFI* = 0.482; $SRMR_{within}$ = 0.125).

At the within-person level, the following two mediated paths were significant, controlling for the effects of afternoon pain and interpersonal stress and joy on social events: 1) sleep quality–positive affect–positive social events; and 2) sleep quality–negative affect–negative social events (See Figure 7 and Table 13a). The asymmetric confidence intervals supported the two mediated paths. Further, the sleep quality–positive affect–positive social events path remained the strongest in magnitude ($p < 0.001$) and positive and negative affect accounted for complete mediation (c'_1 and c'_2 paths, $p > 0.05$).

Unlike the proposed model, this exploratory model did not find the sleep quality–positive affect–negative social events path to be significant (See Figure 7 and Table 13a). Though early-morning reports of greater than usual sleep disturbance last night predicted afternoon reports of lower than usual positive affect (a_1 path, $p < 0.001$), afternoon reports of positive affect did not predict evening reports of negative social events that day, controlling for the effects of afternoon pain and interpersonal stress and joy ($b_{1.2}$ path, $p > 0.05$).

Controlling for the effects of: 1) late-morning pain on both afternoon positive and negative affect; and 2) afternoon interpersonal stress and joy on both evening

***positive and negative social events*.** Overall, the model fit indices indicated poor fit (*RMSEA* = 0.121; *CFI* = 0.548; $SRMR_{within}$ = 0.103; See Figure 8).

After controlling for the effects of late-morning pain on afternoon positive and negative affect and the effects of afternoon interpersonal stress and joy on evening positive and negative social events, two mediated paths were found at the within-person level: 1) sleep quality–positive affect–positive social events; and 2) sleep quality–negative affect–negative social events (See Figure 8 and Table 14a). Of note, the sleep quality–positive affect–negative social events path was not significant. The asymmetric confidence intervals supported the two mediated paths. The strongest mediated path remained the sleep quality–positive affect–positive social events path. Lastly, positive and negative affect accounted for complete mediation in the relations between sleep quality and positive and negative social events (c'_1 and c'_2 paths, $p > 0.05$).

CHAPTER 9

DISCUSSION

Sleep disturbance is prevalent in chronic pain populations and its implications extend to multiple domains of health and functioning. The implications of poor sleep for social functioning, however, have not been studied extensively in those with chronic pain. This gap in the literature is noteworthy, as having positive social relations can help promote higher quality of life and functional health for individuals with chronic pain. Therefore, the current study examined the within-day relation between sleep quality and social events and the extent to which fluctuations in affects mediated that relation, independent of pain, in those with chronic pain due to FM.

Overall, findings from the study were generally consistent with hypotheses regarding the within-person relations among sleep quality, affect, and social events. Specifically, the study findings revealed the following three within-person level mediated paths: 1) sleep quality–positive affect–positive social events; 2) sleep quality–positive affect–negative social events; and 3) sleep quality–negative affect–negative social events. Of note, there was not a significant direct relation between sleep quality and positive or negative social events; thus, positive affect fully mediated the sleep quality–positive social events and sleep quality–negative social events relations, and negative affect fully mediated the sleep quality–negative social events relation. From the three significant within-person level mediated paths, the path that was the strongest in magnitude was the sleep quality–positive affect–positive social events path. Further, evening reports of today's positive and negative social events did not predict tonight's sleep quality, controlling for last night's sleep quality.

The study findings linking a night of greater than usual sleep disturbance with affective experiences the next day are consistent with existing findings from the literature. That is, prior studies using daily diary reports have also found that a night of poorer than usual sleep predicts heightened negative affect and reduced positive affect the next day in individuals with chronic pain, including those with FM (Gerhart et al., 2017; Hamilton et al., 2008; Kothari et al., 2015). Of note, findings from studies with individuals who are healthy have demonstrated similar within-person relations between sleep quality and subsequent positive and negative affect (e.g., McCrae et al., 2008). Among those with chronic pain versus healthy individuals, however, such relations between sleep and affect may be stronger, given that sleep disturbance is often an ongoing occurrence. Thus, waking from a night of worse than usual sleep may be especially potent, as it builds on the accumulating effects of what may be chronic sleep debt. As a step for future research, it is worth considering how many nights of poor sleep need to accumulate to evoke specific changes in health and functioning. Another reason that the within-person relation between sleep and affect may be stronger for those with chronic pain is because the day-to-day accumulating effects of sleep disturbance are exacerbating an already disrupted affectivity. Specifically, individuals with chronic pain report high levels of negative affect and low levels of positive affect (e.g., McWilliams et al., 2003; Tang et al., 2008; Zautra et al., 2005; Zautra et al., 2001). The chronic low level of positive affect, in particular, is considered to be a notable deficit in those with chronic pain, especially FM, contributing to greater pain and disability (Zautra et al., 2005; Finan, Zautra, & Davis, 2009). Adding to the chronic affect deficits, experiencing worse than

usual sleep quality at night appears to contribute to the poor regulation of positive affect the next day in those with FM.

The current study findings linking affective experiences with interpersonal events build on the limited research examining the relation between affect and the number of positive and negative social events experienced in individuals with chronic pain. Prior work examining how affect influences social events has demonstrated within-day relations between negative affect and negative social events, and between negative affect and positive social events in individuals with chronic pain (Wolf & Davis, 2014). Findings from the current study were partially consistent with these existing findings. That is, after controlling for the level of pain, the negative affect–negative social events relation held, but the negative affect–positive social events relation did not. This suggests that negative affect did not account for variance beyond that of pain in predicting reports of positive social events in those with FM. Further, the within-day positive affect–social events relation with positive affect predicting social events has not been examined in those with chronic pain. Within-person level findings gleaned from studies with individuals who are healthy suggest that positive affect predicts positive social events (Vittengl & Holt, 1998). The current study not only demonstrated a within-day relation between positive affect and positive social events, but it also extended the effects of positive affect to include negative social events, while controlling for the level of pain, in those with FM. These findings highlight the key role of affect, particularly positive affect, in contributing to social functioning among individuals experiencing chronic pain. Positive affect is considered to be a protective factor that provides psychosocial resources and it is often associated with approach behaviors related to behavioral activation and

motivational systems (Fredrickson, 2001; Finan & Garland, 2015; Gray, 1982; Lang, Bradley, & Cuthbert, 1998). Negative affect, on the other hand, is associated with avoidance behaviors related to behavioral inhibition and defensive motivational systems (Gray, 1982; Lang et al., 1998). Yet research has suggested that negative stimuli, such as feelings of anger, can trigger approach behaviors as well (Harmon-Jones, Harmon-Jones, & Price, 2013). Indeed, the current study found that both reduced positive affect and elevated negative affect following sleep disturbance predict increased exposure (i.e., approach) to negative social events. However, only reduced positive affect significantly predicts a withdrawal from positive social events. Thus, while maintaining positive affectivity can provide resources and growth, having deficits can be limiting, especially for social relations. Given that positive social engagement can help boost quality of life for individuals with chronic pain (Zautra et al., 2000), it is important to understand the daily mechanisms predicting social functioning.

The within-person level results of the proposed model demonstrate that the implications of poor sleep quality do extend to social functioning via affect in individuals with FM. It is noteworthy that affective experiences fully mediated the relations between sleep quality and positive and negative social events, independent of pain. While negative affect accounted for the relation between sleep quality and negative social events, positive affect accounted for the relation between sleep quality and both positive and negative social events. These findings are not in line with the Dynamic Model of Affect, which suggests that positive and negative affect become negatively correlated following high stress (Zautra, Reich, Davis, Potter, & Nicolson, 2000). In the current study model, the positive and negative affect levels following a night of sleep disturbance had

differential effects on positive and negative social events. It is possible that waking from a night of greater than usual sleep disturbance is not a powerful or sustained enough stressor to cause positive and negative affect to merge onto a single dimension. In the current study, for example, last night's poor sleep predicting today's affect–social functioning process did not carry over and predict tonight's sleep quality. This again raises the question of how many consecutive nights of poor sleep must accrue to elicit specific changes in health and well-being.

In addition to the possibility that disturbed sleep is not a potent stressor to evoke a one-dimensional experience of positive and negative affect, it is also conceivable that poor sleep triggers different mechanisms than those triggered by chronic stress. One possible mechanism underlying the relations among sleep, affect, and social functioning is changes in dopaminergic activity. Existing research demonstrates that the poor affective regulation that is characteristic of chronic pain, and especially FM, may, in part, be due to abnormal dopaminergic activity (Finan & Garland, 2015). In fact, some investigators have suggested that individuals with FM have an impaired dopamine response to pain that can interfere with affective processing (Wood et al., 2007). Further, findings derived from a rodent model suggest that disruption of dopaminergic functioning may be attributable in part to sleep disturbance. Comparisons of mice that were sleep deprived, exposed to chronic stress, or housed in a control, demonstrated that only sleep deprived mice experienced changes in dopamine circuitry in the striatum (Lim, Xu, Holtzman, & Mach, 2012). Thus, the effects of sleep deprivation may be different than those of stress on dopaminergic activity. Research evidence also points to a positive correlation between dopaminergic activity and sense of social support (Lin, Chen, Yeh, &

Yang, 2011). Therefore, such changes in dopaminergic activity may partially account for the relation between sleep disturbance and affect and between affect and social functioning.

Although between-person level relations were not a focus of the current study, they deserve some comment. Similar to the within-person level model, the between-person level model found positive affect to fully mediate the relation between sleep quality and positive social events. Overall, across all diary reports, individuals with FM who experienced poor sleep quality also reported reduced positive affect in the afternoon, and those who reported low afternoon positive affect reported fewer positive social events, controlling for their average afternoon pain. Prior research has demonstrated between-person level associations between sleep disturbance and positive affect (e.g., Evans et al., 2017) and between positive affect and social functioning in those with chronic pain (e.g., Ferreira & Sherman, 2007). Unlike the within-person level model, the between-person level model did not find any other significant mediated paths. It is not surprising that findings differed between the within- and between-person level models as they ask distinct questions related to the relations among sleep, affect, and social events. The within-person level model measured changes within individuals and across multiple time points in a day; as a result, this model was able to evaluate "how" next-day events unfolded when individuals experienced worse than their usual level of sleep quality. The between-person level model examined whether individuals who tended to sleep more poorly also experienced more negative and less positive affects and social relations on average relative to those with better sleep. In sum, the within-person level model assessed for situational effects whereas the between-person level model assessed for stable

attributes in those with FM across the 21-day diary period. Despite differences between the within- and between-person level models, they both indicate that the positive affect system likely plays a central role in the sleep–social functioning process.

Exploratory analyses were conducted to determine whether additional factors could account for the within-day relations among sleep quality, affect, and social events in those with FM. Because sleeping with a partner at night could have implications for sleep quality, affect, and social relations the next day, the study model was examined separately for partnered and non-partnered participants. Findings were mainly consistent between the partnered and non-partnered models; the only difference was that the model with non-partnered participants did not find the sleep quality–positive affect–negative social events path to be significant. Although being partnered versus unpartnered is not an indicator of whether participants were sleeping in the same bed as another individual, findings suggest that partner status may not differentially impact the sleep–social functioning process in those with chronic pain. Nevertheless, research suggests that sleeping with a partner impacts sleep at night. In their diary study, Dittami and colleagues (2007) measured sleep in healthy heterosexual couples who slept apart or together over 28 days; findings revealed that sleeping with a partner was associated with poor sleep in women whereas sleeping alone was associated poor sleep in men. Given potential differences between male and female participants, the study model was examined with female participants only and the main findings held. Therefore, it does not seem that study findings were being significantly affected by the male participants.

A second exploratory analysis addressed a common question when examining diary data: to what extent does the act of completing diaries over time alter individuals'

responses? Thus, a study model that controlled for the effects of diary day on social events was examined; findings revealed that although diary day was a significant predictor in the model, it did not alter the relations observed among sleep disturbance, affect, and social relations. A third exploratory analysis examined whether the mediating roles of positive and negative affect were influenced by pain experienced earlier in the day, by controlling for the effects of prior pain on affects. Again, the original pattern of findings was maintained. Finally, because pain, affect, and interpersonally-specific emotions are intertwined and may have effects that carry over, models controlling for these potential carryover effects were examined. Overall, these models demonstrated poor fit and they did not find the sleep quality–positive affect–negative social events path to be significant. Together, these exploratory analyses demonstrated that the main study findings were largely robust across partnered and unpartnered participants, and not accounted for by repeated diary assessments, morning pain level, or afternoon joy and stress levels.

Study Limitations

Several limitations of the current study are worth noting. First, the sample consisted of those with chronic pain due primarily to FM; therefore, whether findings from the current study are generalizable to other chronic pain groups remains to be determined. It is possible that current findings may be unique to those with FM. Compared to other chronic pain groups, the FM group experiences greater sleep disturbance (Belt et al., 2009), has notable deficits in the regulation of positive affect (Zautra et al., 2005; Finan et al., 2009), and may have poorer social functioning due to

the perceived stigma associated with the FM condition (Davis et al., 2001; Åsbring & Närvänen, 2002; Kool & Geenen, 2012). The key role of positive affect as a mediator of the relation between sleep quality and positive and negative social events may be especially relevant for those with FM than for those with other chronic pain conditions. Second, the majority of the sample consisted of female participants (N = 194; 88.6%), and the study was not powered to test for gender differences in within-person relations. The prevalence of FM is higher in women than men globally (Queiroz, 2013), and the gender ratio of the current sample is consistent with global estimates. Nevertheless, it is not clear that the within-person associations observed in a predominantly female sample hold for men with FM. Additional research designed explicitly to examine gender differences in daily processes can shed light on whether the experiences of men and women with FM vary. Third, because findings from the current study were based on correlational data, causality cannot be inferred. Experimental manipulations of sleep quality, affect, and social events are needed in order to determine causal relations among these study variables. The fact that hypothesized relations among temporally-ordered assessments were significant, however, provides some confidence regarding the relations among study variables.

Future Directions

Despite its limitations, the current study extends findings from current research and provides avenues for future research exploring the implications of sleep disturbance for day-to-day functioning in those with chronic pain. Specifically, it is worth considering other mechanisms that may link sleep quality with social events in those with chronic

pain. In fact, a recent experimental study found that after healthy adults were sleep deprived for one night, they reported feeling more lonely the next day and they were viewed by observers (who did not know that participants were sleep deprived) as appearing lonely and less socially desirable (Simon & Walker, 2018). Further, when participants were well rested and when they were sleep deprived, they viewed videos of individuals with neutral expressions approaching them; findings showed that participants chose to stop the video sooner when they were sleep deprived than when they were well rested. Thus, a night of poor sleep triggers feelings of loneliness, social withdrawal, and perhaps anxiety related to social interactions that can impact engagement in social events. Given that chronic pain itself is associated with feelings of loneliness (e.g., Wolf & Davis, 2014; Jacobs, Hammerman-Rozenberg Cohen, & Stessman, 2006), an area of future research may be to explore whether loneliness and/or anxiety related to social interactions mediates the relation between sleep quality and social events. In addition, the current study relied on subjective reports of sleep quality. Though research shows that subjective assessments of sleep are more highly correlated with reports of pain and disability than objective assessments (e.g., O'Donoghue, Fox, Henegan, & Hurley, 2009), using objective assessments (i.e., actigraphy) would provide novel information about the specific aspects of sleep (e.g., efficiency, latency) that may predict psychosocial functioning the next day in those with chronic pain.

Lastly, the current study did not find a direct association between sleep quality and social events. Specifically, last night's sleep quality was not directly related to today's positive or negative social events. This was surprising given that existing research, especially research conducted in healthy individuals, has demonstrated a

correlation between sleep and social functioning (e.g., Gordon & Chen, 2014; Theadom et al., 2007). It is possible that among those with FM, sleep quality is only indirectly related to the number of social events. Further, limited research has measured social functioning via the number of positive and negative social events experienced. Though a goal of the current study was to capture social functioning objectively through assessment of discrete social events, incorporating subjective assessments that measure the perception of social functioning may provide novel information about the aspects of social functioning that are impacted by sleep disturbance. In addition, today's positive and negative social events did not carry over to predict tonight's sleep quality. This poses the question of what factors impact sleep quality at night and, in turn, predict functioning the next day.

Conclusion

In sum, the current study was the first to demonstrate that poor sleep predicts the extent and type of social engagement through affective experiences in those with chronic pain. Specifically, findings showed that a night of worse than usual sleep predicts higher negative affect and lower positive affect the next day, which, in turn, predicts more negative social events and fewer positive social events that day. Further, findings highlight the likely central role of positive affect in this relation, as it fully mediated the relation between sleep quality and both positive and negative social events. In accordance with existing research, these findings also demonstrate that sleep disturbance may be one route to the positive affect disturbance and social problems seen in those with FM. The current findings can help inform efforts to develop psychological interventions aimed at

improving day-to-day functioning and quality of life in those with chronic pain. Prior research has shown that experiencing positive social relations can help promote higher quality of life for those with chronic pain. The current study demonstrates the daily chain of events that can unfold to predict social functioning in individuals with chronic pain. Thus, the hope is that current findings can over time help those with chronic pain live better despite the persistence and uncertainty of pain.

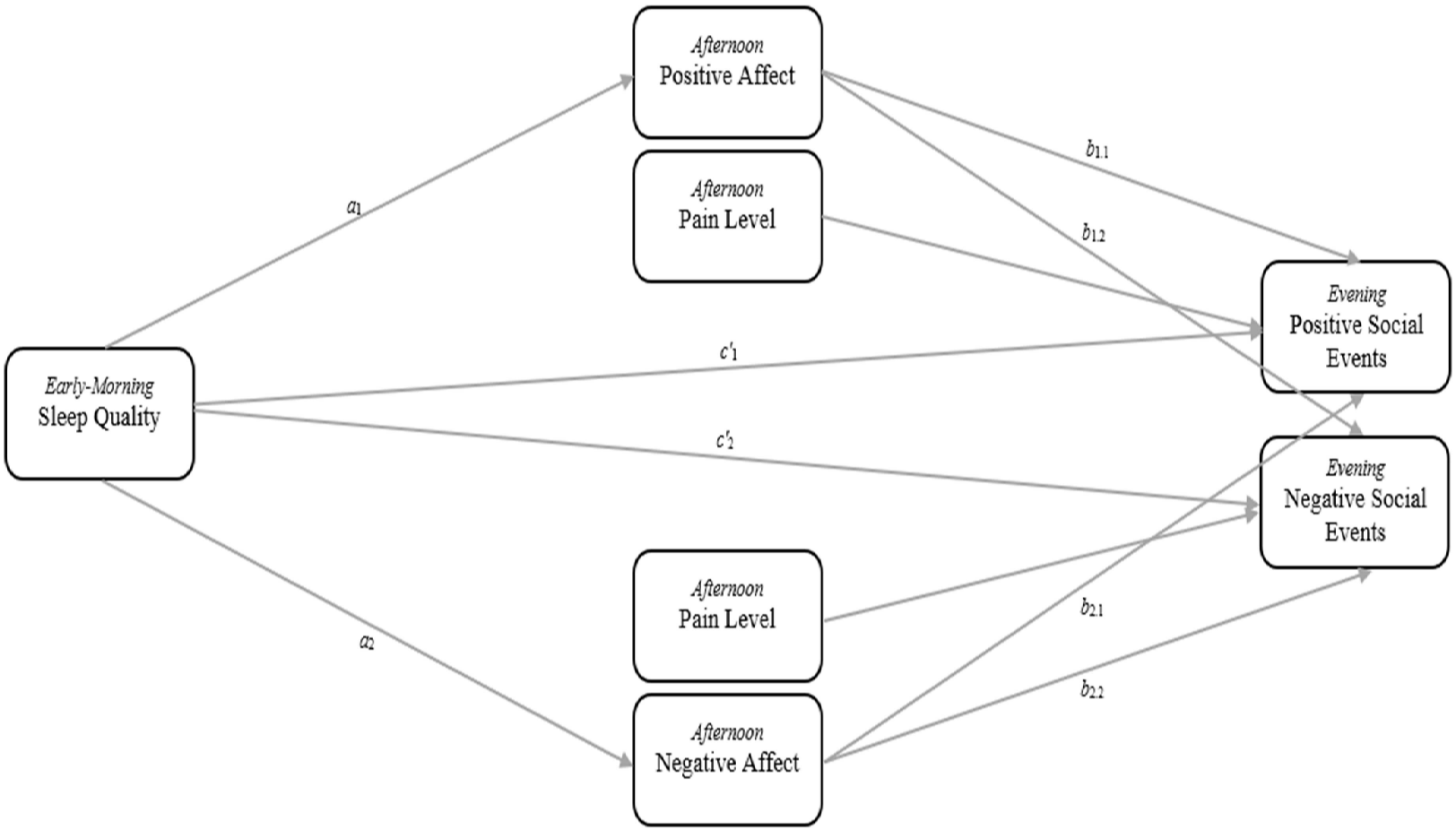

Figure 1a. The main model examining the roles of afternoon positive and negative affect as mediating the relations between early-morning sleep quality and evening positive and negative social events, controlling for the effects of afternoon pain.

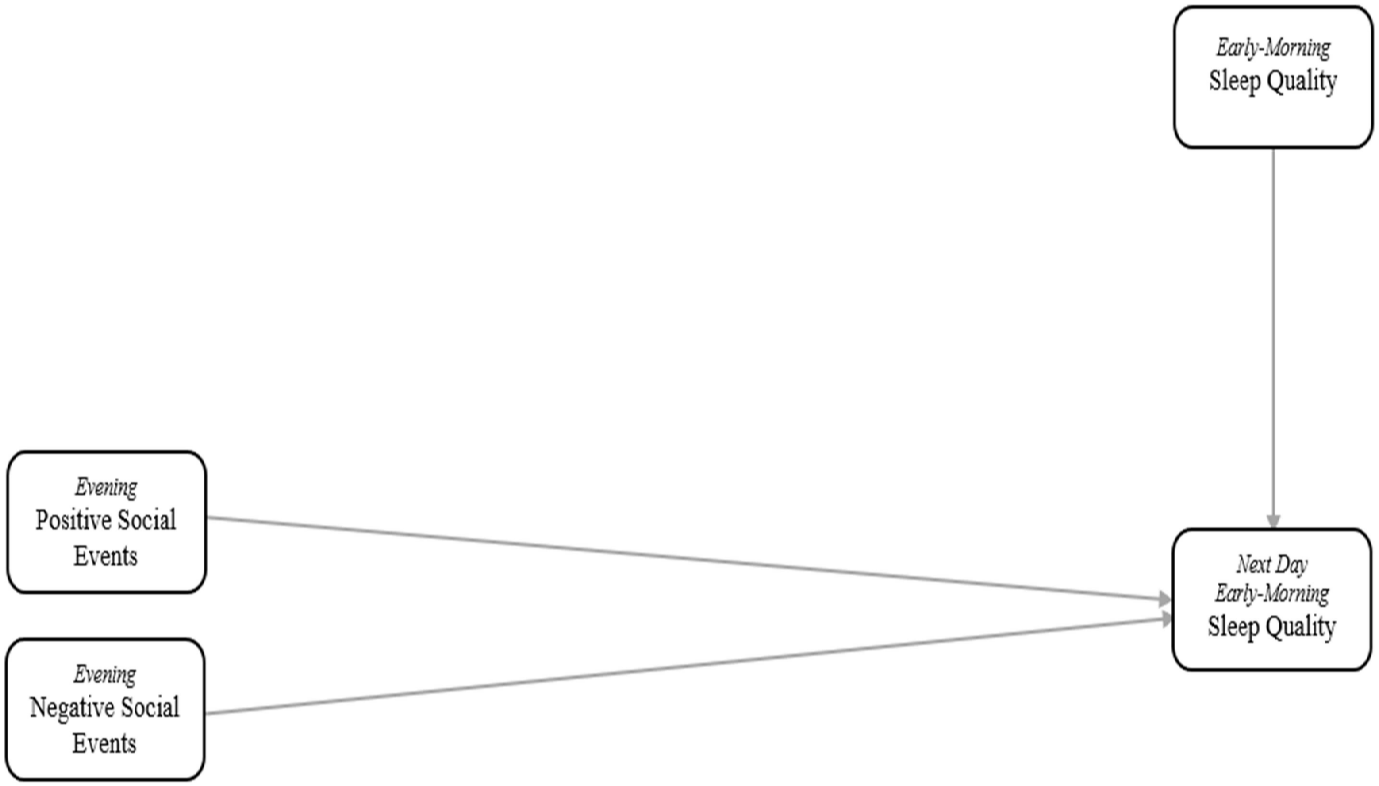

Figure 1b. Evening positive and negative social events predicting tonight's sleep quality reported the next day in the early-morning, controlling for last night's sleep quality.

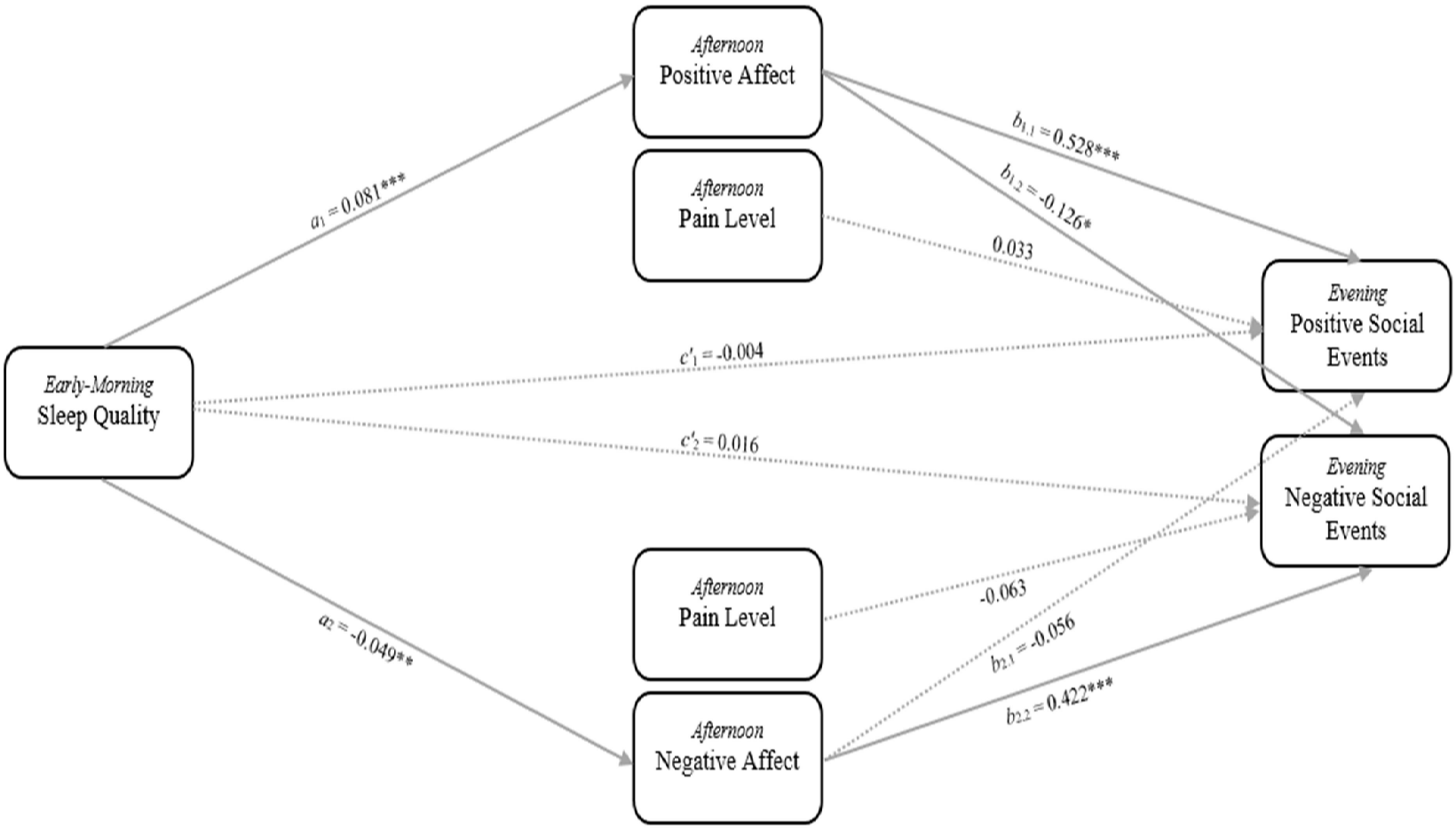

Figure 2a. The within-person level results of the main model in the total sample ($N = 220$) examining the roles of afternoon positive and negative affect as mediating the relations between early-morning sleep quality and evening positive and negative social events, controlling for the effects of afternoon pain (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). The dotted lines represent non-significant paths.

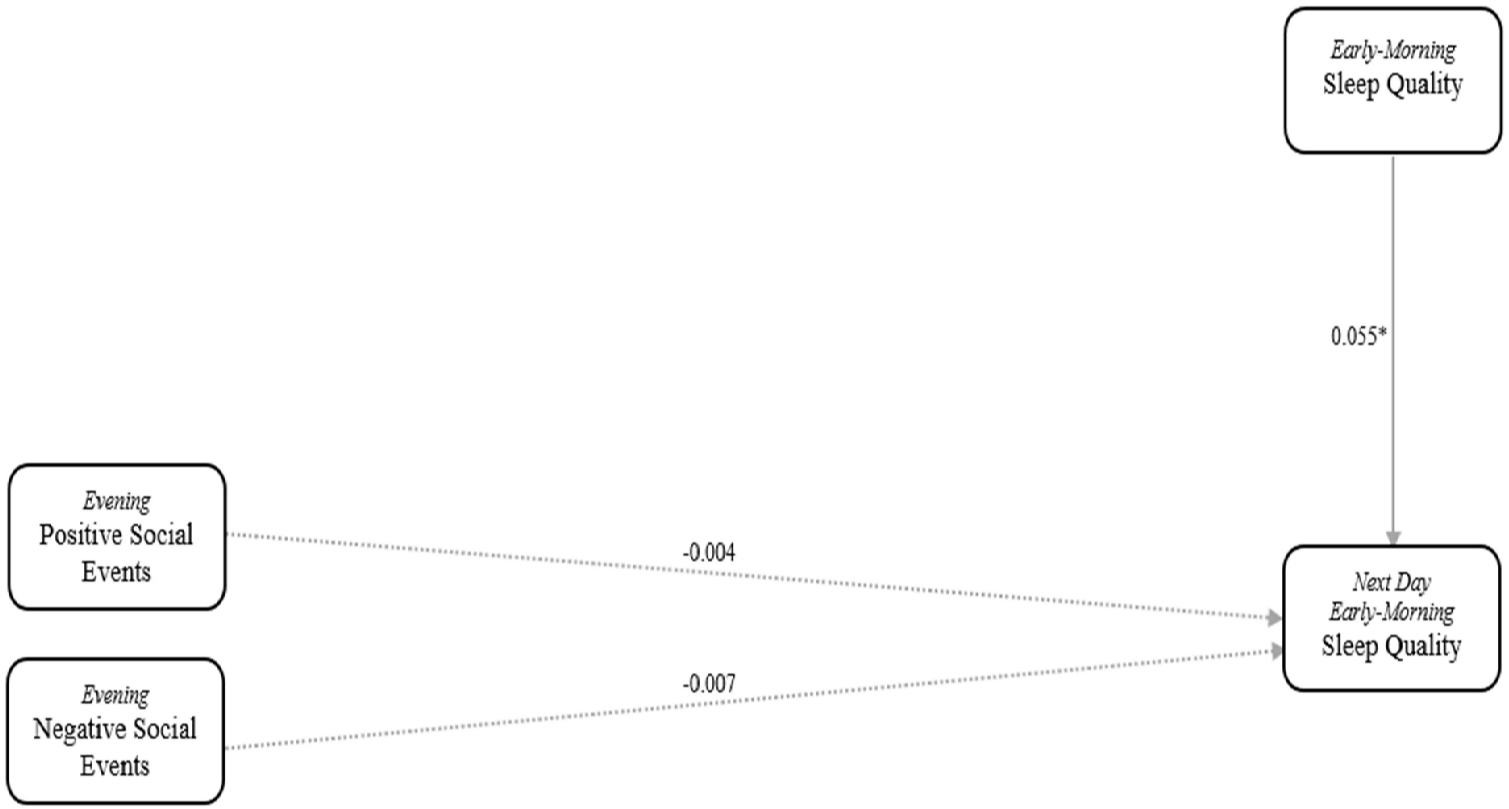

Figure 2b. The within-person level results ($N = 220$) of evening positive and negative social events predicting tonight's sleep quality reported the next day in the early-morning, controlling for last night's sleep quality (* $p < 0.05$). The dotted lines represent non-significant paths.

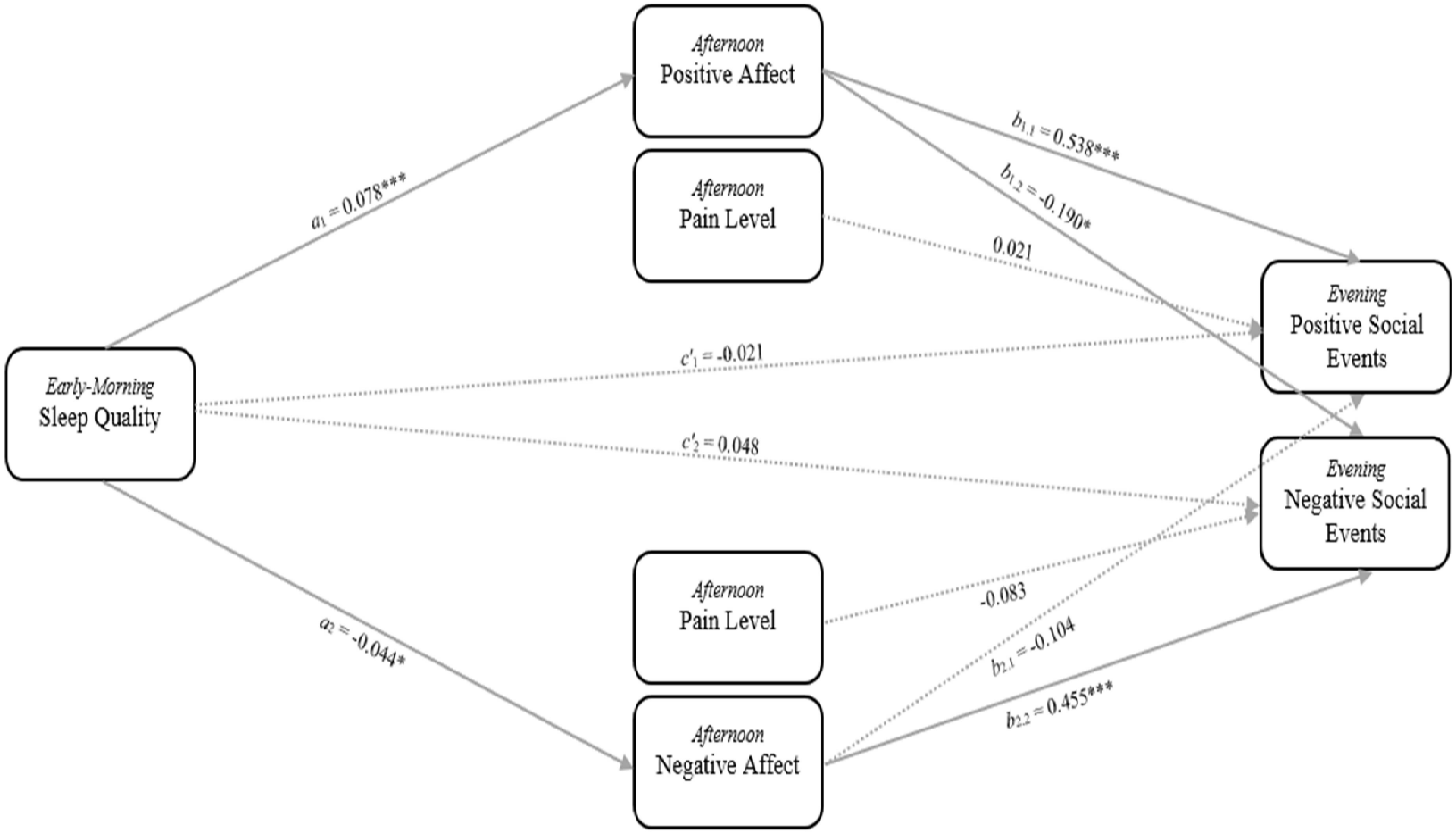

Figure 3. Partnered participants only ($N = 127$): The within-person level results of the main model examining the roles of afternoon positive and negative affect as mediating the relations between early-morning sleep quality and evening positive and negative social events, controlling for the effects of afternoon pain (* $p < 0.05$, *** $p < 0.001$). The dotted lines represent non-significant paths.

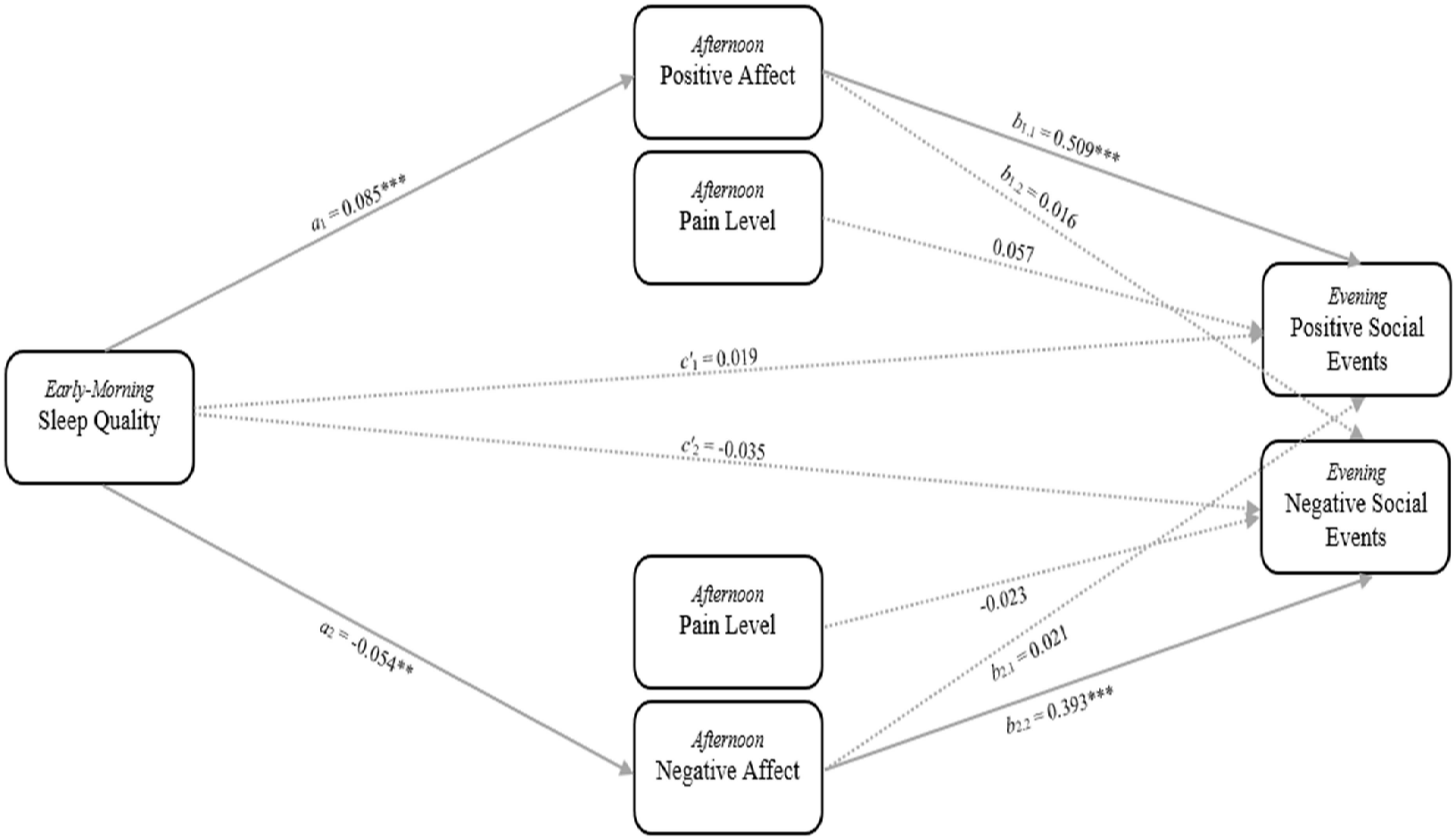

Figure 4. Non-partnered participants only ($N = 93$): The within-person level results of the main model examining the roles of afternoon positive and negative affect as mediating the relations between early-morning sleep quality and evening positive and negative social events, controlling for the effects of afternoon pain (** $p < 0.01$, *** $p < 0.001$). The dotted lines represent non-significant paths.

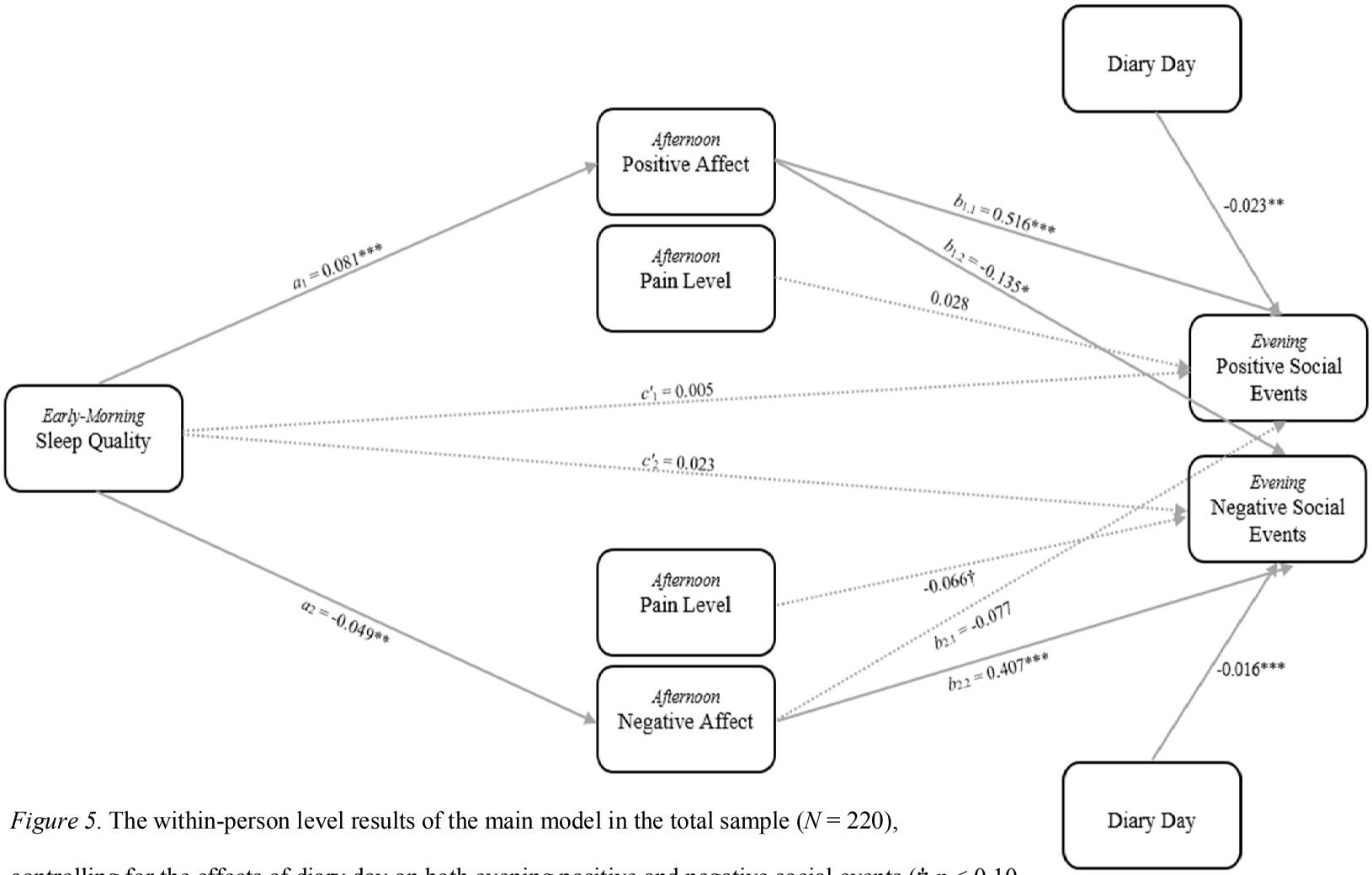

Figure 5. The within-person level results of the main model in the total sample ($N = 220$), controlling for the effects of diary day on both evening positive and negative social events († $p < 0.10$, * $p < 0.05$, ** $p < 0.01$,

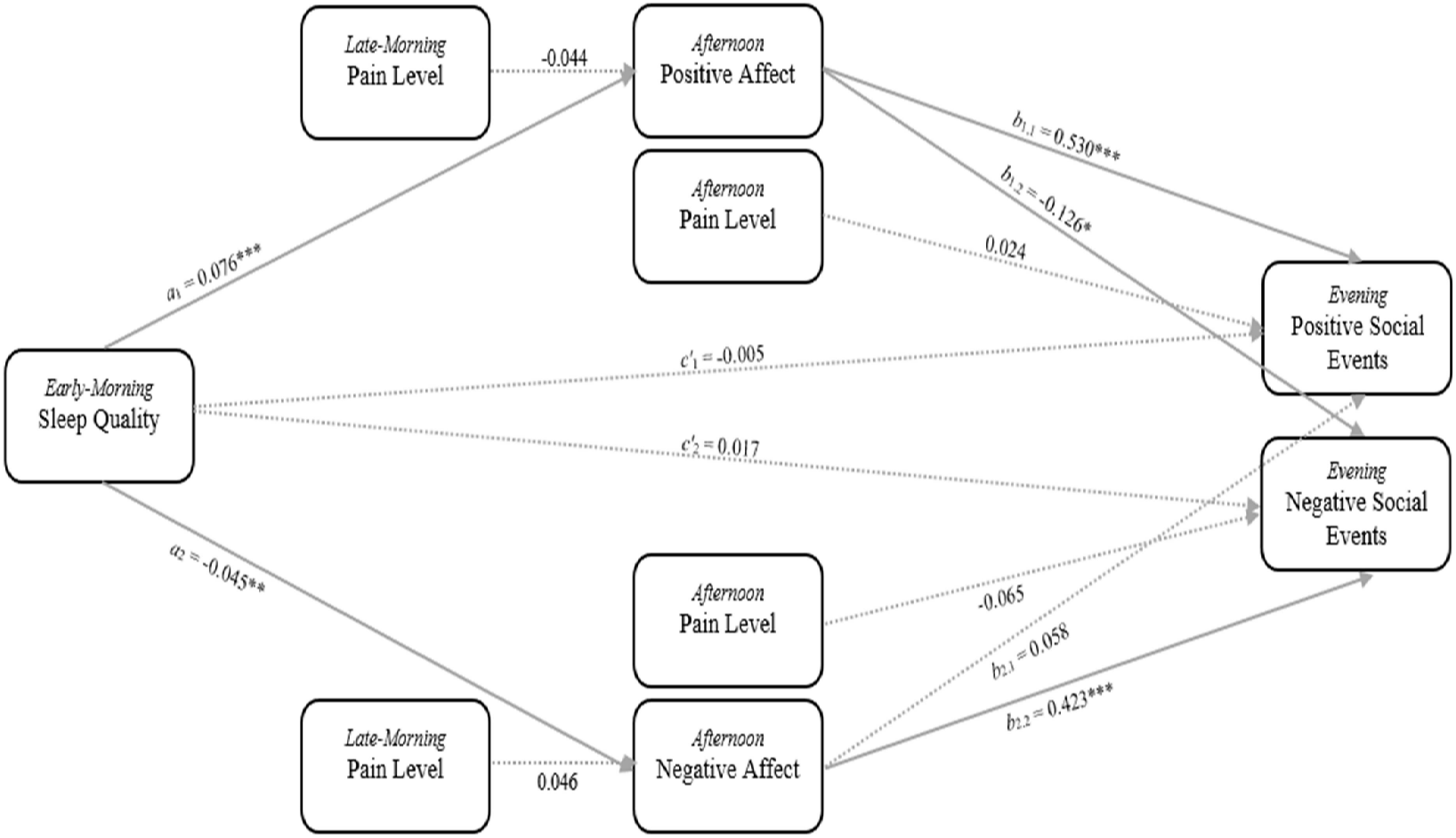

Figure 6. The within-person level results of the main model in the total sample ($N = 220$), controlling for the effects of late-morning pain on both afternoon positive and negative affect (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). The dotted lines represent non-significant

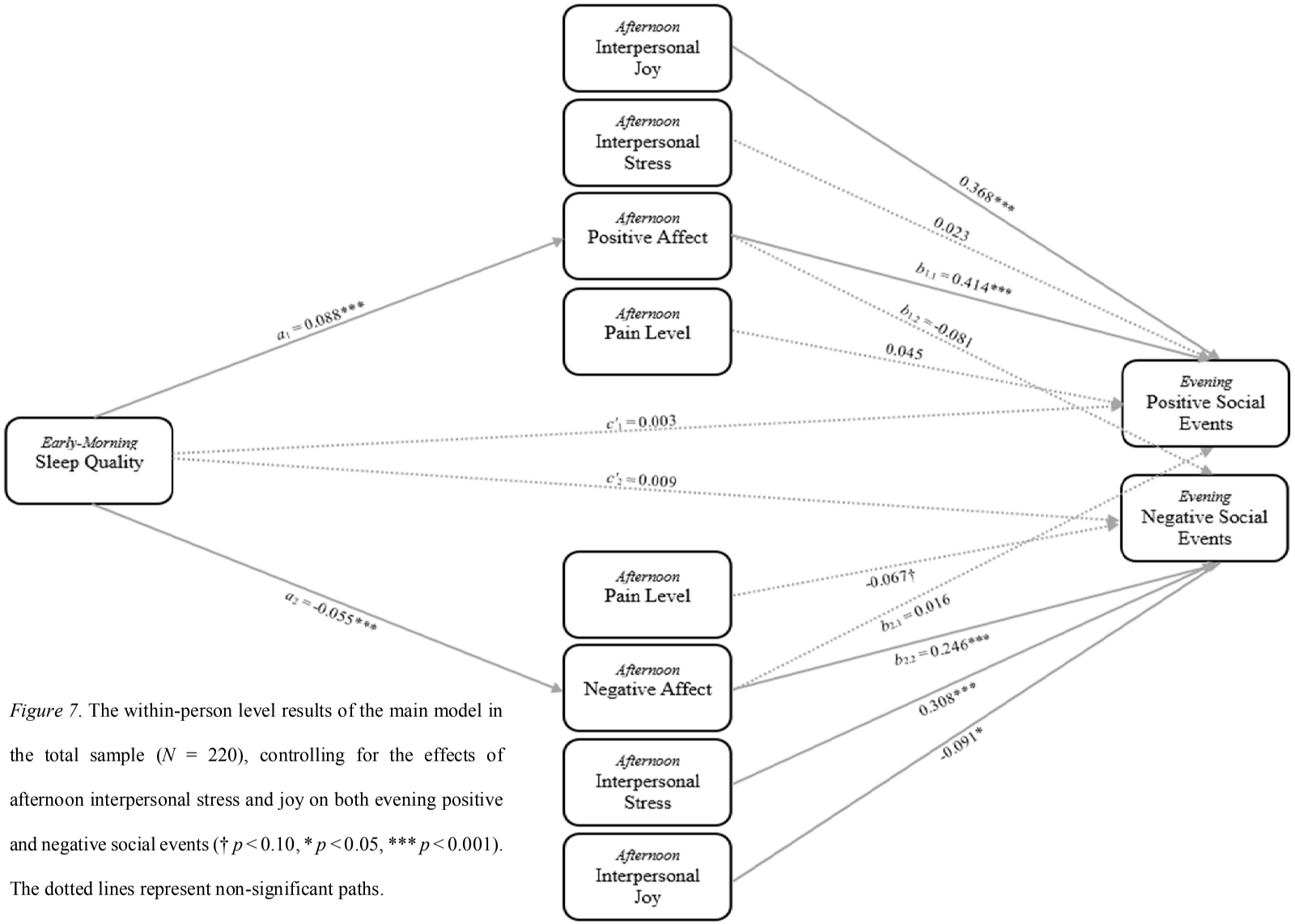

Figure 7. The within-person level results of the main model in the total sample (N = 220), controlling for the effects of afternoon interpersonal stress and joy on both evening positive and negative social events († $p < 0.10$, * $p < 0.05$, *** $p < 0.001$). The dotted lines represent non-significant paths.

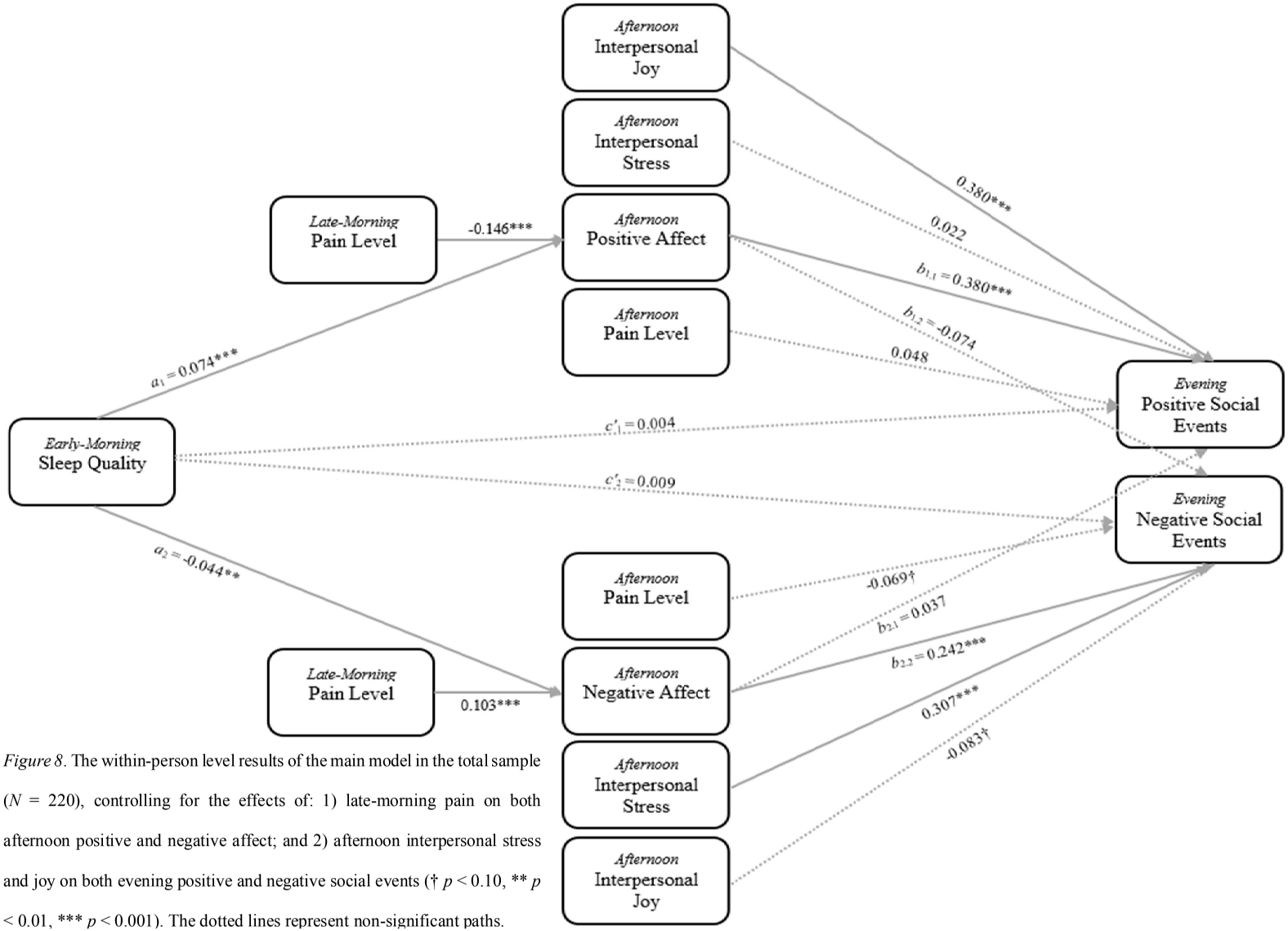

Figure 8. The within-person level results of the main model in the total sample (N = 220), controlling for the effects of: 1) late-morning pain on both afternoon positive and negative affect; and 2) afternoon interpersonal stress and joy on both evening positive and negative social events († $p < 0.10$, ** $p < 0.01$, *** $p < 0.001$). The dotted lines represent non-significant paths.

Table 1

A Summary of Findings from Studies Examining the Effects of Poor Sleep on Positive and Negative Affect in Healthy and Chronic Pain Samples

Study	Design	Study *N*	Findings
Zohar et al. (2005)	Daily diary	78, healthy, adults	Higher negative and decreased positive affect
Haack et al. (2005)	Daily diary	40, healthy, adults	Decreased positive affect
McCrae et al. (2008)	Daily diary	103, healthy, adults	Higher negative and decreased positive affect
Bower et al. (2010)	Daily diary	96, healthy, adults	Decreased positive affect
Minkel et al. (2012)	Experimental	53, healthy, adults	Higher negative affect
Baum et al. (2014)	Experimental	50, healthy, adolescents	Higher negative affect
Finan et al. (2015)	Experimental	62, healthy, adults	Decreased positive affect
Hamilton et al. (2008)	Daily diary	89, fibromyalgia, adults	Higher negative and decreased positive affect
Kothari et al. (2015)	Daily diary	220, fibromyalgia, adults	Higher negative and decreased positive affect
Gerhart et al. (2017)	Daily diary	105, chronic low back pain, adults	Higher negative and decreased positive affect
McCracken et al. (2002)	Cross-sectional	287, chronic pain, adults	Higher depressive symptoms
Naughton et al. (2007)	Cross-sectional	155, chronic pain, adults	Higher depressive symptoms
O'Brien et al. (2010)	Cross-sectional	292, chronic pain, adults	Higher depressive symptoms
Evans et al. (2017)	Cross-sectional	213, chronic pain, children and adolescents	Higher negative and decreased positive affect
Parmelee et al. (2015)	Longitudinal	367, knee osteoarthritis, adults	Higher depressive symptoms

Table 2

The Mediated Paths of the Main Study Model (See Figure 1a)

Predictor Variable	Mediator	Outcome Variable	*a* and *b* Paths
Early-Morning Sleep Quality	Afternoon Positive Affect	Evening Positive Social Events	a_1, $b_{1.1}$
Early-Morning Sleep Quality	Afternoon Positive Affect	Evening Negative Social Events	a_1, $b_{1.2}$
Early-Morning Sleep Quality	Afternoon Negative Affect	Evening Positive Social Events	a_2, $b_{2.1}$
Early-Morning Sleep Quality	Afternoon Negative Affect	Evening Negative Social Events	a_2, $b_{2.2}$

Table 3

Sample Characteristics (N = 220)

Measures	*M* or *n* (% or *SD*)
Age (years)	51.25 (11.02)
Gender	
Male	25 (11.4)
Female	194 (88.6)
Ethnicity	
Caucasian	165 (76.7)
Black/African American	3 (1.4)
Hispanic	25 (11.6)
Native American	2 (.9)
Native Hawaiian or Other Pacific Islander	1 (.5)
Other	2 (.9)
Multiple ethnicities	17 (7.9)
Education	
5 to 8 years	1 (.5)
High school not completed	4 (1.9)
High school completed	29 (13.5)
Post high school	11 (5.1)
Business or trade school	19 (8.8)
1 to 3 years college	74 (34.4)
4 years college	39 (18.1)
Post graduate college	38 (17.7)
Employment Status	
Full-time	52 (23.9)
Part-time	61 (28.0)
Not employed	105 (48.2)
Income	
Under $3,000 to $10,999	23 (11.1)
$11,000 to $20,999	34 (16.3)
$21,000 to $39,999	49 (23.6)
$40,000 to $59,999	40 (19.2)
$60,000 to $99,999	44 (21.2)
$100,000 and over	18 (8.7)
Marital Status	
Not married or partnered	95 (43.6)
Married or partnered	123 (56.4)
Health Issues	
Vascular	22 (10.0)
Renal	14 (6.4)
Diabetes	17 (7.7)
Lung/Breathing	41 (18.6)

Stomach/Abdominal	113 (51.4)
Headache	146 (66.4)
Chronic fatigue	68 (30.9)
Hearing impairment	24 (10.9)
Vision disorder	7 (3.2)
Psychological treatment	123 (55.9)
Endocrine	65 (29.5)
Other health issue	122 (55.5)
Medication	
Tricyclic antidepressants	21 (9.5)
Anticholinergics	91 (41.4)
Opiates	109 (49.5)

Table 4

Data Completion Rates for All Study Variables During the 21-Day Diary (N = 220)

Variable	Range (days)	Mean (days)	Standard Deviation (days)
Early-Morning Sleep Quality	2 to 23	17.84	4.18
Afternoon Pain	1 to 23	16.80	5.07
Afternoon Positive Affect	1 to 23	16.73	5.07
Afternoon Negative Affect	1 to 23	16.73	5.07
Evening Positive Social Events	1 to 23	15.41	5.47
Evening Negative Social Events	1 to 23	15.40	5.47
Late-Morning Pain	1 to 23	17.87	4.43
Afternoon Interpersonal Joy	1 to 22	12.16	5.38
Afternoon Interpersonal Stress	1 to 22	12.15	5.38

Table 5

Descriptives of All Study Variables Aggregated Across the 21-Day Diary (N = 220)

Variable	Scale	Observed Range	Mean	Standard Deviation	Intraclass Correlation
Early-Morning Sleep Quality	0 to 5	0 to 5	2.43	1.17	0.30
Afternoon Pain	0 to 5	0 to 5	2.51	1.22	0.51
Afternoon Positive Affect	1 to 5	1 to 5	2.60	0.87	0.52
Afternoon Negative Affect	1 to 5	1 to 5	1.72	0.92	0.57
Evening Positive Social Events	0 to 22	0 to 17	3.32	2.57	0.40
Evening Negative Social Events	0 to 18	0 to 14	1.28	1.83	0.35
Late-Morning Pain	0 to 5	0 to 5	2.44	1.22	0.49
Afternoon Interpersonal Joy	1 to 5	1 to 5	3.48	1.15	0.35
Afternoon Interpersonal Stress	1 to 5	1 to 5	1.96	1.20	0.27

Table 6

Differences Between Partnered (N = 127) and Non-Partnered Participants (N = 93) on Main Study Variables Aggregated Across the 21-Day Diary

	Partnered		Non-Partnered		
Variable	Mean	Standard Deviation	Mean	Standard Deviation	*t*-Test Significance
Early-Morning Sleep Quality	2.50	1.15	2.33	1.20	$p < 0.001$
Afternoon Pain	2.45	1.19	2.61	1.25	$p < 0.001$
Afternoon Positive Affect	2.65	0.85	2.53	0.88	$p < 0.001$
Afternoon Negative Affect	1.64	0.89	1.84	0.95	$p < 0.001$
Evening Positive Social Events	4.03	2.62	2.14	1.96	$p < 0.001$
Evening Negative Social Events	1.46	2.05	0.98	1.33	$p < 0.001$

Table 7

Within- and Between-person Level Correlations of Study Variables

Variable	1	2	3	4	5	6	7	8	9
1. Early-Morning Sleep Quality	-	-0.11***	-0.03	0.14***	-0.08***	0.03	0.00	0.02	-0.01
2. Late-Morning Pain	-0.11***	-	0.40***	-0.21***	0.15***	-0.10***	0.02	-0.02	0.02
3. Afternoon Pain	-0.06**	0.69***	-	-0.31***	0.20***	-0.14***	0.07**	-0.03†	0.01
4. Afternoon Positive Affect	0.28***	-0.33***	-0.40***	-	-0.36***	0.33***	-0.14***	0.15***	-0.09***
5. Afternoon Negative Affect	-0.10***	0.28***	0.29***	-0.42***	-	-0.27***	0.30***	-0.06***	0.17***
6. Afternoon Interpersonal Joy	0.14***	-0.15***	-0.18***	0.46***	-0.35***	-	-0.26***	0.20***	-0.14***
7. Afternoon Interpersonal Stress	-0.06**	0.08***	0.09***	-0.23***	0.40***	-0.36***	-	-0.05*	0.25***
8. Evening Positive Social Events	0.06**	-0.06**	-0.09***	0.21***	-0.12***	0.32***	-0.11***	-	0.04*
9. Evening Negative Social Events	-0.01	0.04*	0.02	-0.13***	0.24***	-0.22***	0.36***	0.06***	-

Note. The upper diagonal presents the within-person level correlations ($N_{observations}$ = 2313 to 3903) and the lower diagonal presents the between-person level correlations ($N_{participants}$ = 220); † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Both the within- and between-person level correlations were derived from IBM SPSS Statistics (2016).

Table 8a

Within-person Level Results of the Main Model (See Figure 2a)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.081(0.014)***	0.528(0.079)***	0.043(0.010)***	-0.043	[0.025, 0.063]
SQ → PA → NSE	0.081(0.014)***	-0.126(0.057)*	-0.010(0.005)*	0.102	[-0.020, -0.001]
SQ → NA → PSE	-0.049(0.014)**	-0.056(0.078)	0.003(0.004)	-0.221	[-0.005, 0.010]
SQ → NA → NSE	-0.049(0.014)**	0.422(0.061)***	-0.020(0.007)**	-0.069	[-0.035, -0.008]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 8b

Between-person Level Results of the Main Model

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.435(0.059)***	0.580(0.232)*	0.252(0.105)*	-0.055	[0.054, 0.469]
SQ → PA → NSE	0.435(0.059)***	-0.185(0.156)	-0.080(0.069)	0.029	[-0.220, 0.053]
SQ → NA → PSE	-0.105(0.082)	-0.162(0.168)	0.017(0.024)	0.158	[-0.019, 0.089]
SQ → NA → NSE	-0.105(0.082)	0.542(0.135)***	-0.057(0.048)	-0.075	[-0.165, 0.029]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, *** $p < 0.001$.

Table 9a

Within-person Level Results of the Main Model with Partnered Participants Only (N = 127; See Figure 3)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.078(0.018)***	0.538(0.103)***	0.042(0.012)***	-0.087	[0.020, 0.068]
SQ → PA → NSE	0.078(0.018)***	-0.190(0.076)*	-0.015(0.006)*	0.188	[-0.028, -0.003]
SQ → NA → PSE	-0.044(0.020)*	-0.104(0.104)	0.005(0.005)	-0.255	[-0.006, 0.015]
SQ → NA → NSE	-0.044(0.020)*	0.455(0.091)***	-0.020(0.010)†	-0.102	[-0.043, -0.002]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, *** $p < 0.001$.

Table 9b

Between-person Level Results of the Main Model with Partnered Participants Only (N = 127)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.400(0.093)***	0.846(0.268)**	0.338(0.136)†	0.052	[0.105, 0.644]
SQ → PA → NSE	0.400(0.093)***	-0.163(0.234)	-0.065(0.092)	0.179	[-0.250, 0.130]
SQ → NA → PSE	-0.119(0.101)	-0.107(0.225)	0.013(0.029)	0.051	[-0.051, 0.105]
SQ → NA → NSE	-0.119(0.101)	0.660(0.250)**	-0.079(0.078)	-0.184	[-0.276, 0.045]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; † $p < 0.10$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 10a

Within-person Level Results of the Main Model with Non-Partnered Participants Only (N = 93; See Figure 4)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.085(0.022)***	0.509(0.113)***	0.043(0.015)**	0.047	[0.017, 0.077]
SQ → PA → NSE	0.085(0.022)***	0.016(0.068)	0.001(0.006)	-0.132	[-0.011, 0.013]
SQ → NA → PSE	-0.054(0.020)**	0.021(0.111)	-0.001(0.006)	-0.155	[-0.016, 0.011]
SQ → NA → NSE	-0.054(0.020)**	0.393(0.060)***	-0.021(0.008)*	0.099	[-0.038, -0.006]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 10b

Between-person Level Results of the Main Model with Non-Partnered Participants Only (N = 93)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.462(0.070)***	0.309(0.298)	0.143(0.143)	0.174	[-0.120, 0.450]
SQ → PA → NSE	0.462(0.070)***	-0.082(0.170)	-0.038(0.081)	-0.380	[-0.218, 0.104]
SQ → NA → PSE	-0.060(0.132)	0.191(0.196)	-0.011(0.024)	0.345	[-0.076, 0.080]
SQ → NA → NSE	-0.060(0.132)	0.552(0.143)***	-0.033(0.073)	-0.009	[-0.192, 0.113]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; *** $p < 0.001$.

Table 11a

Within-person Level Results of the Main Model, Controlling for the Effects of Diary Day on Both Evening Positive and Negative Social Events (See Figure 5)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.081(0.014)***	0.516(0.079)***	0.042(0.009)***	-0.056	[0.025, 0.062]
SQ → PA → NSE	0.081(0.014)***	-0.135(0.058)*	-0.011(0.005)*	0.093	[-0.021, -0.002]
SQ → NA → PSE	-0.049(0.014)**	-0.077(0.077)	0.004(0.004)	-0.213	[-0.004, 0.011]
SQ → NA → NSE	-0.049(0.014)**	0.407(0.061)***	-0.020(0.007)**	-0.059	[-0.034, -0.008]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 11b

Between-person Level Results of the Main Model, Controlling for the Effects of Diary Day on Both Evening Positive and Negative Social Events

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.435(0.059)***	0.586(0.233)*	0.255(0.105)*	-0.060	[0.055, 0.472]
SQ → PA → NSE	0.435(0.059)***	-0.178(0.156)	-0.077(0.068)	0.021	[-0.217, 0.056]
SQ → NA → PSE	-0.105(0.082)	-0.157(0.168)	0.017(0.024)	0.167	[-0.019, 0.088]
SQ → NA → NSE	-0.105(0.082)	0.543(0.135)***	-0.057(0.048)	-0.074	[-0.165, 0.029]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, *** $p < 0.001$.

Table 12a

Within-person Level Results of the Main Model, Controlling for the Effects of Late-Morning Pain on Both Afternoon Positive and Negative Affect (See Figure 6)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.076(0.014)***	0.530(0.079)***	0.040(0.009)***	-0.031	[0.023, 0.060]
SQ → PA → NSE	0.076(0.014)***	-0.126(0.057)*	-0.010(0.005)*	0.101	[-0.019, -0.001]
SQ → NA → PSE	-0.045(0.015)**	-0.058(0.078)	0.003(0.003)	-0.223	[-0.005, 0.010]
SQ → NA → NSE	-0.045(0.015)**	0.423(0.061)***	-0.019(0.007)**	-0.040	[-0.034, -0.006]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 12b

Between-person Level Results of the Main Model, Controlling for the Effects of Late-Morning Pain on Both Afternoon Positive and Negative Affect

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.434(0.060)***	0.585(0.233)*	0.252(0.105)*	-0.061	[0.055, 0.472]
SQ → PA → NSE	0.434(0.060)***	-0.182(0.156)	-0.080(0.069)	0.027	[-0.218, 0.054]
SQ → NA → PSE	-0.101(0.082)	-0.168(0.168)	0.017(0.024)	0.155	[-0.019, 0.089]
SQ → NA → NSE	-0.101(0.082)	0.541(0.135)***	-0.057(0.048)	-0.067	[-0.146, 0.032]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, *** $p < 0.001$.

Table 13a

Within-person Level Results of the Main Model, Controlling for the Effects of Afternoon Interpersonal Stress and Joy on Both Evening Positive and Negative Social Events (See Figure 7)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.088(0.015)***	0.414(0.078)***	0.037(0.009)***	-0.010	[0.020, 0.056]
SQ → PA → NSE	0.088(0.015)***	-0.081(0.060)	-0.007(0.005)	0.126	[-0.018, 0.003]
SQ → NA → PSI	-0.055(0.015)***	0.016(0.082)	-0.001(0.005)	-0.193	[-0.011, 0.008]
SQ → NA → NSE	-0.055(0.015)***	0.246(0.061)***	-0.013(0.005)**	-0.100	[-0.025, -0.005]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; ** $p < 0.01$, *** $p < 0.001$.

Table 13b

Between-person Level Results of the Main Model, Controlling for the Effects of Afternoon Interpersonal Stress and Joy on Both Evening Positive and Negative Social Events

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.507(0.070)***	-0.240(0.273)	-0.122(0.141)	-0.097	[-0.416, 0.146]
SQ → PA → NSE	0.507(0.070)***	-0.096(0.167)	-0.049(0.085)	0.023	[-0.219, 0.119]
SQ → NA → PSE	-0.161(0.077)*	-0.074(0.202)	0.012(0.033)	-0.048	[-0.061, 0.090]
SQ → NA → NSE	-0.161 (0.077)*	0.016(0.132)	-0.003(0.021)	-0.001	[-0.053, 0.046]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, *** $p < 0.001$.

Table 14a

Within-person Level Results of the Main Model, Controlling for the Effects of: 1) Late-Morning Pain on Both Afternoon Positive and Negative Affect; and 2) Afternoon Interpersonal Stress and Joy on Both Evening Positive and Negative Social Events (See Figure 8)

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.074(0.014)***	0.380(0.078)***	0.028(0.008)***	0.010	[0.014, 0.045]
SQ → PA → NSE	0.074(0.014)***	-0.074(0.061)	-0.005(0.005)	0.092	[-0.015, 0.003]
SQ → NA → PSE	-0.044(0.014)**	0.037(0.083)	-0.002(0.004)	-0.202	[-0.011, 0.005]
SQ → NA → NSE	-0.044(0.014)**	0.242(0.062)***	-0.011(0.004)*	-0.100	[-0.021, -0.003]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 14b

Between-person Level Results of the Main Model, Controlling for the Effects of: 1) Late-Morning Pain on Both Afternoon Positive and Negative Affect; and 2) Afternoon Interpersonal Stress and Joy on Both Evening Positive and Negative Social Events

Mediated Path	*a* Path (SE)	*b* Path (SE)	*ab* Path (SE)	Correlation of *a* and *b*	Asymmetric Confidence Interval
SQ → PA → PSE	0.317(0.049)***	-0.471(0.306)	-0.149(0.102)	-0.129	[-0.396, 0.039]
SQ → PA → NSE	0.317(0.049)***	0.076(0.176)	0.024(0.056)	0.022	[-0.137, 0.087]
SQ → NA → PSE	-0.030(0.064)	0.029(0.216)	-0.001(0.007)	-0.040	[-0.037, 0.030]
SQ → NA → NSE	-0.030(0.064)	0.001(0.133)	-0.000(0.004)	-0.007	[-0.021, 0.020]

Note. SQ = sleep quality, PA = positive affect, NA = negative affect, PSE = positive social events, and NSE = negative social events; *** $p < 0.001$.

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APPENDIX A

STUDY MEASURES

Participants were given the following prompts to assess for sleep, affect, pain, interpersonal stress and joy, and positive (desirable) and negative (undesirable) social events during the pre-intervention 21-day diary.

Sleep Quality

I would like to ask you a few questions about how you slept last night:

- What was the overall quality of your sleep last night? Enter a number between 0 and 100. A zero would mean "extremely poor sleep" and a one hundred (100) would mean "extremely good sleep. Please enter your answer now.

- How refreshed did you feel after waking this morning? Enter a number between 0 and 100. A zero (0) would mean "not at all refreshed" and a one hundred (100) would mean "extremely refreshed."

- Using the four digits, indicate how many hours and minutes of actual sleep you got last night. (This may be different than the number of hours you spent in bed.) For example, if you slept for six and a half hours, you'd enter 0630. Please enter your answer now.

- Last night, did you have trouble staying asleep? Enter a number between 1 and 4 where:

    1 is not at all
    2, a little
    3, some, or
    4, quite a bit

Affect

Using a scale of 1 to 5, where:

    1 is not at all
    2, a little
    3, some
    4, quite a bit, or
    5, completely

Answer the following questions: During the past 2 to 3 hours:

- How *energetic* did you feel?

- How *lonely* did you feel?

- How *calm* did you feel?
- How *sad* did you feel?
- How *angry* did you feel?
- How *cheerful* did you feel?

Pain

During the past 2 to 3 hours, what was your overall level of pain? Enter a number between 0 and 100 that best describes your pain level. A zero would mean "no pain" and a one hundred (100) would mean "pain as bad as it can be."

Interpersonal Stress and Joy

Using a scale of 1 to 5, where:

1 is not at all
2, a little
3, some
4, quite a bit, or
5, completely

- During the past 2 to 3 hours, how stressful were your relations with spouse/partner? Please enter an answer between 1 and 5 now.
- How enjoyable were your relations with spouse/partner? Please enter an answer between 1 and 5 now.
- During the past 2 to 3 hours, how stressful were your relations with family (not including spouse or partner)? Please enter an answer between 1 and 5 now.
- How enjoyable were your relations with family (not including spouse or partner)? Please enter an answer between 1 and 5 now.
- During the past 2 to 3 hours, how stressful were your relations with your friends or acquaintances? Please enter an answer between 1 and 5 now.
- How enjoyable were your relations with your friends or acquaintances? Please enter an answer between 1 and 5 now.

Social Events

Spouse/Partner

Desirable events. I am now going to read a list of 6 desirable events involving your spouse or partner that may have occurred today. For each event I read, I would like you to press 1 if that event occurred and 2 if the event did NOT occur:

1. You received a gift from your spouse or partner – Press 1 for yes or 2 for no;

2. You expressed love to your spouse or partner – Press 1 for yes or 2 for no;

3. You celebrated with your spouse or partner – Press 1 for yes or 2 for no;

4. You had a long conversation with your spouse or partner – Press 1 for yes or 2 for no;

5. You kissed and/or had pleasing physical contact with your spouse or partner – Press 1 for yes or 2 for no;

6. You went out together with your spouse or partner (dinner, movies, dancing, etc.) – Press 1 for yes or 2 for no.

Undesirable events. I am now going to read a list of 8 undesirable events involving your spouse or partner that may have occurred today. For each event, press 1 if the event occurred and 2 if the event did NOT occur:

1. You argued with your spouse or partner about money – Press 1 for yes or 2 for no;

2. You were angry or critical of your spouse or partner's behavior – Press 1 for yes or 2 for no;

3. Your spouse or partner was critical or angry with you – Press 1 for yes or 2 for no;

4. Your spouse or partner ignored you – Press 1 for yes or 2 for no;

5. Your spouse or partner turned down your request for time together – Press 1 for yes or 2 for no;

6. Your spouse or partner was ill-behaved – Press 1 for yes or 2 for no;

7. Your spouse or partner stopped being affectionate – Press 1 for yes or 2 for no;

8. Your spouse or partner was too busy to talk or go out – Press 1 for yes or 2 for no.

Family

Desirable events. I am now going to read a list of 10 desirable events involving your other family members that may have occurred today. This includes parents, children, and ex-spouses. Please keep count to yourself as I read the list:

1. You were praised by a family member;
2. You received a letter or email from family member;
3. A family member or members not living at home visited;
4. You talked with family member you had not seen for a long time;
5. You helped a family member;
6. You received a gift from a family member;
7. You worked out a problem with ex-spouse;
8. Your child or children did something nice for you;
9. You taught your child or grandchild something new;
10. You went out to lunch/dinner, movie, etc. with a family member.

How many of those 10 desirable events occurred today? Please press a number on the keypad between 0 = no events up to 10 = all 10 of those events occurred today.

Undesirable events. I am now going to read a list of 5 undesirable events involving your other family members that may have occurred today. This includes parents, children, and ex-spouses. Please keep count as I read this list:

1. You were criticized or blamed for something by a family member;
2. You had an argument with a family member;
3. You argued with ex-spouse;
4. Your son or daughter was rude or irritable;
5. You had to deal with a stressful family problem.

How many of those 5 undesirable events occurred today? Please press a number on the keypad between 0 = no events up to 5 = all 5 of those events occurred today.

Friend/Acquaintance

Desirable events. I'm now going to ask you about your relations with your friends and acquaintances. I'm going describe 6 desirable events involving your friends or acquaintances that may have occurred today. As I do this, I want you to keep a count to yourself of how many of these events occurred. I will then ask you to indicate how many of those events occurred today:

1. You went to a sport, game, or played cards with friends;
2. You went to a party or other social gathering;
3. You went to a club or organized group meeting;
4. You met a new friend or acquaintance;
5. You went out with friends to lunch, etc.;
6. You received a compliment from a friend or acquaintance.

How many of those 6 desirable events with friends and acquaintances occurred today? Please press a number on the keypad between 0 = no events up to 6 = all 6 of those events occurred today.

Undesirable events. I am now going to read a list of 5 undesirable events involving your friends or acquaintances that many have occurred today. Again, keep a count to yourself about how many of these events occurred:

1. A friend or acquaintance canceled or did not show up for a meeting;
2. A friend or acquaintance did not return your call;
3. You had a conflict with friend or acquaintance;
4. You had to deal with an unfriendly or rude person;
5. You received angry email or phone message from someone you knew.

How many of those 5 undesirable events occurred today? Please press a number on the keypad between 0 = no events up to 5 = all 5 of those events occurred today.