When Resilience Rides the Cycle of Fatigue:

The Role of Interpersonal Enjoyment on Daily Fatigue in Women with Fibromyalgia

by

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ABSTRACT

Fibromyalgia (FM) is a chronic pain condition characterized by debilitating fatigue. This study examined the dynamic relation between interpersonal enjoyment and fatigue in 102 partnered and 74 unpartnered women with FM. Participants provided three daily ratings for 21 days. They rated their fatigue in late morning and at the end of the day. Both partnered and unpartnered participants reported their interpersonal enjoyment in the combined familial, friendship, and work domains (COMBINED domain) in the afternoon. Additionally, partnered participants reported their interpersonal enjoyment in the spousal domain. The study was guided by three hypotheses at the within-person level, based on daily diaries: (1) elevated late morning fatigue would predict diminished afternoon interpersonal enjoyment; (2) diminished interpersonal enjoyment would predict elevated end-of-day fatigue; (3) interpersonal enjoyment would mediate the late morning to end-of-day fatigue relationship. In cross-level models, the study explored whether individual differences (between-person) in late morning fatigue and afternoon interpersonal enjoyment would moderate within-person relations from late morning fatigue to afternoon interpersonal enjoyment, and from afternoon interpersonal enjoyment to end-of-day fatigue. Furthermore, it explored whether the hypothesized relationships at the within-person level would also emerge at the between-person level (between-person mediation models). Multilevel structural equation modeling and multilevel modeling were employed for model testing, separately for partnered and unpartnered participants. Within-person mediation models supported that on high fatigue mornings, afternoon interpersonal enjoyment was dampened in the spousal and combined domains in partnered and unpartnered samples. Moreover, low afternoon interpersonal enjoyment in

both the spousal and combined domains predicted elevated end-of-day fatigue. Afternoon interpersonal enjoyment mediated the relationship of late morning to end-of-day fatigue in the combined domain but in not the spousal domain. Cross-level moderation analyses showed that individual differences in afternoon spousal enjoyment moderated the day-to-day relation between afternoon spousal enjoyment and end-of-day fatigue. Finally, the mediational chain was not observed at the between-person level. These findings suggest that preserving interpersonal enjoyment in non-spousal relations limits within-day increases in FM fatigue. They highlight the importance of examining domain-specificity in interpersonal enjoyment when studying fatigue, and suggest that targeting enjoyment in social relations may improve the efficacy of existing treatments.

DEDICATION

To my Sister, Rosaline

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INTRODUCTION

Fibromyalgia syndrome (FMS) is a chronic pain condition defined by its symptoms. According to the criteria approved by the American College of Rheumatology (ACR), it is diagnosed by the experience of widespread pain and the presence of pain and tenderness on at least 11 of 18 tender points upon pressure applied by a dolorimeter (Wolfe et al., 2010). In addition to pain, FMS is also characterized by fatigue, sleep disturbance, and indicators of psychological dysregulation, such as depression and anxiety (Wolfe, 1997; Wolfe, Ross, Anderson, Russell, & Hebert, 1995). The prevalence rate of FMS is between 2% to 5% in the United States, and women are seven times more likely than men to suffer from FMS (Neumann & Buskila, 2003; Weir et al., 2006; Wolfe et al., 1995).

Fatigue is one of the prominent symptoms in FMS. Epidemiological studies conducted by Wolfe and colleagues have reported that about 76% of patients with FMS complain about fatigue (Wolfe, Hawley, & Wilson, 1996). It is a subjective, physical sensation of unusual tiredness that is disproportional to prior exertion and unalleviated by rest (Barsevick et al., 2010).

Unlike other chronic pain conditions, such as rheumatoid arthritis (RA) and osteoarthritis (OA) that can be diagnosed by known biological markers, the etiology of FMS remains an enigma. Researchers have proposed that FMS might be related to dysregulation in (1) the sympathoadrenal and hypothalamic-pituitary-adrenal (HPA) axes (Neeck & Riedel, 2006), (2) central and peripheral pain mechanisms (Bennett, 1999), and (3) the inflammatory response system (Maes et al., 1999). These pathophysiological

processes might contribute to both pain and fatigue experienced among FMS patients (Afari & Buchwald, 2003; Clauw, 1995; Cruess et al., 1999).

Despite the fact that advances have been made in understanding the etiopathology of FMS in recent years, little success has been obtained in pharmacological treatment. Further, much focus of FMS research has been placed on pain rather than fatigue, even though fatigue is as debilitating as pain to the well-being of FM patients and imposes enormous direct and indirect costs on the society. Thus, it is crucial for research to elucidate the nature of fatigue and its correlates in the study of FMS.

In the absence of any known physical markers and in the presence of multiple known psychological sequelae in FMS, medical and psychological models have been employed simultaneously to generate knowledge with respect to the etiology, assessment, and treatment of the symptoms of FMS. Engel's (1980) biopsychosocial model has afforded researchers a holistic approach in investigating the interplay among biological, psychological, and social factors that contribute to adaptive coping of chronic pain conditions (e.g. Van Houdenhove & Engle, 2004).

There are three components of the biopsychosocial model. (1) The biological components delineate the contributions of genetic predispositions and central and peripheral processes of chronic pain. (2) The psychological components depict the influences of cognitive constructs, such as belief system, appraisal style, and coping-efficacy and affective constructs, such as depression, anxiety, and anger associated with chronic pain. (3) The social components broadly highlight the importance of social elements, such as quality of interpersonal relationships, culture and health care system relate to chronic pain (see Gatchel, Peng, Peters, Fuchs, & Turk, 2007 for a review).

These three components are distinct, yet interdependent and interactive, in accounting for the resilient adaptation to FMS (Gatchel, 2004; Gatchel et al., 2007).

Among many reasons why the biopsychosocial model surpasses other psychological models in addressing the adaptive coping processes in chronic pain, one of them specifically pertains to the current study. The biopsychosocial model brings the interpersonal components forward to the centerpiece of chronic pain research by underscoring the centrality of one's social environment to resilient adaptation to chronic pain (Hadjistavropoulos et al., 2011). Indeed, only through placing the interpersonal factors alongside the intrapersonal factors can one appreciate a more comprehensive picture of chronic pain. Since its inception, the biopsychosocial model has proven its worth in some areas of chronic pain research, while others have yet to benefit from its value. Two of these areas that have not yet benefited are directly relevant to this study – the areas of resilience and FMS.

The biopsychosocial model has been widely applied in studying the vulnerability factors that relate to adaptation to chronic pain. Yet, application of the biopsychosocial model to the study of resilience factors that relate to chronic pain adaptation remains relatively scant. In these few decades, a growing body of literature has shown that resilience factors account for variance above and beyond vulnerability factors in explaining health among chronic pain patients. For instance, Smith and Zautra (2008) found that the vulnerability and resilience factors resembled a bidimensional rather than a unidimensional structure. In their study of chronic pain patients, a vulnerability factor consisted of maladaptive emotionality and personality indicators, such as neuroticism and pessimism, and a resilience factor consisted of beneficial emotionality and personality

indicators, such as purpose in life and optimism. The association between the vulnerability and resilience factors was modest (r = -.314). More importantly, these factors contributed distinctly to the well-being of chronic pain patients. While the vulnerability factor showed a direct association with negative affect and an inverse association with positive affect, the resilience factor merely showed a direct association with positive affect. These findings support the characterization of vulnerability and resilience as two distinct aspects of psychological health among chronic pain patients. Furthermore, that this pattern of results has repeatedly emerged (e.g., Zautra, Johnson, & Davis, 2005) calls for treating the resilience factor as a distinct component in the investigation of adaptive coping processes among patients with chronic pain.

Inspired by the biopsychosocial model and the findings in the study of vulnerability and resilience, the current study focused on interpersonal experience and resilience to elucidate the nature of fatigue over time in FM patients.

A model is proposed that considers the interplay between the experience of fatigue as a hallmark of fibromyalgia and interpersonal enjoyment as a form of resilience resource within days. Interpersonal enjoyment includes the enjoyment derived from interactions with spouse, family, friends, and work colleagues. The model characterizes the links from (1) feeling of fatigue reported in the late morning (referred as late morning fatigue in this study) to (2) the experience of interpersonal enjoyment derived from positive social exchanges that occur in the afternoon (referred as afternoon interpersonal enjoyment in this study) to (3) the feeling of fatigue experienced during the day reported at the end of day (referred as end-of-day fatigue in this study) among patients with FMS. The time frame label of the construct reflects the time at which each of the constructs was

administered. This meditational chain forms the core interest of the current study. Further, this model also proposes that late morning fatigue may directly predict end-of-day fatigue. The sequences of within-day linkages are shown in Figure 1.

It is possible to consider the proposed relations in Figure 1 from both a within-person and a between-person perspective. Both perspectives were taken in the present study. The within-person drew upon daily diary data in which individuals provided assessments of the constructs in Figure 1 on a daily basis. The within-person perspective examined how individuals fluctuated over time around their own average levels, for example, morning fatigue on one particular day versus average morning fatigue over time. Thus, the within-person perspective referred to "change" in constructs as change from the person's own baseline measured at the particular time of the day across days. In other words, an individual's within-person changes in late morning fatigue were the deviation scores from that individual's own late morning baseline. The alternative between-person perspective was based on average levels of an individual on constructs of Figure 1, taken across multiple days of a daily diary. Specifically, the relationships among average late morning fatigue, average afternoon interpersonal enjoyment, and average end-of-day fatigue across individuals were examined.

The model contains intrapersonal constructs—fatigue in the morning and end-of-day. In addition, the model contains the interpersonal construct of social enjoyment; interpersonal enjoyment is assumed to result from cognitive appraisals of positive interpersonal events.

While this study examined both the within- and between-person linkages, the study focused more attention at the within-person than the between-person level for two

reasons. (1) Fatigue manifests high levels of within-person variability among the FM patients (Zautra, Fasman, Parrish, & Davis, 2007); and (2) the psychological constructs that are at the within-person level (state-level) are more susceptible to the influences of intervention than they are at the between-person level (trait-level).

The present study employed data from an extensive study of the daily lives of patients with FM, the Gains in Fibromyalgia Treatment (GIFT) study (see method section for an overview of GIFT). Again the current study investigated both *within-person* relations and *between-person* relations between fatigue and interpersonal enjoyment over time within days. The within-person model that formed the primary inquiries of this study addressed the following questions:

1. Do patients with FM experience lower levels of interpersonal enjoyment in the afternoon on the days on which fatigue experienced in the late morning is higher than the within-person average (Figure 1)?
2. Do patients with FM experience higher levels of end-of-day fatigue on the days on which afternoon interpersonal enjoyment experienced is lower than the within-person average (Figure 1)?
3. Do day-to-day fluctuations of afternoon interpersonal enjoyment mediate the relation between late morning and end-of-day fatigue on a daily basis

In addition, interpersonal enjoyment and interpersonal stress tend to negatively correlate with each other. To examine whether interpersonal enjoyment contributed uniquely to later fatigue above and beyond interpersonal stress, the set of research questions listed above were further examined by including afternoon interpersonal stress

as a covariate in predicting end-of-day fatigue while correlating it with interpersonal enjoyment.

Finally, the study explored three other aspects related to the model constructs. First, it explored whether the relation between late morning fatigue and afternoon interpersonal enjoyment, and the relation between afternoon interpersonal enjoyment and end-of-day fatigue at the within-person level varied across individuals. Second, it explored the interplay between the model constructs at the within-person and the between-person levels by examining whether fatigue at the between-person level moderated the relation between late morning fatigue and afternoon interpersonal enjoyment, and afternoon interpersonal enjoyment and end-of-day fatigue at the within-person level. In addition, this study also examined whether interpersonal enjoyment at the between-person level moderated the relation between late morning fatigue and afternoon interpersonal enjoyment, and afternoon interpersonal enjoyment and end-of-day fatigue at the within-person level. Third, it explored whether the model constructs had significant relations at the between-person level. Specifically, it explored whether an individual's person-average late morning fatigue was related to that individual's person-average afternoon interpersonal enjoyment and whether an individual's person-average afternoon interpersonal enjoyment was related to that individual's person-average end-of-day fatigue. Last, it explored whether average afternoon interpersonal enjoyment at the between-person level mediated the relation between average late morning and average end-of-day fatigue by using person-average scores of the model constructs.

A Process Model of Emotion – the "Modal Model" of Emotion

In the fields of social and clinical psychology, the rise of emotion can be characterized by a process model, called "modal model" of emotion developed by Gross and Thompson (2007). This model proposes that emotion is often elicited by an external situation. Certain aspects of the situation are attended to, followed by cognitive appraisal (i.e. interpretation) of these salience aspects of the situation. The results of the appraisal process give rise to the experience of emotion. This model provides the current study with a heuristic framework not only for depicting the rise of enjoyment from an interpersonal social event, but also for organizing the determinants that may influence the levels of enjoyment induced by the event.

Among the many determinants that may influence the components in the "modal model" of emotion, three of them pertain to the scope of the current study. First, fatigue suffered by the FM patients may limit their opportunities to participate in positive interpersonal events – the fatigue-event link. Second, fatigue may reduce FM patients' cognitive capacity to attend to the positive aspects of the events – fatigue-attention link. Third, fatigue may diminish FM patients' cognitive capacity to fully process the positive aspects of the events, rendering the events less enjoyable – fatigue-appraisal link. For example, when a patient helps a family member, she could attribute the event to personal mastery and self-agency, resulting in a high rating of pleasantness and enjoyment of this event (Ellsworth & Smith, 1988; Kiffin-Petersen, Murphy, & Soutar, 2012). Following this line of reasoning, when patients experience greater degrees of fatigue, they may lack cognitive resources to activate and sustain the operations of appraisal mechanisms (e.g.,

appraisal of personal mastery or self-agency) for interpersonal events, resulting in a reduction at the levels of enjoyment of those events.

Fatigue, Positive Interpersonal Events, and Interpersonal Enjoyment

Human beings are social animals. From a social psychological perspective, according to the belongingness hypothesis postulated by Baumeister and Leary (1995), we have an innate need to belong. These authors proposed that individuals are evolutionarily motivated to form, maintain, and prevent the dissolution of social attachments through engaging in social interactions with others. The quality of these interactions has tremendous impact on our affect, cognition, and behavior. In the social support literature, ample evidence has been garnered to support that positive and negative social exchanges result in beneficial and detrimental effects on health and well-being, respectively (see Okun & Keith, 1998; Rook, 2003).

The need for social engagement is particularly essential for individuals with chronic pain. Social bonds are important currency for pain adaptation (Kawachi, Kennedy, and Glass, 1999; Knorringa & van Staveren, 2007; Putnam, 2000; Seeman, Kaplan, Knudsen, Cohen, & Guralnik, 1987). Ironically, the physical disabilities experienced by chronic pain patients may impose enormous constraints on the opportunities for them to form strong, stable social ties. Understanding how fluctuations in fatigue impact social ties in daily life can inform efforts to foster better adaptation among patients.

In a diary study, Affleck and his colleagues (1998) found that when fatigue was elevated, FM patients reported greater amount of hindrance in achieving their social goals directly due to the fatigue experienced during the day. Moreover, on days when

experienced fatigue was high, the levels of perceived barriers to achieving medium range social goals increased and efforts toward these goals decreased among FM patients (Affleck et al., 2001). Hence, the reduction in progress toward social goals found earlier might be the consequence of the rise in perceived barriers and the decline in effort on the days on which the experience of fatigue was more serious than usual.

Based on the results found in Affleck et al. (1998; 2001), one might expect that on days that are more fatiguing, individuals would be more likely to retreat from social engagements, which, in turn, would limit the opportunities for them to benefit from the positive aspects of social engagements. Surprisingly, empirical findings that address this conjecture are far from consistent.

In a daily diary study, within-person analysis on the end-of-day diary measures did not reveal any relation between fatigue and the number of positive events among RA patients (Davis, Affleck, Zautra, & Tennen, 2006). Consistent with this null finding, Davis et al. (2006) did not find any evidence to suggest a link between changes in fatigue and changes in interpersonal enjoyment in this diary study. To explain these null findings, it is plausible that the sample of RA patients in this particular study might not contain sufficient within-person variability in fatigue to detect predictions from fatigue to the number of interpersonal events and the levels of interpersonal enjoyment at the within-person level. Research showed that within-person variance in fatigue in FM patients was greater than in RA patients in a multi-group study (Zautra et al., 2007). Thus, the fatigue-interpersonal enjoyment relation at the within-person level may be significant in FM patients. Finally, any null finding only indicates evidence has not been found to support the negative association between fatigue and positive social constructs at

the within-person level. However, it does not disprove the relation. Hence, the current study will directly test this relation in FM patients.

Consistent with the plausible explanation stated above, in a chronic pain study that included FM patients as part of the sample, evidence has supported the association between fatigue and interpersonal events at the within-person level. A *within-person* analysis in a daily diary study (Parrish, Zautra, & Davis, 2008) revealed that the level of fatigue experienced was positively associated with the number of negative interpersonal events among patients with OA, RA, and FM. The level of fatigue experienced was negatively associated with the number of positive interpersonal events.

As mentioned above, fatigue may hinder the number of positive social interactions that FM patients may encounter, and/or it may hinder the appraisals of the benefits derived from the positive social events. In addition, the number of daily positive events was found to be highly associated with daily relationship enjoyment (Davis et al., 2006). Appraisal (i.e. interpersonal enjoyment) is central in producing positive affect from a positive interpersonal event. Appraisal is also amenable to modification by clinical intervention. Thus, the current study focused on the participants' positive interpretation (i.e., enjoyment) of the positive events rather than the events themselves as the key variable to be examined.

This study first examined daily within-person variation in each model construct around the overall individual level on the same construct (e.g., deviation from late morning fatigue on a single day from the mean late morning fatigue). It was predicted that on a day on which an FM patient experienced higher levels of fatigue in the late

morning, relative to her own average, she would experience lower levels of interpersonal enjoyment in the afternoon of that day.

Previous studies that examined the relation between interpersonal enjoyment and fatigue were cross-sectional studies. This study is the first to provide some insight into the temporal precedence of this relation. This study predicted that on a day on which an FM patient experienced lower levels of interpersonal enjoyment in the afternoon of the day, relative to her own average, she would experience higher levels of fatigue in the end-of-day of that day. In addition to the within-person examination of links among constructs, the study explored between-person linkages among the same constructs in the hypothesized model (Figure 1) stated above.

Chapter 2

METHOD

Participants

The sample for the present study was drawn from a larger study, the Gains in Fibromyalgia Treatment (GIFT) study (5R01AR053245-06). It consisted of participants who reported symptoms consistent with a diagnosis of fibromyalgia. The larger study had two major aims. (1) It examined the influences of FMS on patients' life experiences. (2) In a randomized trial, it tested the efficacy of two different interventions, the Cognitive Therapy for Pain and Emotion and Cognitive-Behavioral Therapy for Pain, compared to an Education. These interventions targeted physical symptoms (e.g., pain and fatigue), social relations, cognitive functioning, and emotion regulation with the aim of enhancing adaptive coping processes in patients with FMS.

Participants were recruited in the Phoenix, AZ metropolitan area via newspaper and online ads, fliers posted at medical clinics, and referrals from physicians. Respondents who expressed an interest in participation were first screened *via* telephone, and then *via* an in-home assessment conducted by a registered nurse with respect to the following inclusion criteria: (1) 18 years of age or older; (2) English-speaker; (3) no involvement in litigation associated with their pain condition; (4) agreed to be randomized into one of the three conditions – Cognitive Therapy for Pain and Emotion, Cognitive-Behavioral Therapy for Pain, and Education Group; (5) without co-morbid psychological or medical conditions that might interfere with their participation in the study; and (6) fulfilled FM criteria specified by the American College of Rheumatology (ACR) (Wolfe, et al., 1990) that included a tender point assessment (Okifuji, Turk,

Sinclair, Starz, & Marcus, 1997). The current study only included data collected prior to randomization to treatment. Thus, in the following sections, only those aspects of the method and data pertaining to the pre-intervention portion of this study are included. 528 participants were screened and 225 participants were enrolled into the study. 223 participants completed their daily diaries. 198 out of the 223 participants were females. 85% were Caucasian; and mean age was 52.36 years (*SD* = 10.03).

Procedure

All participants received an in-home nurse visit to examine their physical health. Moreover, a tender point examination was conducted at the in-home nurse visit to verify participants' current FM diagnosis utilizing the ACR criterion – pain and tenderness experienced on at least 11 of 18 tender points (Wolfe, et al., 1990). Then, a clinical phone interview was conducted to examine their mental health. In addition, the participants completed an initial and a pre-treatment questionnaire that assessed demographic information, personality, emotionality, and physical and mental functioning. They also participated in a laboratory session that measured their physiological reactivity to experimental stressors. Finally, they filled in the daily diaries that assessed their physical and mental health in their daily lives.

In the diary portion of the larger study, participants were provided with a mobile phone and were trained by a research assistant to use the phone to complete electronic diaries four times a day for 21 days. An automated phone system called each of the participants each morning 20 minutes following his/her specified wake up time for the morning interview, and at 11 a.m. for the late morning interview, at 4 p.m. for the afternoon interview, and at 7 p.m. for the end-of-day interview. If the participant missed

the call, s/he could call the system within two and half hours to complete the call. Participants were encouraged to call our laboratory staff immediately if a problem occurred with the phone system. They were monitored and contacted if failing to complete diaries. Participants were compensated $3 each day for completing a 21-day diary.

Measures

(1) Average Fatigue. Average fatigue was assessed in the late morning and at the end of the day. It was measured by one item (NRS; Jensen, Karoly, & Braver, 1986; Zautra, Smith, Affleck, & Tennen, 2001). The question stated, "What was your overall level of fatigue? Enter a number between 0 and 100 that best describes your fatigue level. A zero (0) would mean 'no fatigue' and a one hundred (100) would mean 'fatigue as bad as it can be'. Please enter your answer now."

(2) Perceived Interpersonal Enjoyment. Perceived interpersonal enjoyment was assessed in the afternoon. It was measured by the Inventory of Small Life Events (ISLE; Zautra, Guarnaccia, & Dohrenwend, 1986). It contained two sets of items that examined interpersonal contact and enjoyment in (1) the domain of spouse/partner, and (2) the domains of family, friends, and co-workers combined.

The first set of items characterized a participant's relationship with her spouse/partner. The first item assessed each participant's marital status. Partnered participants were then asked, "During the past 2-3 hours, did you have contact with your spouse/partner?" If contact was reported, then they were further asked, "How enjoyable were your relations with spouse/partner?" Participants rated the enjoyment they experienced on a five-point scale ranging from 1 (*not at all*) to 5 (*completely*).

The second set of items characterized the participants' relationship with their family, friends, or co-workers. The first item assessed whether they had contact with their family, friends, or co-workers during the past 2-3 hours. If contact was reported, then they were further asked, "How enjoyable were your relations with others, including your family, friends, or co-workers?" For the partnered participants, specific instruction was given to ask the participants to exclude their spouse/partner as family when rating this item. Again, participants rated the enjoyment they experienced on a five-point scale ranging from 1 (*not at all*) to 5 (*completely*).

(3) *Perceived Interpersonal Stress.* Perceived interpersonal enjoyment was assessed in the afternoon. It was measured by the Inventory of Small Life Events (ISLE; Zautra, Guarnaccia, & Dohrenwend, 1986). Parallel to the measures of interpersonal enjoyment, interpersonal stress contained two items that examined stress in (1) the domain of spouse/partner, and (2) the domains of family, friends, and co-workers combined. If contact with partner was reported by partnered participants, they were asked, "How stressful were your relations with spouse/partner?" Participants rated the stress they experienced on a five-point scale ranging from 1 (*not at all*) to 5 (*completely*). Moreover, if contact with family, friends, or coworkers was reported by participants, they were asked, "How stressful were your relations with others, including your family, friends, or co-workers?" by using the same five-point scale stated above. Regarding the order of the items being administered in the diary, the stress item was asked prior to the enjoyment item in all domains. This stress measurement, though not included in the model of Figure 1, was included as a covariate in some estimated models, as described below.

All the items are listed in Table 1. It should be noted that the late morning and afternoon diary measures assessed the participants' experiences of the constructs during the two to three hours prior to the calls. Hence, late morning measures had no temporal overlap with afternoon measures. In contrast, the end-of-day diaries assessed the participants' overall experiences of the constructs during the entire day. Thus, end-of-day measures had temporal overlap with late morning and afternoon measures. Figure 2 depicts the temporal order of the constructs in the hypothesized models of the current study.

Data Analytic Strategy

This study investigated the relations among fatigue and interpersonal enjoyment in a model that took temporal precedence into consideration. A series of models were estimated. Collectively the models examined relations of late morning fatigue to afternoon interpersonal enjoyment to end-of-day fatigue at both the within-person and between-person levels. The following hypotheses were tested at the within-person level (see Figure 1):

1. On days on which FM patients experience higher levels of fatigue in the late morning, relative to their own average fatigue in the late morning, they will experience diminished interpersonal enjoyment in the afternoon of that day.
2. On days on which FM patients experience diminished interpersonal enjoyment in the afternoon, relative to their own average interpersonal enjoyment in the afternoon, they will experience higher levels of fatigue in the end-of-day of that day.

In addition to the tests of these hypotheses, the mediation of the relation from late morning to end-of-day fatigue by afternoon interpersonal enjoyment was examined. Parallel between-person relations were tested in the same model. Due to the exploratory nature of the between-person analyses, no predictions were made with regard to the relations between average late morning fatigue and average afternoon interpersonal enjoyment, and average afternoon interpersonal enjoyment and average end-of-day fatigue.

The hypothesized model shown in Figure 1 contains three latent variables forming a sequential mediational chain in which late morning fatigue predicts afternoon interpersonal enjoyment, which, in turn, predicts end-of-day fatigue of that day. (1) In the observed data, the latent late morning fatigue measure was comprised of only one measured variable – late morning fatigue. (2) The latent afternoon interpersonal enjoyment assessment was comprised of one measured variable representing the enjoyment experienced in its specific domain. This study assessed two major domains: the spousal domain and the combined familial, friendship, and work domains. (3) The latent end-of-day fatigue measure was comprised of only one measured variable – end-of-day fatigue of that day. As noted in the method section, the end-of-day measure of fatigue assessed participants' overall fatigue on that day. The variance in the late morning fatigue was controlled for in the model by specifying a direct path linking late morning to end-of-day fatigue (Kisbu-Sakarya, MacKinnon, & Aiken, 2013).

Inclusion of women only. In the current study, only women were included in analyses. Previous studies have found a few gender differences in the study of social relations. Women place more value, invest more, and experience more stress in their

social relations when compared to men (Davis, Matthews, & Twamley, 1999). Moreover, among RA patients, women had a stronger within-person relation between the number of positive events and fatigue measured on the same day than men (Davis, Okun, Kruszewski, Zautra, & Tennen, 2010). Not surprisingly, in the current study, we only had a small number of male participants, consistent with much lower prevalence of FM among men relative to women. The small number of male participants in the current study would not have allowed us to have enough statistical power to test for gender differences. Thus, the current study included only females to increase homogeneity of the sample. In addition, the current study followed the GIFT protocol by excluding the participants who filled out fewer than 10 out of 21 end-of-day diaries (fewer than 50% of the end-of-day diaries) from the analyses. As a result, 176 out of 198 females were retained in the analyses.

Stratification of sample by presence versus absence of spouse/partner. The sample included participants who had a spouse or partner versus those who had neither a spouse nor partner. Therefore, the sample was stratified into two groups: having spouse/partner, versus no spouse/partner. The measure of interpersonal enjoyment in the spousal/partner domain necessarily was confined to the former subset of participants (see Figure 3).

It was possible that Interpersonal Enjoyment in the combined Familial, Friendship, and Work domains might have different meaning for those with versus without a spouse/partner. Therefore, the examination of models that addressed the role of Interpersonal Enjoyment in the combined Familial, Friendship, and Work domains were

carried out separately for those with versus without a spouse/partner (see Figures 4 and 5, respectively).

Descriptive statistics and intraclass correlations (ICCs). The analyses began with computing the missing data distribution and descriptive statistics, including range, mean, standard deviation, skew, and kurtosis of each of the measured variables. Moreover, intraclass correlation coefficients of the measured variables were computed on the whole sample; each intraclass correlation represents the amount of the between-person variation relative to the total variation for each of the repeated measures. The ICC for a repeated measure represented the differences between the mean of that repeated measure across individuals. In other words, ICC for a repeated measure addressed to what extent the individual participants differed in arithmetic mean of that repeated measure.

Overview of estimated models. Four sets of models were estimated. Set 1 estimated the models specified in Figures 3, 4, and 5; relations were examined at both the within-person and between-person levels. For this set of models, a series of multilevel structural equation models (MSEMs) were estimated for hypothesis testing. Each MSEM involved estimation of the relation from late morning fatigue to afternoon enjoyment, the relation from afternoon enjoyment to end-of-day fatigue, and finally estimation of the predicted mediational path from late morning fatigue to afternoon enjoyment to end-of-day fatigue. Set 2 repeated the models of the first set, with stress added as a covariate in the prediction of end-of-day fatigue. All the models of Sets 1 and 2 were estimated with random intercepts and fixed slopes; Mplus version 7 (Muthen & Muthen, 1998-2012) was employed for estimation. Set 3 of models repeated the models of the first set; however, random slopes as well as random intercepts were estimated; SAS version 9.3

(Littell, Milliken, Stroup, & Wolfinger, 1996) was employed for estimation. Set 4 of models examined cross-level moderation of within-person relations by between-person characteristics. SAS (Littell et al., 1996) was employed for estimation of the cross-level moderation models.

Handling of missing data in modeling. Participants differed in the number of days of diary data they completed; this is comparable to having differing cluster sizes in a design with individuals clustered within groups. Furthermore, on any day on which a participant responded to the diary, one or more time points during the day might have been omitted (e.g., the late morning and end-of-day but not afternoon observations provided on a given day). Full information maximum likelihood (FIML) was employed to estimate models with missing data. The full information maximum likelihood estimation via an accelerated EM algorithm routine used in Mplus version 7 is robust to nonnormality, missing data, and unbalanced cluster size of data (Muthen & Asparouhov, 2008; Preacher, Zyphur, & Zhang, 2010).

Set 1 of Multilevel Structural Equation Models (Preacher et al., 2010) estimated the direct and mediating effects from late morning fatigue to end-of-day fatigue on the same day (shown in Figures 3, 4, and 5) at the within- and between-person levels simultaneously. To do so, MSEM partitions the total variance into two mutually exclusive components – the between- and within-person components. In MSEM, the between-person model uses the latent variables extracted from the manifested variables, whereas the within-person model uses the manifested variables for estimation. The predictor and mediators were subjected to an "implicit, model-based group mean centering" (p. 210, Preacher et al., 2010) by default in Mplus to remove the between-

person variability. As a result, MSEM prevents biasing the standard error estimates and inflating type I error rates of the test statistics of the parameters caused by the clustering effect. It also allows the estimation of the relations among variables to be different at the within- and between-person levels.

The MSEMs were specified to have random intercepts but fixed slopes. At both the within-person and the between-person levels, the path from late morning fatigue to afternoon enjoyment (the *a* path in the mediational chain) and the path from afternoon enjoyment to end-of-day fatigue (the *b* path in the mediational chain) were estimated. The mediated (indirect) effect was computed using the product of the coefficients of the *a* and *b* paths. The distribution of the *ab* path is asymmetrical and varies across the values of correlation between the *a* and *b* paths. Hence, it is important to take this correlation into consideration to obtain an unbiased inference statistic (Kenny, Bolger, & Korchmaros, 2003; MacKinnon, Lockwood, & Williams, 2994). The asymmetric confidence intervals for the mediating effects in these MSEMs were computed using RMediation (Tofighi & Mackinnon, 2011). These models were fully saturated; therefore no fit indices were available.

Set 2 estimated the MSEM models of Set 1 again; interpersonal stress was added as a covariate in predicting end-of-day fatigue. Fit indices were reported in these models. With respect to evaluating model fit, the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) were employed. The traditional recommended cutoff values of these indices are CFI > 0.95, RMSEA < 0.06, and SRMR < 0.08 (Hu & Bentler, 1999) for good fit. To my knowledge, a set of new, widely recognized cutoff values for MCFA and MSEM have

not as yet been established. However, a recent dissertation study recommended a set of more stringent criteria for multilevel data -- CFI > 0.970, RMSEA < 0.054, and SRMR < 0.052 for within models and SRMR < 0.044 for between models with high ICC (Hsu, 2009). In the current study, both sets of cutoff values were employed to evaluate the model fit.

A piecewise strategy *via* multilevel modeling was used to estimate Set 3 of models. These models investigated whether random slopes were present in the path from late morning fatigue to afternoon interpersonal enjoyment, the path from afternoon interpersonal enjoyment to end-of-day fatigue, and the mediating path separately. Estimation was carried out in SAS for the three models among partnered and unpartnered samples. After determining which path(s) in which of the three model(s) had random slopes via the piecewise approach, the model(s) were fit in MSEMs with the path(s) specified to have random slopes. Since these were fully saturated models, no fit indices were available.

Finally, for Set 4 of models, a piecewise approach was adopted to examine whether fatigue and enjoyment at the between-person level moderated the paths from late morning fatigue to afternoon interpersonal enjoyment, from afternoon interpersonal enjoyment to end-of-day fatigue, and the mediating path. These cross-level moderated-mediated models were estimated in SAS.

Chapter 3

RESULTS

The sample comprised 176 female FM patients. Of the 176 participants, 102 had a spouse/partner (57.95%) and 74 did not have a spouse/partner (42.05%). If all participants had provided responses on all 21 days of the protocol, 2142 daily reports would have been collected from the partnered sub-sample and 1554 daily reports would have been collected from the unpartnered sub-sample. Partnered participants provided 92.11% of late morning fatigue reports (1973/ 2142 potential reports) and 90.06% of end-of-day fatigue reports (1929/2142 potential reports). Unpartnered participants provided 89.51% of late morning fatigue reports (1391/1554 potential reports) and 85.14% of end-of-day fatigue reports (1323/1554 potential reports).

When partnered participants were asked the question of whether there was contact with the spouse/partner in the afternoon, they provided a response 88.80% of the time (1902/2142 potential reports). However, of the 1902 responses, only 56.05% indicated that partnered participants actually had contact with the spouse/partner on the afternoon in question. Pooled across partnered participants and days, this yielded 1066 daily reports of actually having contact with the spouse/partner. Out of the 1066 reports, partnered participants provided 99.81% of afternoon interpersonal stress and 99.81% of afternoon interpersonal enjoyment reports in the spousal domain. In addition, there were 88.75% of responses to the question of whether there was contact with family, friends, or coworkers in the afternoon (1901/ 2142 potential reports). However, of the 1901 responses, only 53.13% indicated that partnered participants actually had contact with family, friends, or coworkers on the afternoon in question. Pooled across partnered

participants and days, this yielded 1010 daily reports of actually having contact with family, friends, or coworkers. Out of the 1010 reports, partnered participants provided 99.60% of afternoon interpersonal stress and 100.00% of afternoon interpersonal enjoyment reports in the combined familial, friendship, and work domains.

When unpartnered participants were asked the question of whether there was contact with family, friends, or coworkers in the afternoon, they provided a response 81.85% of the time (1272/1554 potential reports). However, of the 1272 responses, only 66.43% indicated that unpartnered participants actually had contact with family, friends, or coworkers on the afternoon in question. Pooled across unpartnered participants and days, this yielded 845 daily reports of actually having contact with family, friends, or coworkers. Out of the 845 reports, unpartnered participants provided 99.76% of afternoon interpersonal stress and 99.88% of afternoon interpersonal enjoyment reports in the combined familial, friendship, and work domains.

Table 2 shows the ranges, means, standard deviations, skew, kurtosis, and intraclass correlations (ICCs) of late morning fatigue, afternoon interpersonal stress and enjoyment in the spousal domain and the combined familial, friendship, and work domains, and end-of-day fatigue for the partnered sample. Table 3 shows the same descriptive statistics of the same set of variables, except afternoon interpersonal stress and enjoyment in the spousal domain, for the unpartnered sample.

Multilevel Structural Equation Modeling of Relation from Late Morning Fatigue to Afternoon Interpersonal Enjoyment to End-of-day Fatigue

Three multilevel structural equation models with random intercepts and fixed slopes (i.e., the models allow intercepts but not slopes to vary from person to person)

were tested to examine the relations proposed in Figure 1 among late morning fatigue, afternoon interpersonal enjoyment, and end-of-day fatigue. The models were estimated separately for the partnered and unpartnered sub-samples. Two models were estimated in the partnered sub-sample, one for the spousal domain (Model 1) and the other for the combined familial, friendship, and work domains (Model 2). Only one model was estimated in the unpartnered sub-sample, for the combined familial, friendship, and work domains (Model 3). The models estimating the combined familial, friendship, and work domains (Models 2 and 3) were identical for the partnered and unpartnered sub-samples.

(1) Model 1. For the partnered FM sample in GIFT, a model predicted afternoon interpersonal enjoyment in the spousal domain from late morning fatigue; afternoon interpersonal enjoyment in the spousal domain in turn predicted end-of-day fatigue. The model captured both within-person and between-person relations (see Figure 3).

(2) Model 2. For the partnered FM sample in GIFT, a model predicted afternoon interpersonal enjoyment in the combined familial, friendship and work domains from late morning fatigue; afternoon interpersonal enjoyment in the combined familial, friendship, and work domains in turn predicted end-of-day fatigue. The model captured both within-person and between-person relations (see Figure 4).

(3) Model 3. For the unpartnered FM sample in GIFT a model predicted afternoon interpersonal enjoyment in the combined familial, friendship and work domains from late morning fatigue; afternoon interpersonal enjoyment in the combined familial, friendship, and work domains in turn predicted end-of-day fatigue. The model captured both within-person and between-person relations (see Figure 5). Tables 4-9 show correlations among

the variables at the within-person and between-person levels for the partnered and unpartnered samples for Models 1, 2 and 3, respectively.

Three additional multilevel structural equation models were tested. These models included afternoon interpersonal stress as a covariate that predicted end-of-day fatigue, along with afternoon interpersonal enjoyment. Moreover, a correlation between afternoon interpersonal enjoyment and stress was specified in these models. These models served to examine whether interpersonal enjoyment was unique from interpersonal stress in predicting fatigue at a later time point. Specifically, the measure of interpersonal stress was the particular stress experienced in the domain under consideration (spousal; combined familial, friendship, and work) on the specific day in which the social interaction occurred (see Table 1). It should be recalled that stress associated with the social interaction in a specific domain on a particular day was assessed immediately before the rating of enjoyment in the same domain. The fourth, fifth, and sixth models with stress as the covariate paralleled Models 1, 2, and 3, described above: in the partnered sample in the spousal domain, in the partnered sample in the combined familial, friendship, and work domains, and in the unpartnered sample in the combined familial, friendship, and work domains.

Results of Models 1, 2, and 3, which did not contain the stress covariate, are presented in Tables 10, 11, and 12, respectively. For each model, within-person results are presented, followed by between-person results. Asymmetric confidence intervals of the mediated effects estimated by RMediation are also reported (Tofighi & MacKinnon, 2011). No fit indices are available for these models, since they are fully saturated models.

For the partnered sample, the within-person results of the first model, shown in Table 10, indicated that the levels of late morning fatigue significantly negatively predicted the ratings of afternoon interpersonal enjoyment in the spousal domain (a_w = -.005, p < .05). Again at the within-person level, ratings of afternoon interpersonal enjoyment in the spousal domain significantly negatively predicted the levels of end-of-day fatigue, independent of late morning fatigue (b_w = -1.043, p < .05). Ratings of afternoon interpersonal enjoyment in the spousal domain did not significantly mediate the relation between the levels of late morning and end-of-day fatigue (ab_w = .005, p > .10). At the between-person level, also reported in Table 10, late morning fatigue was unrelated to afternoon interpersonal enjoyment in the spousal domain (a_b = -.007 p > .10). Afternoon interpersonal enjoyment in the spousal domain measured at the between-person level marginally negatively predicted end-of-day fatigue, independent of late morning fatigue (b_b = -1.799, p < .10). Finally, at the between-person level, ratings of spousal interpersonal enjoyment did not mediate the relation of late morning fatigue to end-of-day fatigue (ab_b = .012 p > .10). The correlation between the *a* and *b* paths was close to zero at both the within-person and between-person levels; the correlation was slightly positive at the within-person level (.024) and slightly positive at the between-person level (.033). After taking these correlations into consideration, the asymmetric confidence intervals indicated that the mediated effects at the within-person level [0, .013] and between-person level [-.006, .004] remained non-significant (recall that the asymmetric confidence interval provides a more accurate assessment of the significance of the mediated effect compared to the significance of the mediated effect stated above).

For the partnered sample, the results of the second model, shown in Table 11, indicated that at the within-person level, late morning fatigue significantly negatively predicted afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (a_w = -.006, p < .01). In turn, afternoon interpersonal enjoyment in the combined familial, friendship, and work domains significantly negatively predicted the levels of end-of-day fatigue, independent of late morning fatigue, at the within-person level (b_w = -1.803, p < .01). Finally, ratings of afternoon interpersonal enjoyment in the combined familial, friendship, and work domains significantly mediated the relation between the late morning and end-of-day fatigue at the within-person (ab_w = .010, p < .05). In contrast to the within-person level, at the between-person level, there was neither a significant relation of late morning fatigue to afternoon enjoyment in the combined familial, friendship, and work domains (a_b = -.007, p > .10), nor a significant relation of afternoon enjoyment to end-of-day fatigue, independent of late morning fatigue (b_b = -.976, p > .10). As a consequence, the mediation effect from late morning to end-of-day fatigue through afternoon enjoyment was not significant at the between-person level (ab_b = .007 p > .10). The correlation between the *a* and *b* paths was positive at the within-person level (.065) but negative at the between-person level (-.168). After taking these correlations into consideration, the asymmetric confidence interval indicated that the mediated effect at the within-person level remained significant [.002, .023] while the mediated effect at the between-person level remained non-significant [-.014, .031].

Within-person relations among late morning fatigue, afternoon interpersonal enjoyment in the combined familial, friendship, and work domains and end-of-day fatigue observed in the partnered sample were replicated in the third model with the

unpartnered sample, as shown in Table 12. Late morning fatigue significantly negatively predicted afternoon interpersonal enjoyment in the combined familial, friendship, and work domains at the within-person level (a_w = -.005, p < .05). In turn, interpersonal enjoyment significantly negatively predicted end-of-day fatigue, independent of late morning fatigue, at the within-person level (b_w = -1.997, p < .01). Afternoon interpersonal enjoyment in the combined familial, friendship, and work domains significantly mediated the relation between afternoon and end-of-day fatigue at the within-person level (ab_w = .010 p < .05). At the between-person level, late morning fatigue significantly negatively predicted afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (a_b = -.017 p < .001). However, afternoon interpersonal enjoyment in the combined familial, friendship, and work domains was unrelated to end-of-day fatigue, independent of late morning fatigue, at between-person level (b_b = .441, p > .10). As a result, afternoon interpersonal enjoyment in the combined familial, friendship, and work domains did not significantly mediate the relation between the levels of afternoon and end-of-day fatigue at the between-person level (ab_b = -.008 p > .10). The correlation between the *a* and *b* paths was positive at the within-person level (.037) and at the between-person level (.032). After taking the correlations into consideration, the asymmetric confidence interval indicated that the mediated effect at the within-person level remained significant [.002, .022], while the mediated effect at the between-person level remained non-significant [-.069, .053].

Multilevel Structural Equation Modeling of Relation from Late Morning Fatigue to Afternoon Interpersonal Enjoyment to End-of-day Fatigue, with Interpersonal Stress Controlled

To investigate whether afternoon interpersonal enjoyment uniquely predicted end-of-day fatigue, Models 4 through 6 included afternoon interpersonal stress as a covariate that predicted end-of-day fatigue. Additionally, interpersonal stress and enjoyment were allowed to correlate. The remainder of model specification was identical to that in Models 1 through 3. Again results are presented for the within-person aspect of each model first, followed by the between-person component of the same model. Fit indices are also presented for these models, since the models are not fully saturated.

Table 13 provides the model addressing enjoyment in the spousal domain in the partnered sample with stress added, and parallels Model 1 presented in Table 10 without the stress covariate. Model results with the stress covariate included replicated those without this covariate. Consistent with within-person results in the original model of Table 10, the within-person path from late morning fatigue to afternoon spousal enjoyment was significant and negative (a_w = -.004, p < .05). The within-person path from spousal enjoyment to end-of-day fatigue was also significant and negative (b_w = -1.030, p < .05). Although these two individual paths were significant, the mediated path was not significant (ab_w = .004 p > .10). As in Model 1 without stress (Table 10), the asymmetric confidence interval on the mediated effect had a lower bound of zero. The between-person results with stress included replicated those without the stress covariate as well. There was marginal significant path from morning fatigue to afternoon enjoyment (a_b = -.007, p < .10), but a non-significant path from afternoon enjoyment to

end-of-day fatigue (b_b = -1.195, p > .10). The mediated path did not reach significance (ab_b = .009 p > .10), as also confirmed by the asymmetric confidence interval. The ratings of afternoon interpersonal stress in the spousal domain were unrelated to the levels of end-of-day fatigue at both the within-person (b_{covw} = 0.042, p > .10) and between-person (b_{covb} = 1.192, p > .10) levels. With stress in the model, the correlation between the *a* and *b* paths was positive at the within-person (.033) and the between-person (.085) levels. After taking the correlations into consideration, the asymmetric confidence intervals indicated that the mediated effects at the within-person level [0, .011] and between-person level [-.011, .039] remained non-significant. The fit indices: Comparative Fit Index (CFI = 1.00) and Root Mean Square Error of Approximation (RMSEA = 0.000) for the overall model, and Standardized Root Mean Square Residual at the within-person (SRMR = .008) and at the between-person (SRMR = .016) levels indicated good fit based on both Hu and Bentler (1999) and Hsu (2009) recommended cutoff values.

Table 14 provides the model addressing enjoyment in the combined familial, friendship and work domains in the partnered sample with stress as a covariate, and parallels Model 2 presented in Table 11 without the stress covariate. Model results with the stress covariate included replicated those without this covariate. Consistent with the original model of Table 11, the path from late morning fatigue to afternoon enjoyment was significant and negative (a_w = -.006, p < .01). The path from afternoon enjoyment to end-of-day fatigue was also significant and negative (b_w = -2.035, p < .01). Replicating the original finding for Model 2, the mediated path was also significant (ab_w = .013, p < .05). As in the original finding for Model 2, there were no significant relations at the

between-person level, with a_b = -.005, p > .10; b_b = -.491, p > .10, and the mediated path did not reach significance (ab_b = .002, p > .10). The ratings of afternoon interpersonal stress in the combined familial, friendship, and work domains significantly negatively predicted end-of-day fatigue at the within-person level (b_{covw} = -.866, p < .05). However, the ratings of afternoon interpersonal stress in the combined familial, friendship, and work domains were unrelated to the levels of end-of-day fatigue at the between-person level (b_{covb} = 1.322, p > .10). With stress in the model, the correlation between the *a* and *b* paths was positive at the within-person (.050) but negative at the between-person (-.241) levels. After taking the correlations into consideration, the asymmetric confidence interval indicated that the mediated effect at the within-person level remained significant [.003, .025] and the mediated effect at the between-person levels remained non-significant [-.019, .020]. The fit indices were as follows: Comparative Fit Index (CFI = .998) and Root Mean Square Error of Approximation (RMSEA = .017) for the overall model, and Standardized Root Mean Square Residual at the within-person (SRMR = .017) and at the between-person (SRMR = .060) levels indicated good fit based on Hu and Bentler (1999) recommended cutoff values. All the indices, except SRMR at the between-person level, also indicated good fit based on Hsu (2009) recommended cutoff values.

Table 15 provides the model addressing interpersonal enjoyment in the combined familial, friendship and work domains in the unpartnered sample with the stress covariate, and parallels Model 3 presented in Table 12 without the stress covariate. Model results with the stress covariate included replicated those without this covariate. Consistent with the original model of Table 12, the within-person path from late morning

fatigue to afternoon enjoyment was significant and negative (a_w = -.005, p < .05). The within-person path from afternoon enjoyment to end-of-day fatigue was also significant and negative (b_w = -1.854, p < .01). The within-person mediated path was marginally significant (ab_w = .009, p < .10). As in the original finding for Model 3, there was a significant relation between late morning fatigue and afternoon enjoyment at the between-person level, with a_b = -.013, p < .001, but no significant relation between afternoon enjoyment and end-of-day fatigue, with b_b = .397, p > .10. The mediated path did not reach significance at the between-person level (ab_b = -.005, p > .10). The ratings of afternoon interpersonal stress in the combined familial, friendship, and work domains were unrelated to end-of-day fatigue at the within-person (b_{covw} = 0.383, p > .10) and between-person (b_{covb} = 0.234, p > .10) levels. With stress in the model, the correlation between the *a* and *b* paths was positive at both the within-person (.019) and between-person (.135) levels. After taking these correlations into consideration, the asymmetric confidence interval indicated that the mediated effect at the within-person was significant [.001, .021], and the mediated effect at the between-person level remained non-significant [-.056, .051]. Again, the asymmetric confidence interval provides a more accurate indication of mediation than does the statistical test of the *ab* path. The fit indices were as follows: Comparative Fit Index (CFI = .986) and Root Mean Square Error of Approximation (RMSEA = .044) for the overall model, and Standardized Root Mean Square Residual at the within-person (SRMR = .006) and at the between-person (SRMR = .148) levels. All the indices, except SRMR at the between-person level indicated good fit based on both Hu and Bentler (1999) and Hsu (2009) recommended cutoff values.

Multilevel Mediation Models with Random Slopes

In the previous analyses, the multilevel mediation models were specified to only contain random intercepts. However, in addition to random intercepts, it is possible that these models might contain random slopes. In other words, the magnitude and direction of the relation between late morning fatigue and afternoon interpersonal enjoyment might vary from person to person – the *a* path of the mediation models. In addition, the relation between enjoyment and end-of-day fatigue might also fluctuate from person to person – the *b* path of the models. Finally, the mediating relation from late morning fatigue to enjoyment to end-of-day fatigue might also vary from person to person – the *ab* path of the models. In order for the *ab* path to exhibit random slopes, the *a* and *b* paths have to exhibit random slopes. Although all paths in the models could be specified to have random intercepts and random slopes, the complexity of such models might not be necessary and might decrease the probability of model convergence. Therefore, a piecewise approach was used to test each path independently for random slopes as the preliminary step. According to the results of piecewise investigation, random slopes would be estimated in certain path(s) in the MSEM framework in which all paths in the mediation models would be estimated simultaneously.

The piecewise strategy contained three steps: (1) test the significance of random slopes in the *a* path, (2) test the significance of random slopes in *b* path, and finally (3) if both the *a* and *b* paths were significant, test the significance of random slopes in *ab* path. These analyses were conducted in SAS PROC MIXED (Littell et al., 1996). The within-person predictor was represented by the person-centered deviation scores of the predictor on each day from the mean across days, computed separately for each participant (e.g.,

for each participant, late morning fatigue each day minus the arithmetic mean late morning fatigue across the whole diary for that participant) (Kreft, De Leeuw, & Aiken, 1995).

The following paragraphs delineate the detail of the research question, the multilevel regression model, and the findings in each step in each mediation model. In the multilevel regression models, deviation scores were signified with the Greek letter Δ. Late morning fatigue at the within-person level was referred to as $\Delta \text{Fatigue}_{\text{late morning}}$ .and afternoon interpersonal enjoyment at the within-person level in the spouse domain and the combined familial, friendship, and work domains were referred to as $\Delta \text{IntEnjoy}_{\text{spouse}}$ and $\Delta \text{IntEnjoy}_{\text{famfrwk}}$, respectively. End-of-day fatigue was referred to as $\text{Fatigue}_{\text{end-of-day}}$ without the Δ notation, since the within-person outcome variable was left in raw score form. The equations associated with these steps are shown in equation form below, with notation for coefficients following that employed by Taylor, Davis and Zautra (2013). The random slope parameter is shown as Greek letter τ_{11}; this parameter is the variance of the slope estimates of the individual participants.

The first mediation model was divided into two research questions asked in two steps for the partnered sample: (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the spousal domain (the *a* path) exhibited random slopes, and (2) whether the within-person path from afternoon interpersonal enjoyment in spousal domain to end-of-day fatigue controlling for late morning fatigue at the within-person level exhibited random slopes (the *b* path).

Step 1: $\text{IntEnjoy}_{\text{spouse}} = \beta_0 + \beta_1 \Delta \text{ Fatigue}_{\text{late morning}} + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta \text{ IntEnjoy}_{\text{spouse}} + \beta_2 \Delta \text{ Fatigue}_{\text{late morning}} + r$

The estimates and standard errors (in parentheses underneath the estimates) are shown in Tables 16 and 17. The estimates of τ_{11}, the variance of the random slopes, in both steps were not significant (step 1: $\tau_{11} = .000$, $p > .10$; step 2: $\tau_{11} = .000$, $p > .10$). Hence, the random slope parameters were not significant and the investigation of this mediation model was terminated at step 2.

The second mediation model was the same as the first mediation model, except that enjoyment in the combined familial, friendship, and work domains was examined for the partnered sample. The two steps within the partnered sample analyses included testing: (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (the *a* path) exhibited random slopes, and (2) whether the within-person path from afternoon interpersonal enjoyment in combined familial, friendship, and work domains to end-of-day fatigue controlling for late morning fatigue at the within-person level exhibited random slopes (the *b* path).

Step 1: $\text{IntEnjoy}_{\text{famfrwk}} = \beta_0 + \beta_1 \Delta \text{Fatigue}_{\text{late morning}} + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta \text{IntEnjoy}_{\text{famfrwk}} + \beta_2 \Delta \text{Fatigue}_{\text{late morning}} + r$

The estimates and standard errors (in parentheses underneath the estimates) are shown in Tables 18 and 19. The estimate of τ_{11} was significant in the first step ($\tau_{11} = .0001$, $p < .05$), but not in the second step ($\tau_{11} = .000$, $p > .10$). Since only one of the two paths showed significant random slopes, *ab* path was not tested for random slopes. However, whether the *a* path exhibited random slopes in the MSEM framework was further investigated.

The third mediation model was the same as the second mediation model, except that it was the examination of fatigue-enjoyment relations for the unpartnered sample. The two steps within the unpartnered sample analyses included testing: (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (the *a* path) exhibited random slopes, and (2) whether the within-person path from afternoon interpersonal enjoyment in combined familial, friendship, and work domains to end-of-day fatigue controlling for late morning fatigue at the within-person level exhibited random slopes (the *b* path).

Step 1: $\text{IntEnjoy}_{\text{famfrwk}} = \beta_0 + \beta_1 \Delta \text{Fatigue}_{\text{late morning}} + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta \text{IntEnjoy}_{\text{famfrwk}} + \beta_2 \Delta \text{Fatigue}_{\text{late morning}} + r$

The estimates and standard errors (in parentheses underneath the estimates) are shown in Tables 20 and 21. The estimates of τ_{11} in both steps were not significant (step 1: $\tau_{11} = .000$, $p > .10$; step 2: $\tau_{11} = .000$, $p > .10$). Hence, the random slope parameters were not significant, and the investigation of this mediation model was terminated at step 2.

Multilevel structural equation modeling of the relation of late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains to end-of-day fatigue for the partnered sample was tested. This model was the same as the second MSEM model discussed previously with one additional condition – the slope of the *a* path was specified as random allowing the relation from late morning fatigue to enjoyment to vary from person to person. However, this random slope model did not reach convergence.

Moderation of Within-person Relations by Between-person Differences in Late Morning Fatigue and Afternoon Interpersonal Enjoyment

Finally, the possibility that between-person components of fatigue and interpersonal enjoyment (specified as the arithmetic mean level of late morning fatigue and the arithmetic mean level of interpersonal enjoyment in each domain) moderated the within-person relations in the meditational chain from late morning fatigue to afternoon interpersonal enjoyment to end-of-day fatigue was explored. The analyses were divided into two sets that examined the following: (1) the moderating role of between-person late morning fatigue and (2) the moderating role of between-person afternoon interpersonal enjoyment. Each set of analyses included the moderation analysis of each of the original mediation models: spousal enjoyment in the partnered sample; combined familial, friendship, and work enjoyment in the partnered sample; and combined familial, friendship, and work enjoyment in the unpartnered sample.

To test each moderated-mediation model, a piecewise strategy was adopted that considered moderation of each path in the model separately. In Step 1, the role of the moderator on the *a* path, (i.e., the path representing the influence of late morning fatigue on afternoon interpersonal enjoyment), was tested. In Step 2, the role of the moderator on the *b* path, (i.e., the path representing the influence of afternoon interpersonal enjoyment on end-of-day fatigue), was tested. Each test of moderation is a test of a cross-level interaction. Finally, in any instance in which the cross-level interacting effects of the moderator on both the *a* and *b* paths were significant, the moderation of the mediated *ab* path, (i.e., the path representing the mediating role of afternoon interpersonal enjoyment in the relation between late morning and end-of-day fatigue) was tested.

However, if moderation of either the *a* or *b* path was non-significant, then testing for moderation of the mediated path was not warranted. All the models in this section were specified as fixed slope, random intercept models. These analyses were tested in SAS PROC MIXED (SAS Institute, Cary, NC, USA). If a cross-level interaction was not significant, no further examination of the moderation of this path was required; in this case, the value of the within-person regression coefficient (*a* or *b* path) remained as the within person coefficient in the original models without cross-level interactions. In any instance in which a cross-level interaction was significant, post hoc probing of the interaction was carried out according to Aiken and West (1991) to determine the magnitude and direction of the within-person path across the range of the between-person moderator. Simple slopes of the outcome on the predictor at various levels of the moderator were computed.

In each step of the cross-level analysis, the between-person moderator was represented by the arithmetic mean of all available ratings of the moderating variable across the diary days (i.e. one mean score per person). The within-person predictor was represented by the person-centered deviation scores of the predictor on each day from the mean across days, computed separately for each participant (e.g., for each participant, late morning fatigue each day minus the arithmetic mean late morning fatigue across the whole diary for that participant). In other words, even though the moderator and predictor were based on the same variable, the total variance of a variable was partitioned into two orthogonal components, the between-person variance and the within person variance. The distinct within-person versus between-person computed scores (i.e., within person deviations from the person mean versus the person mean itself) were allowed to

interact in predicting the outcome at the within-person level (i.e., end-of-day fatigue rating generated by subtracting late morning from end-of-day fatigue on each day in the diary).

The following paragraphs delineate the detail of the research question, the multilevel regression model, and the findings in each step in each moderated-mediation model. In the multilevel regression models, the notation was the same as in the random slope presentation given above. Recall that deviation scores were signified with the Greek letter Δ. Late morning fatigue at the within-person level was referred to as $\Delta \text{Fatigue}_{\text{late morning}}$ .and afternoon interpersonal enjoyment at the within-person level in the spouse domain and the combined familial, friendship, and work domains were referred to as $\Delta \text{IntEnjoy}_{\text{spouse}}$ and $\Delta \text{IntEnjoy}_{\text{famfrwk}}$, respectively. End-of-day fatigue was referred to as $\text{Fatigue}_{\text{end-of-day}}$ without the Δ notation, since the within-person outcome variable was left in raw score form. The moderators, arithmetic mean late morning fatigue, afternoon spousal enjoyment, and combined familial, friendship, and work enjoyment were referred to as "mean $\text{Fatigue}_{\text{late morning}}$", "mean $\text{IntEnjoy}_{\text{spouse}}$", and "mean $\text{IntEnjoy}_{\text{famfrwk}}$", respectively.

The first moderated-mediation model was carried out in two steps within the partnered sample to test: (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the spousal domain (the *a* path) was moderated by between-person late morning fatigue, and (2) whether the within-person path from afternoon interpersonal enjoyment in the spousal domain to end-of-day fatigue controlling for late morning fatigue at the within-person level (the *b* path) was moderated by between-person late morning fatigue. The equations for the steps were as follows:

Step 1: $\text{IntEnjoy}_{\text{spouse}} = \beta_0 + \beta_1 \Delta\ \text{Fatigue}_{\text{late morning}} + \beta_2\ \text{mean Fatigue}_{\text{late morning}}$

$+ \beta_3\ (\Delta\text{Fatigue}_{\text{late morning}})*(\text{mean Fatigue}_{\text{late morning}}) + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta\ \text{IntEnjoy}_{\text{spouse}} + \beta_2\ \text{mean Fatigue}_{\text{late morning}}$

$+ \beta_3\ (\Delta\text{IntEnjoy}_{\text{spouse}})*(\text{mean Fatigue}_{\text{late morning}}) + \beta_4 \Delta\ \text{Fatigue}_{\text{late morning}} + r$

The findings shown in Table 22 and 23 indicated that neither of the cross-level interaction effects was significant. Hence, the investigation of this moderated-mediation model was terminated at step 2.

Cross-level analysis of the second moderated-mediation model for the partnered sample examined moderation with the same two steps, testing: (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains was moderated by late morning fatigue at the between-person level (the *a* path), and (2) whether the within-person path from afternoon interpersonal enjoyment in the combined familial, friendship, and work domains to end-of-day fatigue controlling for late morning fatigue (the *b* path) was moderated by late morning fatigue at the between-person level.

Step 1: $\text{IntEnjoy}_{\text{famfrwk}} = \beta_0 + \beta_1 \Delta\ \text{Fatigue}_{\text{late morning}} + \beta_2\ \text{mean Fatigue}_{\text{late morning}}$

$+ \beta_3\ (\Delta\ \text{Fatigue}_{\text{late morning}})*(\text{mean Fatigue}_{\text{late morning}}) + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta\ \text{IntEnjoy}_{\text{famfrwk}} + \beta_2\ \text{mean Fatigue}_{\text{late morning}}$

$+ \beta_3\ (\Delta\ \text{IntEnjoy}_{\text{famfrwk}})*(\text{mean Fatigue}_{\text{late morning}}) + \beta_4 \Delta\ \text{Fatigue}_{\text{late morning}} + r$

The findings shown in Table 24 and 25 indicated that neither of the cross-level interaction effects was significant. Hence, the investigation of this moderated-mediation model was terminated at step 2.

The third moderated-mediation model for the unpartnered sample was examined with the same two steps, testing: (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains was moderated by late morning fatigue at the between-person level (the *a* path), and (2) whether the within-person path from afternoon interpersonal enjoyment in the combined familial, friendship, and work domains to end-of-day fatigue controlling for late morning fatigue at the within-person level (the *b* path) was moderated by late morning fatigue at the between-person level.

Step 1: $\text{IntEnjoy}_{\text{famfrwk}} = \beta_0 + \beta_1 \Delta\ \text{Fatigue}_{\text{late morning}} + \beta_2\ \text{mean Fatigue}_{\text{late morning}}$

$+ \beta_3\ (\Delta\ \text{Fatigue}_{\text{late morning}})*(\text{mean Fatigue}_{\text{late morning}}) + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta\ \text{IntEnjoy}_{\text{famfrwk}} + \beta_2\ \text{mean Fatigue}_{\text{late morning}}$

$+ \beta_3\ (\Delta \text{IntEnjoy}_{\text{famfrwk}})*(\text{mean Fatigue}_{\text{late morning}}) + \beta_4\ \Delta\ \text{Fatigue}_{\text{late morning}} + r$

The findings shown in Table 25 and 26 indicated that neither of the cross-level interaction effects was significant. Hence, the investigation of this moderated-mediation model was terminated at step 2.

The examination of moderation of within-person paths by between-person differences was repeated with between-person average afternoon enjoyment as the moderator. The fourth moderated-mediation model was examined in the partnered sample in two steps, determining: (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the spousal domain (the *a* path) was moderated by between-person afternoon interpersonal enjoyment in the spousal domain, and (2) whether the within-person path from afternoon interpersonal enjoyment in the spousal domain to end-of-day fatigue controlling for late morning fatigue at the within-

person level (the *b* path) was moderated by between-person afternoon interpersonal enjoyment in the spousal domain.

Step 1: $\text{IntEnjoy}_{\text{spouse}} = \beta_0 + \beta_1 \Delta \text{ Fatigue}_{\text{late morning}} + \beta_2 \text{ mean IntEnjoy}_{\text{spouse}}$

$+ \beta_3 (\Delta \text{ Fatigue}_{\text{late morning}})*(\text{mean IntEnjoy}_{\text{spouse}}) + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta \text{ IntEnjoy}_{\text{spouse}} + \beta_2 \text{ mean IntEnjoy}_{\text{spouse}}$

$+ \beta_3 (\Delta \text{ IntEnjoy}_{\text{spouse}})*(\text{mean IntEnjoy}_{\text{spouse}}) + \beta_4 \Delta \text{ Fatigue}_{\text{late morning}} + r$

The findings shown in Table 28 and 29 indicated that only the cross-level interaction effect at step 2 (cross-level interaction at "b" path) was significant. Hence, no test for moderation of the mediated effect was performed.

The significant cross-level interaction in step 2 was probed with by computing simple regression equations of within-person end-of-day fatigue on afternoon spousal enjoyment at three levels of between-person spousal enjoyment. Figure 6 depicts the simple slopes showing the moderating role of spousal enjoyment at between-person level on the relation between fluctuations in spousal enjoyment reported in the afternoon and fatigue reported in the end-of-day. In Figure 6, the three regression lines for three between-person values of average, high, and low interpersonal enjoyment represent the regression of end-of-day fatigue (Y axis) on centered within-person afternoon spousal enjoyment (X-axis) at the arithmetic mean between-person afternoon spousal enjoyment, enjoyment one standard deviation above the mean of between-person enjoyment, and one standard deviation below the mean of between-person enjoyment, respectively.

The simple slope analyses reveal two main findings (1) On days in which spousal enjoyment was very low (within-person), there was no difference in level of fatigue as a function of average spousal enjoyment (between-person). As the level of within day

spousal enjoyment increased (within-person), the level of end-of-day fatigue diverged across levels of between-person spousal enjoyment. The direction of the difference was as follows: highest fatigue at low average spousal enjoyment and lowest fatigue at high spousal enjoyment, with fatigue at average spousal enjoyment between the two more extreme levels of average spousal enjoyment. (2) Regarding the slopes, the relation between fluctuations in within-person spousal enjoyment and within-person fatigue was strongly negative at a high value of between-person spousal enjoyment. Put another way, end-of-day fatigue decreased as within-day spousal enjoyment increased at high average spousal enjoyment. In contrast, at a low level of between-person spousal enjoyment, within-person end-of-day fatigue did not decrease as within-person daily spousal enjoyment increased. In fact, within person daily fatigue remained high regardless of the level of within-person daily spousal enjoyment when between-person spousal enjoyment was low. At the arithmetic mean level of spousal enjoyment, the regression of end-of-day fatigue on within-person level of spousal enjoyment was also negative. At the arithmetic mean between-person level of spousal enjoyment, the relationship of daily spousal enjoyment to end-of day fatigue resembled the relationship at high between-person spousal enjoyment.

The fifth moderated-mediation model was carried out in two steps for the partnered sample to test (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (the *a* path) was moderated by between-person afternoon interpersonal enjoyment in the combined familial, friendship, and work domains, and (2) whether the within-person path from afternoon interpersonal enjoyment in the combined familial,

friendship, and work domains to end-of-day fatigue controlling for late morning fatigue at the within-person level (the *b* path) was moderated by the between-person afternoon interpersonal enjoyment in the combined familial, friendship, and work domains.

Step 1: $\text{IntEnjoy}_{\text{famfrwk}} = \beta_0 + \beta_1 \Delta\ \text{Fatigue}_{\text{late morning}} + \beta_2\ \text{mean IntEnjoy}_{\text{famfrwk}}$

$+ \beta_3\ (\Delta\ \text{Fatigue}_{\text{late morning}})*(\text{mean IntEnjoy}_{\text{famfrwk}}) + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta\ \text{IntEnjoy}_{\text{famfrwk}} + \beta_2\ \text{mean IntEnjoy}_{\text{famfrwk}}$

$+ \beta_3\ (\Delta\ \text{IntEnjoy}_{\text{famfrwk}})*(\text{mean IntEnjoy}_{\text{famfrwk}}) + \beta_4 \Delta\ \text{Fatigue}_{\text{late morning}} + r$

The findings shown in Table 30 and 31 indicated that neither of the cross-level interaction effects was significant. Hence, the investigation of this moderated-mediation model was terminated at step 2.

The sixth moderated-mediation model was carried out in two steps for the unpartnered sample, testing: (1) whether the within-person path from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (the *a* path) was moderated by between-person afternoon interpersonal enjoyment in the combined familial, friendship, and work domains, and (2) whether the within-person path from afternoon interpersonal enjoyment in the combined familial, friendship, and work domains to end-of-day fatigue controlling for late morning fatigue (the *b* path) was moderated by between-person afternoon interpersonal enjoyment at the combined familial, friendship, and work domains.

Step 1: $\text{IntEnjoy}_{\text{famfrwk}} = \beta_0 + \beta_1 \Delta\ \text{Fatigue}_{\text{late morning}} + \beta_2\ \text{mean IntEnjoy}_{\text{famfrwk}}$

$+ \beta_3\ (\Delta\ \text{Fatigue}_{\text{late morning}})*(\text{mean IntEnjoy}_{\text{famfrwk}}) + r$

Step 2: $\text{Fatigue}_{\text{end-of-day}} = \beta_0 + \beta_1 \Delta\ \text{IntEnjoy}_{\text{famfrwk}} + \beta_2\ \text{mean IntEnjoy}_{\text{famfrwk}}$

$+ \beta_3\ (\Delta\ \text{IntEnjoy}_{\text{famfrwk}})*(\text{mean IntEnjoy}_{\text{famfrwk}}) + \beta_4 \Delta\ \text{Fatigue}_{\text{late morning}} + r$

The findings shown in Table 32 and 33 indicated that neither of the cross-level interaction effects was significant. Hence, the investigation of this moderated-mediation model was terminated at step 2.

In sum, there was little evidence of cross-level moderation of within-person relations by between-person characteristics of average late morning fatigue and average afternoon enjoyment. Only one of twelve cross-level interactions reached significance—the moderation of the within-person relation of spousal enjoyment to end-of-day fatigue by the average level of spousal enjoyment.

It is worth noting that the end-of-day measure of fatigue assessed participants' overall fatigue on that day as described in the method section. Therefore, the measure was not a pure measure of end-of-day experience (which would have included only fatigue felt after participants responded to their late morning diaries). To ensure the conclusions of the analyses conducted remained the same when a pure measure of end-of-day experience was used, this study obtained a pure end-of-day fatigue that only measured the experiences during the period from the afternoon to the end-of-day of that day by subtracting late morning fatigue from the end-of-day fatigue. This different score was called evening fatigue. All the analyses described above were repeated by using this pure measure of end-of-day measure of fatigue (i.e. evening fatigue) as the outcome variable. Findings confirmed that all conclusions remained. The results were reported in Table 34-62 in Appendix A.

Chapter 4

DISCUSSION

The current study examined the interplay between the experience of fatigue and enjoyment of interpersonal interactions in 176 women with fibromyalgia (FM). A mediational chain was hypothesized from late morning fatigue to afternoon interpersonal enjoyment to end-of-day fatigue. Daily diary data included assessment of target variables at three distinct points during the day. First, in the late morning, late morning fatigue was assessed; second, in the afternoon, afternoon interpersonal enjoyment was assessed. Finally, at the end of each day, end-of-day fatigue was assessed. These within-day measures, collected over 21 days, permitted an analysis of hypothesized relationships at the individual within-person level over the course of each day as the day unfolded, which was the primary focus of this study (within-person mediation model). Beyond addressing the primary aim, this study also conducted three sets of exploratory analyses. First, this study explored whether the magnitude or possibly direction of the relations from late morning fatigue to afternoon interpersonal enjoyment, and from afternoon interpersonal enjoyment to end-of-day fatigue varied across persons. Second, for each participant, average summary scores collapsed across her whole diary were computed on the variables of interest. These summary scores served as individual difference measures and permitted an exploration of whether the within-person relationships were moderated by between-person individual differences. Specifically, moderation of the within-person relationships from late morning fatigue to afternoon interpersonal enjoyment and from afternoon interpersonal enjoyment to end-of-day fatigue by between-person differences in these same variables was examined in cross-level interaction models. Third, the study

explored whether the same hypothesized relationships held between individuals, that is, whether individual differences in late morning fatigue related to individual differences in afternoon enjoyment, and whether individual differences in afternoon enjoyment related to individual differences in end-of-day fatigue. Finally, the study also explored whether the mediational chain hypothesized at the within-person level was also supported at the between-person level (between-person mediation model).

The following sections first summarize findings of two sets of analyses that examined the primary hypothesized mediational relationship at the within-person level: (1) multilevel structural equation models (MSEMs) of the relation from late morning fatigue to afternoon interpersonal enjoyment to end-of-day fatigue at the within-person level, with random intercepts but fixed slopes specified in the model; and (2) MSEMs of these same relationships at the within-person level controlling for afternoon interpersonal stress at the within-person level to provide support for the unique contribution of interpersonal enjoyment to fatigue in FM. This summary of findings is followed by the findings of three sets of exploratory analyses: (1) multilevel models with random slopes estimated in addition to random intercepts to explore the possibility of individual differences in the magnitude and possibly direction of relationships from late morning fatigue to afternoon interpersonal enjoyment to end-of-day fatigue at the within-person level; (2) moderation of within-person relations by between-person differences in late morning fatigue and afternoon interpersonal enjoyment; and (3) multilevel structural equation models (MSEMs) with random intercepts and fixed slopes of relation from late morning fatigue to afternoon interpersonal enjoyment to end-of-day fatigue at the between-person level.

Two distinct categories of social interactions were considered: interactions with one's spouse, and interactions with other family members, friends, and co-workers. Of the 176 participants, 102 had a spouse/partner (58%) and 74 did not have a spouse/partner (42%). All analyses were carried out separately on the partnered and unpartnered participants. Among partnered individuals, analyses were carried out separately for enjoyment in the spousal domain and in the combined familial, friendship, and work domains. The analysis of the mediational role of enjoyment in the combined familial, friendship, and work domains was replicated among unpartnered individuals.

Summary of Findings from the Primary Analyses

Multilevel Structural Equation Modeling with Random Intercepts and Fixed Slopes of Relation from Late Morning Fatigue to Afternoon Interpersonal Enjoyment to End-of-day Fatigue at the Within-person Level

Three hypotheses addressed within-person relations from late morning fatigue to afternoon enjoyment to end-of-day fatigue.

3. On days on which FM patients experience elevated late morning fatigue, relative to their own average late morning fatigue, they would experience lower levels of afternoon interpersonal enjoyment on that day.
4. On days on which FM patients experience lower levels of afternoon interpersonal enjoyment, relative to their own average afternoon interpersonal enjoyment, they would experience higher degrees of end-of-day fatigue on that day.

5. The day-to-day fluctuations of afternoon interpersonal enjoyment would mediate the relation between late morning and end-of-day fatigue on a daily basis.

The MSEMs for addressing these research questions were specified as fully saturated models. Thus, no fit indices were available. The results of MSEMs at the within-person level were consistent with all three hypotheses in the combined familial, friendship, and work domains for both partnered and unpartnered FM patients. Late morning fatigue was significantly negatively related to afternoon enjoyment. Controlling for late morning fatigue, afternoon interpersonal enjoyment in the combined familial, friendship, and work domains was negatively related to end-of day fatigue. The hypothesized mediational path was significant for both partnered and non-partnered individuals. In the spousal domain, the negative relationship from late morning fatigue to afternoon enjoyment and the negative relationship from afternoon enjoyment to end-of-day fatigue were also observed. The trend of the overall mediational path was manifested, though not significant. These findings strongly support a mediating role of afternoon interpersonal enjoyment in the combined familial, friendship, and work domains in the relation between late morning and end-of-day fatigue at the within-person level. The results for enjoyment in the spousal domain are ambiguous in that both paths of the mediation model were significant and in the predicted direction, but the mediated path did not reach significance.

A close inspection of these three models suggests that while the mediation pattern in the spousal domain closely resembles the mediation pattern in the combined familial, friendship, and work domains, the effect size may be smaller in the spousal domain than

in the combined familial, friendship, and work domains. Statistical power in the repeated measures multilevel framework is determined by three factors: the statistical significance criterion (Type 1 error); the sample size, which is a combination of the number of clusters (i.e., number of individual participants) and cluster size (i.e., the number of observations per individual); and effect size. The statistical significance criterion was held constant at alpha = .05 across all models. The number of clusters was constant across the two enjoyment domains for the partnered sample (n=102), which was larger than the number of clusters in the unpartnered sample (n=74). Further, the actual number of responses to the question of afternoon enjoyment in the spousal domain (1064 observations) was slightly larger than the number in the combined familial, friendship, and work domains (1010 observations) in the partnered sample, and in the combined familial, friendship, and work domains (844 observations) in the unpartnered sample. Thus it appears that the effect size must be smaller for the spousal domain. The case is more apparent by comparing the model of the spousal domain with the model of the combined familial, friendship, and work domains domain in the unpartnered sample. The partnered sample had a much larger number of individuals and repeated measures than the unpartnered sample. The fact that the mediation path lacked significance in the spousal domain whereas it was significant in the combined familial, friendship, and work domains in the unpartnered sample indicates that the effect size may be smaller in the former than the latter. A direct comparison of the effect sizes across models requires either knowing the standardized solution of the model or calculating it based on the magnitude of the effect and its standard error. However, a standardized solution for MSEM is unavailable in Mplus verion 7.0. Additionally, the way in which Mplus takes the asymmetrical

distribution of the *ab* path and the values of correlation between the *a* and *b* paths into consideration when calculating the standard error of the mediated path is not yet publically available, to my knowledge. Hence, a formal test of the difference in effect sizes between the spousal domain and the combined familial, friendship, and work domains awaits future investigation.

The possible difference in effect sizes is noteworthy because if the effect size were actually smaller in the spousal domain than the combined familial, friendship, and work domains, it may indicate that the influence of spousal enjoyment may be more complex than the enjoyment derived from the combined familial, friendship, and work domains in relation to fatigue. According to the widely accepted operant model of chronic pain, social support is a double-edged sword (e.g., Fordyce, Shelton, & Dundore, 1982; Hadjistavropoulos et al, 2011; Turk, Kerns, & Rosenberg, 1992). The positive attention resulting from solicitous behaviors from caregivers may reinforce maladaptive symptom coping and is associated with increases in pain and disability. Among partnered patients, their partners tend to be the primary caregivers. It is plausible that one of the determinants of perceived spousal enjoyment is spousal solicitation. Hence, consistent with the operant model, spousal enjoyment may not always reduce disability or symptoms, including fatigue. It is true that family members may be the primary caregivers among unpartnered patients. However, the combined domain includes friends and co-workers as well. Hence, the influence of a particular person may not be prominent when the patient "sums up" her perception of interpersonal enjoyment across many people in the combined domain. If evidence were to be found in support for this logic, it would be important to examine interpersonal enjoyment derived from the

primary caregiver separately from other social network members in the study of fatigue in FM.

It was important to take into account the experience of interpersonal stress when considering the relationship of interpersonal enjoyment to end-of-day fatigue. To this end, the initial within-person mediation models were repeated, including day-to-day fluctuations in perceived stress of interpersonal relations in addition to afternoon interpersonal enjoyment predicting end-of-day fatigue. These analyses yielded three well-fitting models. All findings concerning the role of afternoon enjoyment in predicting end-of-day fatigue, as well as the tests of mediation reported above were replicated when interpersonal stress was controlled. These results indicate that interpersonal enjoyment is not simply the inverse of interpersonal stress (i.e., interpersonal enjoyment and stress are two inversely related, yet unique constructs in predicting fatigue at a subsequent time).

Summary of Findings from the Exploratory Analyses

Multilevel Mediation Models with Random Slopes

Random slopes analyses were employed to investigate whether the within-person relations between late morning fatigue and afternoon interpersonal enjoyment (*a* path), and afternoon interpersonal enjoyment and end-of-day fatigue (*b* path) varied across participants. Among six tests of random slopes (*a* path and *b* path for partnered individuals in the spouse domain and for both partnered and unpartnered individuals in the combined familial, friendship, and work domains), there was evidence of variation in random slopes across individuals for a single slope. Among partnered participants, random slopes were evidenced in the within-person relation path from late morning

fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains.

This finding suggests that some individuals among the partnered patients are more resilient than others when confronting morning fatigue. A significant random slope finding in the *a* path indicates that the magnitude and possibly direction of the relation between fluctuation of late morning fatigue and afternoon interpersonal enjoyment in the combined familial, friendship, and work domains vary across individuals. To elaborate, a flat or positive slope linking late morning fatigue with afternoon interpersonal enjoyment in the combined familial, friendship, and work domains characterizes the resilient patients who can sustain interpersonal enjoyment in the combined familial, friendship, and work domains even on days with high morning fatigue. In contrast a negative slope characterizes the less resilient patients who lose the ability to experience interpersonal enjoyment in the combined familial, friendship, and work domains on days with high morning fatigue.

It is valuable to identify plausible individual differences (level-2 predictors in multilevel modeling terminology) that may predict the magnitude and direction of the slopes. For instance, partners' ability to encourage the patients to adopt adaptive coping strategies to manage symptoms may be a good predictor. To illustrate, evidence in this study showed that increases in interpersonal enjoyment in the combined familial, friendship, and work domains were associated with decreases in end-of-day fatigue, as reflected in the significant *b* path and non-significant random slopes of *b* path in the partnered sample. Hence, positive social engagement can be classified as an adaptive coping strategy. The more resilient patients may have partners who encourage them to

have an enjoyable visit with friends even on days with high morning fatigue. The "encouragement" may take a number of forms, e.g., by providing instrumental support such as taking care of household chores, or by not being too solicitous toward the patient on mornings with high fatigue. These patients may exhibit a zero or positive slope. In contrast, less resilient patients may have solicitous partners who urge more rest in the fact of elevated morning fatigue, thereby discouraging patients from having extended contact with friends on the patients' high fatigue days. As a result, even when the patients are having social engagements with their friends, the disapproval from their spouses hinders them to fully enjoy their social interactions. These patients may exhibit a negative slope. In general, successful identification of these individual differences distinguishing more from less resilient patients informs clinicians of the ingredients of resilience coping. Strategies to cultivate these stable resilience resources can be built into therapies for improving resilience coping for FM. For example, spouse-assisted coping skills training (CST) developed by Keefe and colleagues (1996) has demonstrated the efficacy of educating the spouses of chronic pain patients regarding how to identify effective coping strategies for the patients and how to facilitate the patients' use of these strategies. Spouse-assisted CST was found to promote both resilience outcomes, such as increases in patients' self-efficacy in coping and marital satisfaction, and decreases in levels of pain and disability (Keefe et al., 1999).

Moderation of Within-person Relations by Between-person Differences in Late Morning Fatigue and Afternoon Interpersonal Enjoyment

Cross-level interaction analyses were employed to explore whether within-person linkages from late morning fatigue to afternoon interpersonal enjoyment (*a* path) and

from afternoon enjoyment to end-of-day fatigue (*b* path) were moderated by individual differences in late morning fatigue. Parallel analyses explored moderation of the within-person *a* and *b* paths by individual differences in interpersonal enjoyment. Participants' average levels of late morning fatigue and afternoon interpersonal enjoyment served as between-person individual difference measures in these analyses. No cross-level interactions were found in the combined familial, friendship, and work domains for either partnered or unpartnered samples. In contrast, the linkage from afternoon interpersonal enjoyment in the spousal domain to end-of-day fatigue was moderated by partnered participants' average level of afternoon interpersonal enjoyment in the spousal domain.

The simple slope analysis clarified the nature of the significant moderation effect. Specifically, at a high level of average enjoyment from spousal interactions, level of enjoyment on a particular day was substantially negatively related to end-of-day fatigue on that day. The pattern at the moderate level of average enjoyment in the spousal domain closely resembled that for high average spousal enjoyment. In contrast, at low average enjoyment in the spousal domain (i.e., representing individuals who did not on average experience positive enjoyment from social interactions with their spouses), level of spousal enjoyment on a particular day had no relationship with end-of-day fatigue. These cross-level moderation analyses were exploratory in nature. Hence, no hypotheses were formulated. Post hoc examination of the significant moderation relation shown in Figure 6 indicates the value of individual difference in afternoon spousal enjoyment in moderating the day-to-day relation between afternoon spousal enjoyment and end-of-day fatigue.

Multilevel Structural Equation Modeling with Random Intercepts and Fixed Slopes of Relation from Late Morning Fatigue to Afternoon Interpersonal Enjoyment to End-of-day Fatigue at the Between-person Level

Beyond the analyses that involved the within-person relations among the variables, the last set of analyses assessed the relation from late morning fatigue to afternoon interpersonal enjoyment to end-of-day fatigue at the pure between-person level by asking the following questions without hypothesizing the directions of the relations:

4. Does individuals' average late morning fatigue experience relate to individuals' average afternoon interpersonal enjoyment?
5. Does individuals' average afternoon interpersonal enjoyment relate to individuals' average end-of-day fatigue?
6. Does individuals' average afternoon interpersonal enjoyment mediate the relation between person-average late morning and end-of-day fatigue?

The findings of this set of analyses did not show any significant linkages regarding the three research questions asked above in both the spousal domain and the combined familial, friendship, and work domains for both the partnered and unpartnered samples with one exception. For the unpartnered sample, late morning fatigue was significantly negatively related to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains. It is noted that the directions of relationships at the between-person level were all in the same direction as at the within-person level.

The null findings can be attributed to the lack of statistical power at the between-person level. Simple mediation analyses were conducted in SPSS on aggregated data (i.e., person-mean scores calculated for each construct in the mediation model) to shed

light on the statistical power issue at the between-person level. In the model for spousal social interaction in the partnered sample, late morning fatigue was not associated with afternoon interpersonal enjoyment (a_b = -.145, p > .10). Afternoon interpersonal enjoyment was marginally associated with end-of-day fatigue (b_b = -.063, p < .10). In the model of enjoyment in the combined familial, friendship, and work domains for partnered sample, late morning fatigue was not associated with afternoon interpersonal enjoyment (a_b = -.155, p > .10). Afternoon interpersonal enjoyment was also not associated with end-of-day fatigue (b_b = -.048, p > .10). In the model of enjoyment in the combined familial, friendship and work domains for the unpartnered sample, late morning fatigue was significantly associated with afternoon interpersonal enjoyment (a_b = -.445, p < .001). Afternoon interpersonal enjoyment was not associated with end-of-day fatigue (b_b = -.017, p > .10). The coefficient estimates are reported in a standardized metric. These standardized effect sizes allow us to determine the approximate sample sizes required for .80 power to detect the mediated effects in a mediation analysis that takes into account the asymmetric distribution of *ab* path and the correlation between *a* and *b* paths by using PRODCLIN (MacKinnon, Fritz, Williams, & Lockwood, 2007) – a program similar to RMediation. According to Fritz and MacKinnon (2007), the required samples size for the two models for the partnered sample are approximately 500 participants; for the model in the unpartnered sample, approximately 400 participants are required. Even though the sample sizes needed to achieve .80 power for the mediated effects may be different in MSEMs, these post hoc investigations of statistical power may still provide some insight in addressing the null findings at the between-person level, as the current

study only has 102 and 74 participants in the partnered and unpartnered sample, respectively.

Implications

The current findings build on earlier work documenting the day-to-day and within-day associations between aspects of social engagements and fatigue among individuals with chronic pain. One of the earliest investigations in this realm examined the association between changes in within-day fatigue (*via* controlling morning fatigue in evening fatigue) and end-of-day progress toward social-interpersonal goals in FM patients (Affleck et al., 1998; 2001). Their findings indicated that on days on which fatigue increased across the day, patients felt that fatigue interfered with progress toward their social goals. In this seminal work, the aspect of social engagement (i.e., progress toward social goals) was modeled as an outcome in relation to fatigue. From a clinical intervention perspective, the current findings together with existing work encourage the development of socially-oriented treatments that might reduce fatigue, which, in turn, may improve interpersonal functioning among FM patients.

More recent studies have included a focus on the occurrence of discrete daily positive events to elaborate the relation between aspects of social engagements and fatigue on daily basis among individuals in chronic pain (Parrish et al., 2008; Finan, Okun, Kruszewski, Davis, Zautra, & Tennen, 2010). Their findings indicated that daily increases in positive social interactions were associated with decreases in levels of fatigue on the same day. The contributions of these studies are two–fold. (1) They provided knowledge on one aspect of social engagement—the occurrence of daily positive interpersonal events—in relation to fatigue. (2) They initiated the effort to address an

important research question, that is, to what extent do aspects of social engagements promote resilient functioning by mitigating fatigue? In so doing, they afforded an additional perspective for targeted clinical intervention. It is noteworthy that both the predictor and the outcome in these studies were assessed at the end of the day. Thus, a more fine-grained approach that includes repeated assessments of aspects of social engagements and fatigue within day will allow evaluation of the temporal aspects of the social event-fatigue relation.

To move the field forward, it is important to examine within-day processes of fatigue. After all, fatigue exhibits a circadian rhythm. Researchers have suggested that fatigue has an endogenous rhythm that is consistent with our biological clock, which has evolved to maximize our opportunities to seize rewards in the environment (Watson, Wiese, Vaidya, & Tellegen, 1999). In healthy individuals, levels of fatigue were relatively low in the morning and continued to climb and reached their peaks between 6 to 9 PM in the evening (Watson et al., 1999). Individuals with chronic fatigue syndrome manifested a similar diurnal pattern, though their overall levels of fatigue were higher than among healthy individuals (Stone, Broderick, Porter, & Krupp, 1994). In the chronic pain literature, a study specifically targeting arthritis patients also detected a very similar cyclicity in fatigue. That is, levels of fatigue were lowest between 10 to 11 AM, and began to rise and peaked at around 9 PM, although differences in fatigue across the day only reached statistical significance in about 35% of their sample (Stone, Broderick, Porter, & Kaell, 1997). Fatigue is more prominent in FM than arthritis patients; thus it is plausible that a larger percentage of FM patients may experience the diurnal pattern in their fatigue than was evident among arthritis patients.

Building on the previous studies, the current study had two primary aims: (1) to fill the gap in the literature by examining within-day processes of fatigue and (2) to push forward the horizon that covers the relation between social engagements and fatigue. To address the first aim, this study assessed fatigue at its possibly lowest levels between 8 and 11 AM (reported at the late morning), and again at its possibly highest levels at around 7 PM (reported at the end-of-day fatigue) to capture the possible diurnal pattern of fatigue among FM patients in our sample. In addition, one aspect of social engagement was tested as a mediator in the relation between late morning and end-of-day fatigue. The *a* path in this mediation chain allowed the replication of the notion suggested in Affleck et al. (1998, 2001) that fatigue might negatively affect social engagement on a daily basis. The *b* path provided more solid evidence than previous studies regarding the influence of social engagement on fatigue. The examination of the mediational chain was achieved via the collection of multiple repeated measures within a day. The recent advancement in statistical methods provides researchers with a unique opportunity to test mediational chains at the within-person level by employing multilevel structural equation modeling. This fine-grained approach provides meaningful clues for developing efficacious interventions.

The second aim of the current study drew on one aspect of social engagement—interpersonal enjoyment. In the previous studies, participants responded to checklists of events that were defined *a priori* to be positive (e.g., had long conversation with spouse/partner or had a party or other social gathering with friends). The occurrence of social events was then tested in relation to fatigue (Parrish et al., 2008; Finan et al., 2010). However, these studies have not tapped into the quality of the relationship

resulting from the appraisal of the social contact. Thus, the current study investigated the daily fluctuations of a more proximal social resilience variable – interpersonal enjoyment that is the result of cognitive appraisal of social contact – in relation to daily fatigue.

Additionally, again from a clinical intervention perspective, it may be more important to examine the appraisal of the interpersonal contact than exposure to a particular event because appraisal is likely to be more easily modifiable than exposure. After all, the occurrences of positive interpersonal events depend on the patients' social milieu, a circumstance is more difficult to alter than the patients' perception. Currently, clinical interventions have the capacity to train patients to maximize their enjoyment when a positive interpersonal event presents itself. These clinical approaches include cognitive behavioral therapy, mindfulness mediation (Kabat-Zinn, 1994), gratitude interventions (Emmons & McCullough, 2003), and Fordyce's happiness program (Fordyce, 1983) (c.f. Sin & Lyubomirsky, 2009 meta-analysis on positive interventions). The current findings suggest that including a focus on how to savor feelings of interpersonal enjoyment in current inventions may help FM patients dampen their fatigue at the end of the day.

Continuing to address the second aim, this is the first study to tease apart the role of one's spouse/partner from one's family members, friends, and coworkers in the study of fatigue in FM. This study reveals several similarities across domains, but also uncovers some important differences. These differences include the following: (1) MSEMs show that spousal enjoyment may be less influential than enjoyment in combined familial, friendship, and work domains in mediating fatigue over time. (2) Random slope analyses show that the relation between late morning fatigue and afternoon

spousal enjoyment contains more variability across participants than the relation between late morning and afternoon interpersonal enjoyment in combined familial, friendship, and work domains. (3) Cross-level interaction analyses show that the higher the overall level of spousal enjoyment as an individual difference variable, the stronger the negative relationship of daily spousal enjoyment to daily end-of-day fatigue. In contrast, individual differences in combined familial, friendship, and work domains did not show a similar moderating effect in both partner and unpartnered samples. Together, these findings suggest that enjoyment derived from different domains may influence or be influenced by fatigue *via* different mechanisms. Moreover, enjoyment associated with different domains may have interacting effects at the within- and between-person levels, as well as cross-level interaction effects on fatigue. These findings speak to the importance of examining domain-specific enjoyment in future studies of fatigue in FM. Indeed, these findings have significant implications in the development of clinical interventions. As the majority of clinical interventions that involve interpersonal components tend to focus on the spousal relationship (e.g., Keefe et al., 1999; Manne et al., 2008), the findings of this study may inform clinicians to also pay attention to patients' relationships with people other than their partners when designing interventions for FM patients.

Limitations

There are several limitations of this study that deserve comment. First, the FM sample contained only females. As discussed in the method section, previous findings have suggested some gender differences in individuals' experience of interpersonal relationships among general population and rheumatoid arthritis patients. For example,

among female pain patients, days of increased positive events were associated with lower same-day fatigue but higher next-day fatigue (Davis et al., 2010). However, there was no relation between positive events and fatigue among male pain patients (Davis et al., 2010). According to a meta-analysis of gender differences in life events among healthy individuals (Davis et al., 1999), gender differences emerge in reports of not only exposure to negative events, but also in the appraisal of negative events. Specifically, women reported being exposed to more stressors and rated those stressors as more intense when compared to men. Interestingly, the gender differences were more prominent for appraisals of interpersonal events than for exposure to interpersonal events per se. These studies indicate that there are gender differences in exposure to and appraisal of life events among healthy individuals, as well as gender differences in consequences of interpersonal events among pain patients. As yet, no study has examined whether the relation between fatigue and interpersonal enjoyment resulting from the *appraisal* of *exposure* to positive interpersonal events differs between women and men. If gender differences exist, then it is important for clinical interventions to tailor treatments targeting fatigue based on the gender of the patient to achieve the optimal treatment effect. Hence, it is important to include males in the future for studying the fatigue-interpersonal enjoyment relation.

Another limitation is that only one item was used to assess fatigue in this study. Fatigue in FM may be caused by psychological factors related to motivation and emotion or physiological factors related to disease processes. Fatigue caused by different factors may have differential relations with social enjoyment. In this study, the item assessing fatigue precluded any possibilities to investigate the relations between social enjoyment

and various forms of fatigue. Last but not least, interpersonal enjoyment in the combined familial, friendship, and work domains was assessed with a single item that was an aggregated rating across the familial, friendship, and work domains, rather than one item for each group of individuals—family, friends, and work colleagues. Thus the assessment of interpersonal enjoyment in the combined domain did not allow the examination of fatigue in relation to each specific group of individuals—friends versus family versus co-workers. In the future, researchers may consider using more items to measure the various aspects of fatigue and to assess each specific domain of enjoyment individually to provide a more comprehensive understanding of the fatigue-social enjoyment relation.

Future Directions

The current study sheds light on the within-day process linking changes from morning to evening in fatigue with positive interpersonal engagement in FM. The focus, however, was on examining positive engagement as a single mediator in what is undoubtedly a much more complex process. Thus, one future direction is to extend the mediational chain investigated in this study to include another mediator. A prime potential mediator between afternoon interpersonal enjoyment and end-of-day fatigue is positive affect. According to Gross and Thompson (2007), an emotional response is elicited as the result of the appraisal of the positive events. Thus, enjoyment of relations is likely to predict positive affect. Yet the next step in the mediational chain, the relation between positive affect and same-day fatigue, is characterized by greater complexity, represented by two competing models. The first model proposes that positive affect replenishes or rebuilds energy, whereas the second model proposes that positive affect

depletes energy. Researchers in the first camp believe that positive affect signals a safe environment for exploration and approach behavior (Sutton & Davidson, 1997). It facilitates cognitive processing, creativity, decision making, and coping (Folkman & Moskowitz, 2000; Isen, 2004). It broadens our thought-action repertoires and builds resources (Fredrickson, 1998; 2000). Consequently, positive affect replenishes energy. In contrast, researchers in the second camp believe that the very acts of resource building demand attention and effort (Beal, Weiss, Barros, & MacDermid, 2005; Zohar, Tzischinski, Epstein, 2003). As a result, positive affect drains energy.

To reconcile these two positions, Gross and colleagues suggested that positive affect both builds and depletes energy, but the net gain in energy is determined by the levels of negative affect and chronic stress experienced by the individuals (Gross, et al., 2011). These authors proposed their hypothesis based on the undoing effect of positive affect – positive affect had the capacity to undo the detrimental effects induced by negative affect and stress, which, in turn, revitalized energy (e.g., Fredrickson & Levenson, 1998; Fredrickson, Mancuso, Branigan, & Tugade, 2000). The finding based on a daily diary study conducted by Gross and colleagues (2011) was consistent with the undoing hypothesis. Among healthy participants, elevation of positive affect was associated with reduction in fatigue only on those days which participants rated high on negative affect or stress.

In the pain literature, chronic pain has often been conceptualized as chronic stressor (Carr & Goudas, 1999). Following the logic proposed by Gross and colleagues (2011), the relation between positive affect and fatigue at the within-person level may be negative, as data drawn from chronic pain patients have yielded findings that were

consistent with the energy revitalizing argument. In a recent daily diary study, a high number of within-person positive social events was associated with low levels of fatigue among women with RA; this relation was mediated by high levels of within-person positive affect (Davis et al., 2010). A similar study in FM patients found that positive affect negatively predicted fatigue above and beyond pain and negative affect at the within-person level (Davis, 2008, unpublished pilot data). Hence, it is likely that on a day on which an FM patient experiences elevated positive affect in the evening of the day, relative to her own average, she will experience lower levels of fatigue in the evening of that day.

In a related vein, it is important for future work to investigate the carryover effects of interpersonal enjoyment and positive affect to the next day. The examination of the carry-over effect is important because it can provide evidence addressing whether these two resilience factors – interpersonal enjoyment and positive affect – generate an upward spiral pattern that fosters long-term improvement of well-being among patients with FM. In contrast with the relation between positive affect and same-day fatigue, the relation between positive affect and next-day fatigue may be more elusive. In a daily diary study, a *within-person lagged* analysis demonstrated that the beneficial effect of one day's positive events was not carried over to influence the levels of fatigue reported on the next evening. Surprisingly, the beneficial effect of positive affect on alleviating the same-day fatigue was followed by higher levels of fatigue on the next day (Parrish et al., 2008).

It is worth noting that both positive events and next-day fatigue were measured at bedtime on two consecutive days in the study conducted by Parrish et al. (2008). One

plausible explanation to this finding is that the participants might experience an increase in positive affect in the evening due to an increase in same-day positive events, which might be associated with a lesser amount of fatigue in the evening. Then, the participants might experience a greater amount of energy on the next morning that might lead to higher levels of activity on the next day. Finally, the elevation of activity levels might cause a greater amount of fatigue on the next evening. In short, the relation between positive events and next-day fatigue might be mediated by the lack of fatigue-related coping skills, such as activity pacing at the within-person level.

To closely examine the relation between positive affect and next-day fatigue, instead of testing the levels of fatigue assessed at bedtime on the next day, the levels of fatigue on the morning of the next day should be tested, especially before the next day's potentially fatiguing activities occur. It is likely that on a day on which an FM patient experiences elevated positive affect in the evening of the day, relative to her own average, she will experience lower levels of fatigue in the late-morning on the next day. In addition, this relation may be mediated by lower levels of fatigue in the evening of that day.

Conclusion

In summary, from the substantive perspective, this study advances our understanding of the relations from late morning fatigue to afternoon interpersonal enjoyment to end-of-day fatigue at the within-person level. The findings in this study highlight the central role of positive interpersonal relations in the daily experience of fatigue in women with FM, a disabling symptom with few options for treatment. From the methodological perspective, this study underscores the value of diary studies that

allow researchers to capture the richness and diversity of life even with the simple assessment of two constructs. Looking to the future, the findings also point to areas ripe for additional research, including the contributions of distinct interpersonal domains, the roles of positive affect, and the carryover of effects of social and affective experiences on fatigue. Gaining a fuller understanding of the social contextual factors that influence the daily dynamics of fatigue in FM is an important step toward developing more effective clinical interventions.

Table 1

Scales assessed at each of three time points during each day.

Scale	Item [Possible Range of Items]
Late Morning Fatigue	What was your overall level of fatigue in the past 2-3 hours? [0 (No fatigue) - 100 (Fatigue as bad as it can be)]
Afternoon Interpersonal Contact, Stress (as Covariate) and Enjoyment (as Mediator)	
	What is your marital status? [0 (no spouse/partner), 1 (have spouse/partner)]
Spousal domain (If participants were married)	
	During the past 2-3 hours, did you have contact with your spouse/partner? [1 (Yes), 2 (No)]
	How stressful were your relations with spouse/partner? [1 (Not at all) - 5 (Completely)]
	How enjoyable were your relations with spouse/partner? [1 (Not at all) - 5 (Completely)]
Combined Familiar, friendship, and work domains (If participants were married)	
	During the past 2-3 hours, did you have contact with others, including your family (not including spouse or partner), friends, or co-workers? [1 (Yes), 2 (No)]
	How stressful were your relations with others (not including spouse or partner)? [1 (Not at all) - 5 (Completely)]
	How enjoyable were your relations with others (not including spouse or partner)? [1 (Not at all) - 5 (Completely)]
Combined Familiar, friendship, and work domains (If participants were unmarried)	
	During the past 2-3 hours, did you have contact with others, including your family, friends, or co-workers? [1 (Yes), 2 (No)]
	How stressful were your relations with others? [1 (Not at all) - 5 (Completely)]
	How enjoyable were your relations with others? [1 (Not at all) - 5 (Completely)]
End-of-Day Fatigue	What was your overall level of fatigue today? [0 (No fatigue) - 100 (Fatigue as bad as it can be)]

Note. Items are listed in the order in which they were administered each day.

Table 2

Number of observations, range, mean, standard deviation, skew, kurtosis, and intraclass correlation coefficient (ICC) of measures employed for 102 partnered FM patient. Computations are based on individual daily diary raw scores of all participants.

Repeated Measure	Number of observations[a]	Range	M(SD)	Skew	Kurtosis	ICC
Late Morning Fatigue	1973	0-100	50.94(25.93)	-0.13	-0.90	0.49
Afternoon Interpersonal Stress -Spousal Domain	1064	1-5	1.68(1.15)	1.67	1.70	0.22
Afternoon Interpersonal Enjoyment -Spousal Domain	1064	1-5	3.46(1.24)	-0.45	-0.75	0.39
Afternoon Interpersonal Stress -Combined Familial, Friendship, & Work Domains	1006	1-5	1.84(1.10)	1.20	0.54	0.20
Afternoon Interpersonal Enjoyment -Combined Familial, Friendship, & Work Domains	1010	1-5	3.50(1.12)	-0.42	-0.48	0.35
End-of-Day Fatigue	1929	0-100	54.00(24.46)	-0.25	-0.64	0.55

[a]Number of observations is the number of individual daily diary scores aggregated across all participants.

Table 3

Number of observations, range, mean, standard deviation, skew, kurtosis, and intraclass correlation coefficient (ICC) of measures employed for 74 unpartnered FM patient. Computations are based on individual daily diary raw scores of all participants.

Repeated Measure	Number of observations[a]	Range	M(SD)	Skew	Kurtosis	ICC
Late Morning Fatigue	1391	0-100	52.64(25.41)	-0.11	-0.91	0.53
Afternoon Interpersonal Stress						
-Combined Familial, Friendship, &Work Domains	843	1-5	1.94(1.18)	1.10	0.19	0.36
Afternoon Interpersonal Enjoyment						
-Combined Familial, Friendship, & Work Domains	844	1-5	3.28(1.18)	-0.29	-0.76	0.33
End-of-Day Fatigue	1323	0-100	55.27(24.75)	-0.17	-0.80	0.56

[a]Number of observations is the number of individual daily diary scores aggregated across all participants.

Table 4

Within-Person Correlations Estimated via Maximum Likelihood in a Two-Level Random Coefficient Model in Mplus in the Spousal Domain Model for 102 Partnered FM Patients

Variables	1	2	3	4
1. Late Morning Fatigue (Predictor)	-			
2. Afternoon Interpersonal Enjoyment - Spousal Domain (Mediator)	-.086	-		
3. End-of-Day Fatigue (Outcome)	.471	-.102	-	
4. Afternoon Interpersonal Stress - Spousal Domain (Covariate)	.023	-.291	.031	-

Table 5

Between-Person Correlations Estimated via Maximum Likelihood in a Two-Level Random Coefficient Model in Mplus in the Spousal Domain Model for 102 Partnered FM Patients

Variables	1	2	3	4
1. Late Morning Fatigue (Predictor)	-			
2. Afternoon Interpersonal Enjoyment - Spousal Domain (Mediator)	-.152	-		
3. End-of-Day Fatigue (Outcome)	.952	-.219	-	
4. Afternoon Interpersonal Stress - Spousal Domain (Covariate)	-.034	-.673	.040	-

Table 6

Within-Person Correlations Estimated via Maximum Likelihood in a Two-Level Random Coefficient Model in Mplus in the Combined Familial, Friendship, and Work Domains Model for 102 Partnered FM Patients

Variables	1	2	3	4
1. Late Morning Fatigue (Predictor)	-			
2. Afternoon Interpersonal Enjoyment - Combined Familial, Friendship, and Work Domains (Mediator)	-.116	-		
3. End-of-Day Fatigue (Outcome)	.471	-.153	-	
4. Afternoon Interpersonal Stress - Combined Familial, Friendship, and Work Domains (Covariate)	-.047	-.260	-.044	-

Table 7

Between-Person Correlations Estimated via Maximum Likelihood in a Two-Level Random Coefficient Model in Mplus in the Combined Familial, Friendship, and Work Domains Model for 102 Partnered FM Patients

Variables	1	2	3	4
1. Late Morning Fatigue (Predictor)	-			
2. Afternoon Interpersonal Enjoyment - Combined Familial, Friendship, and Work Domains (Mediator)	-.191	-		
3. End-of-Day Fatigue (Outcome)	.952	-.217	-	
4. Afternoon Interpersonal Stress - Combined Familial, Friendship, and Work Domain (Covariate)	.128	-.579	.163	-

Table 8

Within-Person Correlations Estimated via Maximum Likelihood in a Two-Level Random Coefficient Model in Mplus in the Combined Familial, Friendship, and Work Domains Model for 74 Unpartnered FM Patients

Variables	1	2	3	4
1. Late Morning Fatigue (Predictor)	-			
2. Afternoon Interpersonal Enjoyment - Combined Familial, Friendship, and Work Domains (Mediator)	-.092	-		
3. End-of-Day Fatigue (Outcome)	.442	-.156	-	
4. Afternoon Interpersonal Stress - Combined Familial, Friendship, and Work Domains (Covariate)	.017	-.348	.067	-

Table 9

Between-Person Correlations Estimated via Maximum Likelihood in a Two-Level Random Coefficient Model in Mplus in the Combined Familial, Friendship, and Work Domains Model for 74 Unpartnered FM Patients

Variables	1	2	3	4
1. Late Morning Fatigue (Predictor)	-			
2. Afternoon Interpersonal Enjoyment - Combined Familial, Friendship, and Work Domains (Mediator)	-.476	-		
3. End-of-Day Fatigue (Outcome)	.962	-.447	-	
4. Afternoon Interpersonal Stress - Combined Familial, Friendship, and Work Domains (Covariate)	.316	-.533	.298	-

Table 10

Mediation model of afternoon interpersonal enjoyment in the spousal domain as the mediator between late morning fatigue and end-of-day fatigue for 102 partnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.005(.002)*	-1.043(.467)*	.005(.003)	.024	[0, .013]
Between-person	-.007(.005)	-1.799(1.024)†	.012(.011)	.033	[-.006, .044]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 11

Mediation model of afternoon interpersonal enjoyment in the combined familial, friendship, and work domains as the mediator between late morning fatigue and end-of-day fatigue for 102 partnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.006(.002)**	-1.803(.600)**	.010(.005)*	.065	[.002, .023]
Between-person	-.007(.005)	-.976(1.194)	.007(.009)	-.168	[-.014, .031]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 12

Mediation model of afternoon interpersonal enjoyment in the combined familial, friendship, and work domains as the mediator between late morning fatigue and end-of-day fatigue for 74 unpartnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.005(.002)*	-1.997(.605)***	.010(.005)*	.037	[.002, .022]
Between-person	-.017(.004)***	.441(1.742)	-.008(.030)	.032	[-.069, .053]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 13

Mediation model of afternoon interpersonal enjoyment in the spousal domain as the mediator between late morning fatigue and end-of-day fatigue with afternoon interpersonal stress in the spousal domain as covariate for 102 partnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.004(.002)*	-1.030(.462)*	.004(.003)	.033	[0, .011]
Between-person	-.007(.004)†	-1.195(1.398)	.009(.012)	.085	[-.011, .039]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table14

Mediation model of afternoon interpersonal enjoyment in the combined familial, friendship, and work domains as the mediator between late morning fatigue and end-of-day fatigue with afternoon interpersonal stress in the combined familial, friendship, and work domains as covariate for 102 partnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.006(.002)**	-2.035(.588)**	.013(.006)*	.050	[.003, .025]
Between-person	-.005(.004)	-.491(1.441)	.002(.007)	-.241	[-.019, .020]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 15

Mediation model of afternoon interpersonal enjoyment in the combined familial, friendship, and work domains as the mediator between late morning fatigue and end-of-day fatigue with afternoon interpersonal stress in the combined familial, friendship, and work domains as covariate for 74 unpartnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.005(.002)*	-1.854(.609)**	.009(.005)†	.019	[.001, .021]
Between-person	-.013(.004)**	.397(1.952)	-.005(.025)	.135	[-.056, .051]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 16

Prediction of afternoon enjoyment in the spousal domain from late morning fatigue (a path), with slope specified as random; path coefficient (a path) and slope variance (tau_{11}) are based on 102 partnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Late morning fatigue	-0.004	0.002	0.020	0.00000	> .10
Intercept	3.412				

Note. Delta refers to within-person scores as deviations from the person mean.

Table 17

Prediction of end-of-day fatigue from afternoon enjoyment in the spousal domain (b path), with slope specified as random; and late morning fatigue included with fixed slope; path coefficient (b path) and slope variance (tau_{11}) are based on 102 partnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Afternoon interpersonal enjoyment in spousal domain	-1.057	0.533	0.048	0.00000	> .10
Delta Late morning fatigue	0.392	0.026	0.000		
Intercept	54.128				

Note. Delta refers to within-person scores as deviations from the person mean.

Table 18

Prediction of afternoon enjoyment in the combined domains from late morning fatigue (a path), with slope specified as random; path coefficient (a path) and slope variance (tau_{11})are based on 102 partnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Late morning fatigue	-0.006	0.002	0.006	0.00012	< .05
Intercept	3.493				

Note. Delta refers to within-person scores as deviations from the person mean.
Combined familial, friendship, and work domains refers to combined familial, friendship, and work domains.

Table 19

Prediction of end-of-day fatigue from afternoon enjoyment in the combined domains (b path), with slope specified as random; and late morning fatigue included with fixed slope; path coefficient (b path) and slope variance (tau_{11}) are based on 102 partnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Afternoon interpersonal enjoyment in combined domains	-1.672	0.561	0.003	0.00000	> .10
Delta Late morning fatigue	0.374	0.027	0.000		
Intercept	53.839				

Note. Delta refers to within-person scores as deviations from the person mean.
Combined familial, friendship, and work domains refers to combined familial, friendship, and work domains.

Table 20

Prediction of afternoon enjoyment in the combined domains from late morning fatigue (a path), with slope specified as random; path coefficient (a path) and slope variance (tau_{11}) are based on 74 unpartnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Late morning fatigue	-0.006	0.002	0.013	0.00000	> .10
Intercept	3.256				

Note. Delta refers to within-person scores as deviations from the person mean.
Combined familial, friendship, and work domains refers to combined familial, friendship, and work domains.

Table 21

Prediction of end-of-day fatigue from afternoon enjoyment in the combined domains (b path), with slope specified as random; and late morning fatigue included with fixed slope; path coefficient (b path) and slope variance (tau_{11}) are based on 74 unpartnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Afternoon interpersonal enjoyment in combined domains	-2.281	0.601	0.000	0.00000	> .10
Delta Late morning fatigue	0.393	0.032	0.000		
Intercept	54.603				

Note. Delta refers to within-person scores as deviations from the person mean.
Combined familial, friendship, and work domains refers to combined familial, friendship, and work domains.

Table 22

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the spousal domain by between-person average late morning fatigue (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta late morning fatigue	-0.002	0.005	0.707
Mean late morning fatigue	-0.007	0.005	0.125
Delta late morning fatigue x Mean late morning fatigue	0.000	0.000	0.605
Intercept	3.769		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 23

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the spousal domain to end-of-day fatigue by between-person average late morning fatigue (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta afternoon enjoyment in spousal domain	-2.197	1.443	0.128
Mean late morning fatigue	0.919	0.043	0.000
Delta afternoon enjoyment in spousal domain x Mean late morning fatigue	0.023	0.027	0.389
Delta late morning fatigue	0.397	0.026	0.000
Intercept	7.487		

Note. Delta Refers to within-person scores as deviations from the person mean.

Table 24

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains by between-person average late morning fatigue (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta late morning fatigue	-0.009	0.005	0.063
Mean late morning fatigue	-0.008	0.004	0.055
Delta late morning fatigue x Mean late morning fatigue	0.000	0.000	0.448
Intercept	3.895		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 25

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the combined familial, friendship, and work domains to end-of-day fatigue by between-person average late morning fatigue (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta afternoon enjoyment in combined domains	-2.142	1.528	0.161
Mean late morning fatigue	0.932	0.049	0.000
Delta afternoon enjoyment in combined domains x Mean late morning fatigue	0.010	0.030	0.735
Delta late morning fatigue	0.387	0.026	0.000
Intercept	6.751		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 26

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains by between-person average late morning fatigue (N=74 unpartnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta late morning fatigue	0.004	0.006	0.549
Mean late morning fatigue	-0.016	0.005	0.001
Delta late morning fatigue x Mean late morning fatigue	0.000	0.000	0.136
Intercept	4.110		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 27

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the combined familial, friendship, and work domains to end-of-day fatigue by between-person average late morning fatigue (N=74 unpartnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta afternoon enjoyment in combined domains	-0.357	1.903	0.851
Mean late morning fatigue	0.998	0.048	0.000
Delta afternoon enjoyment in combined domains x Mean late morning fatigue	-0.036	0.035	0.302
Delta late morning fatigue	0.397	0.032	0.000
Intercept	2.237		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 28

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the spousal domain by between-person average afternoon interpersonal enjoyment in the spousal domain (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta late morning fatigue	-0.011	0.007	0.126
Mean afternoon enjoyment in spousal domain	1.023	0.037	0.000
Delta late morning fatigue x Mean afternoon enjoyment in spousal domain	0.002	0.002	0.322
Intercept	-0.085		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 29

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the spousal domain to end-of-day fatigue by between-person average afternoon interpersonal enjoyment in the spousal domain (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta afternoon enjoyment in spousal domain	4.461	2.666	0.095
Mean afternoon enjoyment in spousal domain	-3.805	2.200	0.087
Delta afternoon enjoyment in spousal domain x Mean afternoon enjoyment in spousal domain	-1.635	0.770	0.034
Delta late morning fatigue	0.393	0.026	0.000
Intercept	67.128		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 30

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains by between-person average afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta late morning fatigue	-0.005	0.007	0.473
Mean afternoon enjoyment in combined domains	1.001	0.040	0.000
Delta late morning fatigue x Mean afternoon enjoyment in combined domains	0.000	0.002	0.952
Intercept	-0.005		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 31

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the combined familial, friendship, and work domains to end-of-day fatigue by between-person average afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta afternoon enjoyment in combined domains	2.425	3.412	0.477
Mean afternoon enjoyment in combined domains	-4.734	2.489	0.060
Delta afternoon enjoyment in combined domains x Mean afternoon enjoyment in combined domains	-1.182	0.968	0.223
Delta late morning fatigue	0.372	0.027	0.000
Intercept	70.466		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 32

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains by between-person average afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (N=74 unpartnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta late morning fatigue	-0.007	0.008	0.365
Mean afternoon enjoyment in combined domains	1.023	0.044	0.000
Delta late morning fatigue x Mean afternoon enjoyment in combined domains	0.001	0.002	0.796
Intercept	-0.081		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 33

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the combined familial, friendship, and work domains to end-of-day fatigue by between-person average afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (N=74 unpartnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta afternoon enjoyment in combined domains	-3.121	3.307	0.346
Mean afternoon enjoyment in combined domains	-11.282	2.979	0.000
Delta afternoon enjoyment in combined domains x Mean afternoon enjoyment in combined domains	0.265	1.001	0.791
Delta late morning fatigue	0.392	0.032	0.000
Intercept	91.324		

Note. Delta refers to within-person scores as deviations from the person mean.

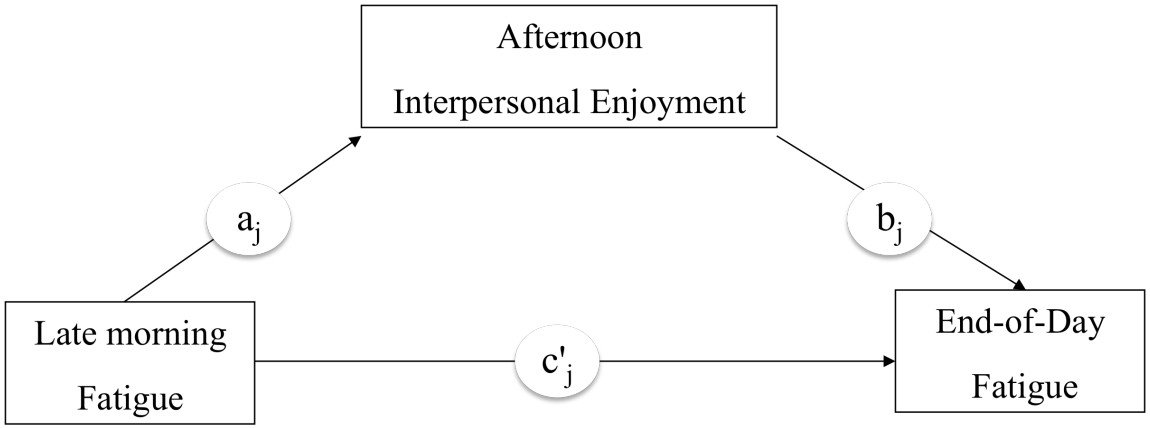

Figure 1. Model depicting the hypothesized relations among late morning fatigue, afternoon interpersonal enjoyment, and end-of-day fatigue on the same day for FM sample in GIFT.

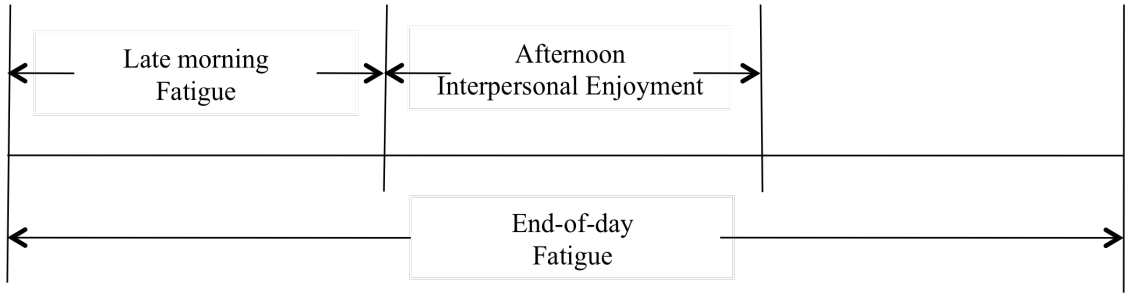

Figure 2. Model depicting the temporal order of the late morning fatigue, afternoon interpersonal enjoyment, and end-of-day fatigue.

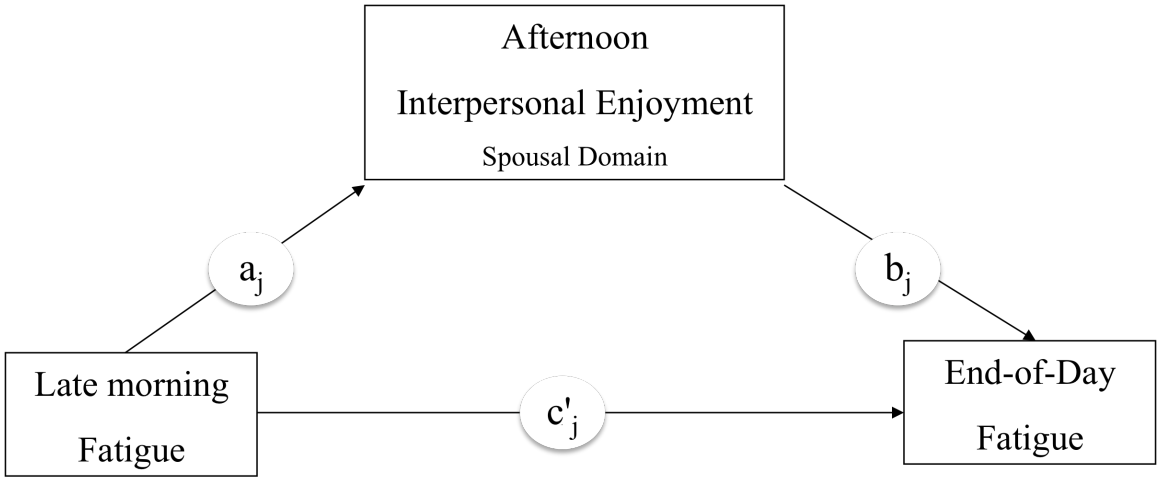

Figure 3. Model depicting the hypothesized relations among late morning fatigue, afternoon interpersonal enjoyment in spousal domain, and end-of-day fatigue on the same day for partnered FM sample in GIFT.

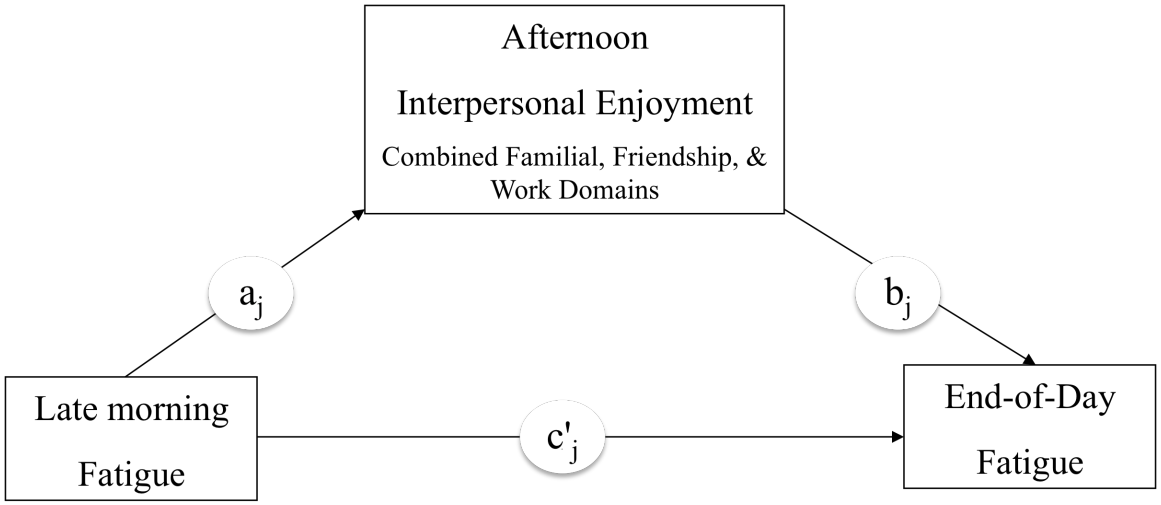

Figure 4. Model depicting the hypothesized relations among late morning fatigue, afternoon interpersonal enjoyment in combined familial, friendship, and work domains, and end-of-day fatigue on the same day for partnered FM sample in GIFT.

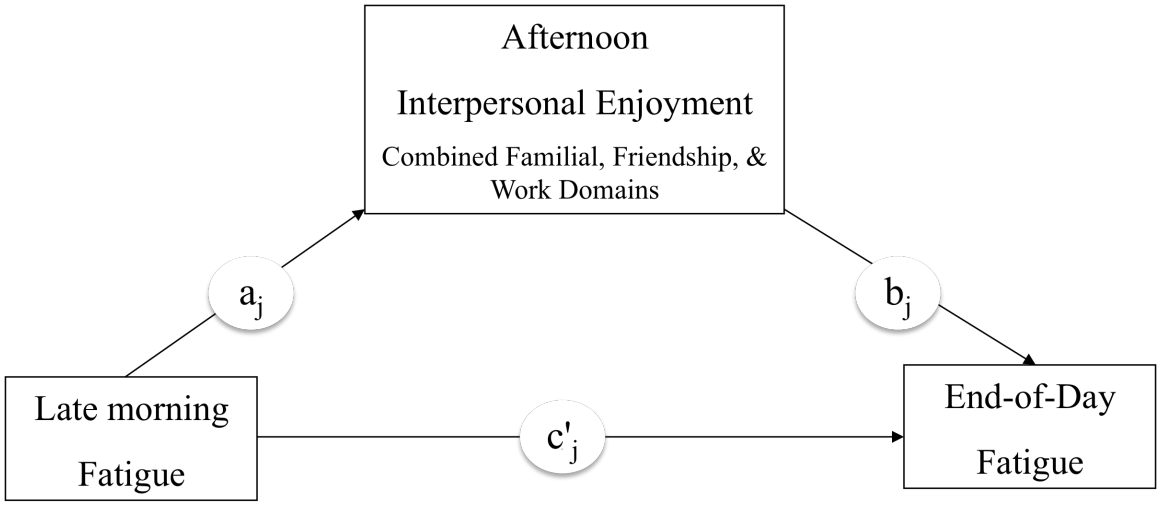

Figure 5. Model depicting the hypothesized relations among late morning fatigue, afternoon interpersonal enjoyment in combined familial, friendship, and work domains, and end-of-day fatigue on the same day for unpartnered FM sample in GIFT.

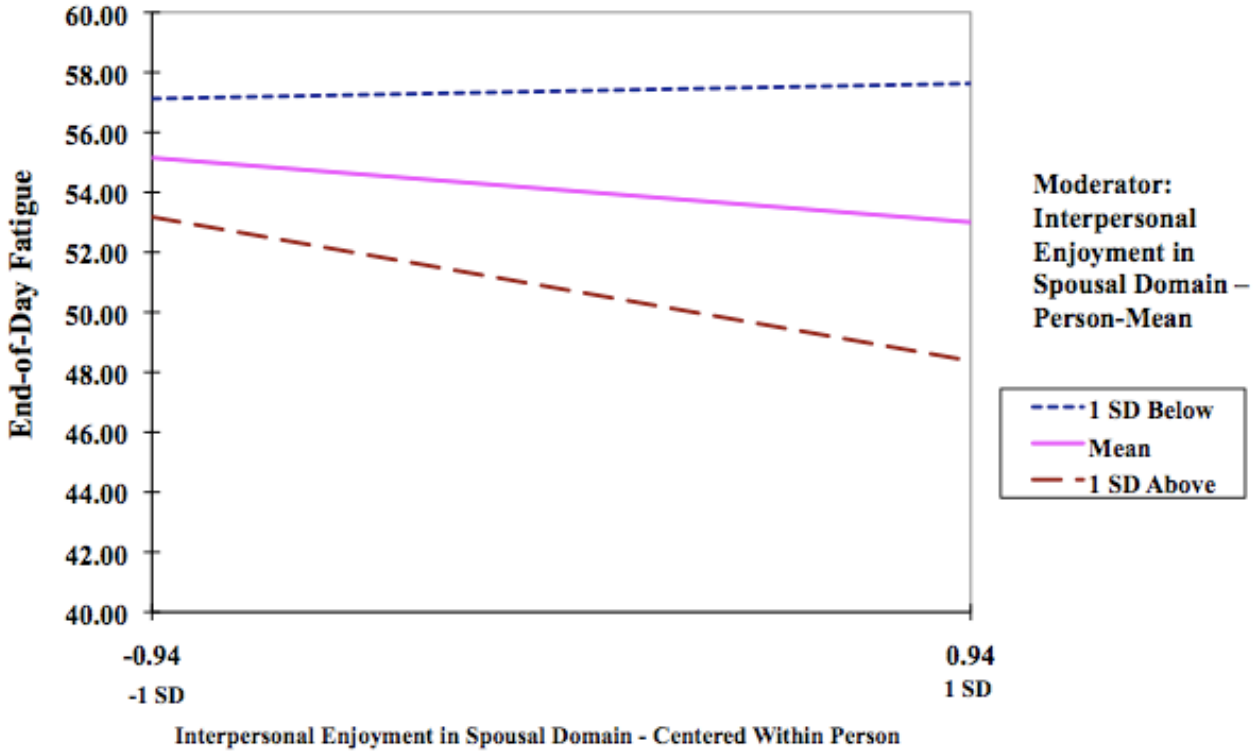

Figure 6. The relation between Interpersonal enjoyment reported in the afternoon at the within-person level and fatigue reported at the end of day was moderated by interpersonal enjoyment at the between-person level in the spousal domain among partnered FM patients.

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APPENDIX A

FINDINGS ASSOCIATED WITH USING EVENING FATIGUE AS OUTCOME

Table 34

Range, Mean, Standard Deviation, Skew, Kurtosis, and Intraclass Correlation Coefficient for the Repeated Measure—Evening Fatigue in the Hypothesized Models for 102 Partnered FM Patients

Repeated Measure	Range	M(SD)	Skew	Kurtosis	ICC
Evening Fatigue (End-of-Day Fatigue - Late Morning Fatigue)	0-100	3.27(19.12)	0.12	4.08	0.09

Table 35

Range, Mean, Standard Deviation, Skew, Kurtosis, and Intraclass Correlation Coefficient for the Repeated Measure—Evening Fatigue in the Hypothesized Models for 74 Unpartnered FM Patients

Repeated Measure	Range	M(SD)	Skew	Kurtosis	ICC
Evening Fatigue (End-of-Day Fatigue - Late Morning Fatigue)	0-100	2.39(18.53)	-0.05	4.99	0.08

Table 36

Correlations in the Spousal Domain Model for 102 Partnered FM Patients

Variables	1	2	3	4
1. T1 Fatigue (Predictor)	-	-.115	.011	-.043
2. T2 IE - Spousal Domain (Mediator)	-.088	-	-.310	-.674
3. T3 Fatigue (Outcome)	-.611	0.002	-	.289
4. T2 IS - Spousal Domain (Covariate)	.022	-.291	.006	-

Note. Within-person model correlations are below the diagonal; between-person correlations are above the diagonal
T1 = Late morning. T2 = Afternoon. T3 = Evening. IE = Interpersonal enjoyment. IS = Interpersonal stress.

Table 37

Correlations in the Combined Familial, Friendship, and Work Domains Model for 102 Partnered FM Patients

Variables	1	2	3	4
1. T1 Fatigue (Predictor)	-	-.201	.103	.138
2. T2 IE - Combined Familial, Friendship, and Work Domains (Mediator)	-.111	-	-.138	-.580
3. T3 Fatigue (Outcome)	-.631	-.013	-	.201
4. T2 IS - Combined Familial, Friendship, and Work Domains (Covariate)	-.050	-.260	.008	-

Note. Within-person model correlations are below the diagonal; between-person correlations are above the diagonal
T1 = Late morning. T2 = Afternoon. T3 = Evening. IE = Interpersonal enjoyment. IS = Interpersonal stress.

Table 38

Correlations in the Combined Familial, Friendship, and Work Domains Model for 74 Unpartnered FM Patients

Variables	1	2	3	4
1. T1 Fatigue (Predictor)	-	-.498	.154	.356
2. T2 IE - Combined Familial, Friendship, and Work Domains (Mediator)	-.094	-	.050	-.549
3. T3 Fatigue (Outcome)	-.586	-.064	-	.024
4. T2 IS - Combined Familial, Friendship, and Work Domains (Covariate)	.015	-.347	.050	-

Note. Within-person model correlations are below the diagonal; between-person correlations are above the diagonal
T1 = Late morning. T2 = Afternoon. T3 = Evening. IE = Interpersonal enjoyment. IS = Interpersonal stress.

Table 39

Mediation model examining the role of afternoon interpersonal enjoyment in spousal domain in mediating the relation between late morning fatigue and evening fatigue for 102 partnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.004(.002)*	-.888(.460)†	.004(.003)	-.018	[0, .01]
Between-person	-.007(.005)	-1.930(1.028)†	.013(.012)	.023	[-.006, .045]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 40

Mediation model examining the role of afternoon interpersonal enjoyment in combined familial, friendship, and work domains in mediating the relation between late morning fatigue and evening fatigue for 102 partnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.006(.002)**	-1.737(.597)**	.010(.005)*	.055	[.002, .022]
Between-person	-.007(.005)	-1.047(1.215)	.008(.009)	-.173	[-.014, .032]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 41

Mediation model examining the role of afternoon interpersonal enjoyment in combined familial, friendship, and work domains in mediating the relation between late morning fatigue and evening fatigue for 74 unpartnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.005(.002)**	-2.176(.569)***	.012(.006)*	.031	[.002, .023]
Between-person	-.017(.004)***	.358(1.733)	-.006(.030)	.028	[-.067, .055]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 42

Mediation model examining the role of afternoon interpersonal enjoyment in spousal domain in mediating the relation between late morning fatigue and evening fatigue with afternoon interpersonal stress in spousal domain as covariate for 102 partnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.004(.002)*	-.988(.501)*	.004(.003)	-.037	[0, .011]
Between-person	-.005(.005)	-1.702(1.241)	.009(.011)	-.084	[-.011, .037]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 43

Mediation model examining the role of afternoon interpersonal enjoyment in combined familial, friendship, and work domains in mediating the relation between late morning fatigue and evening fatigue with afternoon interpersonal stress in familial, friendship,and work domains combined as covariate for 102 partnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.005(.002)*	-1.932(.579)**	.010(.005)*	-.057	[.002, .02]
Between-person	-.008(.005)	-.293(1.449)	.002(.012)	-.081	[-.027, .031]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 44

Mediation model examining the role of afternoon interpersonal enjoyment in combined familial, friendship, and work domains in mediating the relation between late morning fatigue and evening fatigue with afternoon interpersonal stress in familial, friendship,and work domains combined as covariate for 74 unpartnered FM patients

Model	a path B (SE B)	b path B (SE B)	ab path B (SE B)	Correlation of a and b	Asymmetric Confidence Interval
Within-person	-.005(.002)*	-2.119(.590)***	.011(.006)*	.055	[.002, .023]
Between-person	-.018(.004)***	1.430(2.410)	-.026(.043)	.065	[-.116, .062]

† p <.10. * p < .05. ** p <.01. *** p < .001.

Table 45

Prediction of afternoon enjoyment in the spousal domain from late morning fatigue (a path),with slope specified as random; path coefficient (a path) and slope variance (tau_{11}) are based on 102 partnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Late morning fatigue	-0.004	0.002	0.020	0.00000	> .10
Intercept	3.412				

Note. Delta refers to within-person scores as deviations from the person mean.

Table 46

Prediction of evening fatigue from afternoon enjoyment in the spousal domain (b path), with slope specified as random;and late morning fatigue included with fixed slope; path coefficient (b path) and slope variance (tau_{11}) are based on 102 partnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Afternoon interpersonal enjoyment in spousal domain	-1.012	0.532	0.057	0.00000	> .10
Delta Late morning fatigue	-0.599	0.026	0.000		
Intercept	3.400				

Note. Delta refers to within-person scores as deviations from the person mean.

Table 47

Prediction of afternoon enjoyment in the combined domains from late morning fatigue (a path),with slope specified as random; path coefficient (a path) and slope variance (tau_{11}) are based on 102 partnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Late morning fatigue	-0.006	0.002	0.006	0.00012	< .05
Intercept	3.493				

Note. Delta refers to within-person scores as deviations from the person mean.
Combined familial, friendship, and work domains refers to combined familial, friendship, and work domains.

Table 48

Prediction of evening fatigue from afternoon enjoyment in the combined domains (b path), with slope specified as random; and late morning fatigue included with fixed slope; path coefficient (b path) and slope variance (tau_{11}) are based on 102 partnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Afternoon interpersonal enjoyment in combined domains	-1.677	0.558	0.003	0.00000	> .10
Delta Late morning fatigue	-0.611	0.026	0.000		
Intercept	3.366				

Note.Delta refers to within-person scores as deviations from the person mean.
Combined familial, friendship, and work domains refers to combined familial, friendship, and work domains.

Table 49

Prediction of afternoon enjoyment in the combined domains from late morning fatigue (a path),with slope specified as random; path coefficient (a path) and slope variance (tau_{11})are based on 74 unpartnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Late morning fatigue	-0.006	0.002	0.013	0.00000	> .10
Intercept	3.256				

Note. Delta refers to within-person scores as deviations from the person mean.
Combined familial, friendship, and work domains refers to combined familial, friendship, and work domains.

Table 50

Prediction of evening fatigue from afternoon enjoyment in the combined domains (b path), with slope specified as random; and late morning fatigue included with fixed slope; path coefficient (b path) and slope variance (tau_{11}) are based on 74 unpartnered FM patients.

	Path Coefficient			Variance Component	
Predictor	*Path Estimate*	*SE*	*p*	*Slope Variance (tau_{11})*	*p*
Delta Afternoon interpersonal enjoyment in combined domains	-2.284	0.599	0.000	0.00000	> .10
Delta Late morning fatigue	-0.602	0.032	0.000		
Intercept	2.165				

Note. Delta refers to within-person scores as deviations from the person mean.
Combined familial, friendship, and work domains refers to combined familial, friendship, and work domains.

Table 51

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the spousal domain by between-person average late morning fatigue (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Late morning fatigue	-0.002	0.005	0.707
Mean late morning fatigue	-0.007	0.005	0.125
Delta Late morning fatigue x Mean late morning fatigue	0.000	0.000	0.605
Intercept	3.769		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 52

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the spousal domain to evening fatigue by between-person average late morning fatigue (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Afternoon enjoyment in spousal domain	-2.197	1.443	0.128
Mean late morning fatigue	-0.081	0.043	0.061
Delta Afternoon enjoyment in spousal domain x Mean late morning fatigue	0.023	0.027	0.389
Delta Late morning fatigue	-0.603	0.026	0.000
Intercept	7.487		

Note. Delta Refers to within-person scores as deviations from the person mean.

Table 53

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains by between-person average late morning fatigue (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Late morning fatigue	-0.009	0.005	0.063
Mean late morning fatigue	-0.008	0.004	0.055
Delta Late morning fatigue x Mean late morning fatigue	0.000	0.000	0.448
Intercept	3.895		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 54

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the combined familial, friendship, and work domains to evening fatigue by between-person average late morning fatigue (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Afternoon enjoyment in combined domains	-2.142	1.528	0.161
Mean late morning fatigue	-0.068	0.049	0.173
Delta Afternoon enjoyment in combined domains x Mean late morning fatigue	0.010	0.030	0.735
Delta Late morning fatigue	-0.613	0.026	0.000
Intercept	6.751		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 55

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains by between-person average late morning fatigue (N=74 unpartnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Late morning fatigue	0.004	0.006	0.549
Mean late morning fatigue	-0.016	0.005	0.001
Delta Late morning fatigue x Mean late morning fatigue	0.000	0.000	0.136
Intercept	4.110		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 56

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the combined familial, friendship, and work domains to evening fatigue by between-person average late morning fatigue (N=74 unpartnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Afternoon enjoyment in combined domains	-0.357	1.903	0.851
Mean late morning fatigue	-0.002	0.048	0.970
Delta Afternoon enjoyment in combined domains x Mean late morning fatigue	-0.036	0.035	0.302
Delta Late morning fatigue	-0.603	0.032	0.000
Intercept	2.237		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 57

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the spousal domain by between-person average afternoon interpersonal enjoyment in the spousal domain (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Late morning fatigue	-0.011	0.007	0.126
Mean afternoon enjoyment in spousal domain	1.023	0.037	0.000
Delta Late morning fatigue x Mean afternoon enjoyment in spousal domain	0.002	0.002	0.322
Intercept	-0.085		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 58

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the spousal domain to evening fatigue by between-person average afternoon interpersonal enjoyment in the spousal domain (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Afternoon enjoyment in spousal domain	4.458	2.647	0.093
Mean afternoon enjoyment in spousal domain	-1.189	0.970	0.223
Delta Afternoon enjoyment in spousal domain x Mean afternoon enjoyment in spousal domain	-1.617	0.764	0.035
Delta Late morning fatigue	-0.599	0.026	0.000
Intercept	7.459		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 59

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains by between-person average afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Late morning fatigue	-0.005	0.007	0.473
Mean afternoon enjoyment in combined domains	1.001	0.040	0.000
Delta Late morning fatigue x Mean afternoon enjoyment in combined domains	0.000	0.002	0.952
Intercept	-0.005		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 60

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the combined familial, friendship, and work domains to evening fatigue by between-person average afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (N=102 partnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Afternoon enjoyment in combined domains	2.748	3.370	0.415
Mean afternoon enjoyment in combined domains	-0.919	1.203	0.447
Delta Afternoon enjoyment in combined domains x Mean afternoon enjoyment in combined domains	-1.268	0.956	0.185
Delta Late morning fatigue (within-person)	-0.612	0.026	0.000
Intercept	6.600		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 61

Step 1: Cross-level moderation of the within-person relationship from late morning fatigue to afternoon interpersonal enjoyment in the combined familial, friendship, and work domains by between-person average afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (N=74 unpartnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Late morning fatigue	-0.007	0.008	0.365
Mean afternoon enjoyment in combined domains	1.023	0.044	0.000
Delta Late morning fatigue x Mean afternoon enjoyment in combined domains	0.001	0.002	0.796
Intercept	-0.081		

Note. Delta refers to within-person scores as deviations from the person mean.

Table 62

Step 2: Cross-level moderation of the within-person relationship from interpersonal enjoyment in the combined familial, friendship, and work domains to evening fatigue by between-person average afternoon interpersonal enjoyment in the combined familial, friendship, and work domains (N=74 unpartnered FM patients).

Predictor	*Unstandardized Coefficient*	*SE*	*p*
Delta Afternoon enjoyment in combined domains	-2.464	3.298	0.455
Mean afternoon enjoyment in combined domains	-0.151	1.217	0.902
Delta Afternoon enjoyment in combined domains x Mean afternoon enjoyment in combined domains	0.075	0.999	0.940
Delta Late morning fatigue	-0.602	0.032	0.000
Intercept	2.650		

Note. Delta refers to within-person scores as deviations from the person mean.

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL FOR FIBROMYALGIA: INTERVENTIONS FOR PAIN AND MOOD REGULATION

ASU Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	Mary Davis PSYCHOLOGY
From:	for Carol Johnston, Chair Biosci IRB
Date:	06/12/2013
Committee Action:	**Renewal**
Renewal Date:	06/12/2013
Review Type:	Expedited F8
IRB Protocol #:	0807003098
Study Title:	Fibromyalgia: Interventions for pain and mood regulation
Expiration Date:	07/10/2014

The above-referenced protocol was given renewed approval following Expedited Review by the Institutional Review Board.

It is the Principal Investigator's responsibility to obtain review and continued approval of ongoing research before the expiration noted above. Please allow sufficient time for reapproval. Research activity of any sort may not continue beyond the expiration date without committee approval. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol on the expiration date. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study termination.

This approval by the Biosci IRB does not replace or supersede any departmental or oversight committee review that may be required by institutional policy.

Adverse Reactions: If any untoward incidents or severe reactions should develop as a result of this study, you are required to notify the Biosci IRB immediately. If necessary a member of the IRB will be assigned to look into the matter. If the problem is serious, approval may be withdrawn pending IRB review.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, or the investigators, please communicate your requested changes to the Biosci IRB. The new procedure is not to be initiated until the IRB approval has been given.

Please retain a copy of this letter with your approved protocol.