Does Negative Emotion Differentiation Buffer the Effects of Daily Pain on Stress in Individuals with Chronic Pain?

by

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ABSTRACT

Chronic pain is among the most prevalent health issues experienced by older adults and negatively impacts daily functioning and psychosocial well-being through mechanisms that include energy depletion, pain interference, and pain-related changes in negative affect. The capacities to be aware of and regulate negative emotions play a critical role in the successful management of chronic pain. One dimension of negative emotion awareness, termed negative emotion differentiation (NED), is the ability to discriminate between negative affective experiences and recognize them as discrete categories. The ability to identify and distinguish between the various emotions that accompany pain flares and other stressors may enhance the precision of the individual's regulatory efforts. In doing so, NED may be one possible resilience resource that can facilitate adaptive functioning in the context of chronic pain by buffering the effects of chronic pain flares on daily interpersonal stress. However, this has not yet been investigated. The current study aimed to examine the moderating effect of trait NED on the relationship between daily pain and same-day stress in 259 patients diagnosed with osteoarthritis (OA) or fibromyalgia syndrome (FMS). Individuals completed daily diaries each evening for 30 days reporting on average daily pain, negative emotions, interpersonal stress, and depressive symptoms. It was hypothesized that higher levels of NED would buffer the effects of daily pain on same-day stress. In exploratory analyses, it was evaluated whether the buffering effects were larger for individuals with FMS versus OA. Results of multilevel models revealed that, as expected, higher levels of trait NED predicted lower levels of same-day negative interpersonal events and perceived interpersonal stress. Trait NED also moderated the relationship between pain-related

increases in same-day perceived interpersonal stress. Additionally, findings indicated that NED was similarly important for those with FMS and OA. Taken together, the current findings suggest that NED is an important resilience trait that can attenuate chronic pain-related increases in daily experiences of interpersonal stress.

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Introduction

Chronic pain is among the most prevalent health issues, with between 20% and 40% of adults reporting that they experience chronic pain (Dahlhamer et al., 2018; Verhaak et al., 1998). Lasting at least three months or more, this long-term health condition is among the most commonly expressed complaints to health care practitioners (Lumley et al., 2011). Beyond their increased health care usage, individuals with chronic pain experience negative quality of life, daily functional limitations, impaired psychological well-being, poorer mental health outcomes, and increased rates of substance abuse (Gureje et al., 1998; Kawai et al., 2017; Aaron et al., 2020). Research also suggests that chronic pain patients exhibit deficits in aspects of emotion regulation, including emotional awareness and identification (Baeza-Velasco et al., 2012), and a diminished ability to regulate their emotions (Baker et al., 2016). Of note, existing evidence suggests that the ability to regulate emotions moderates the relations between chronic pain and health outcomes (Burns et al., 2009). Because the experience of chronic pain encompasses not only sensory but also emotional features, researchers have theorized that the capacity to regulate emotions, including emotion identification and negative emotion down-regulation, may play a key role in preserving quality of life among those with chronic pain (Aaron et al., 2020).

Pain and Emotion

The International Association for the Study of Pain defines pain as an "unpleasant sensory and emotional experience associated with actual or potential damage, or described in terms of such damage," (Merskey & Bogduk, 1994), suggesting that emotions and pain are inherently connected. Empirical findings support the relationship

between pain and emotions, showing that individuals experience an increase in negative affect following a painful experience and that even the uncertainty of pain onset and course can elevate negative affect (Affleck et al., 1991; Yoshida, 1997; Zautra et al., 1995). Furthermore, in a study examining women with chronic pain, increases in weekly negative affect and higher average negative affect predicted greater levels of pain in subsequent weeks (Zautra et al., 2005). Additionally, higher rates of depression are observed among chronic pain patients, especially those with fibromyalgia (Creed & Asch, 1992; Aguglia et al., 2011), and pain patients with more depressive symptoms have shown to report more intense pain than those with fewer depressive symptoms (Affleck et al., 1991). Moreover, the biopsychosocial model of emotion and pain (Lumley et al., 2011) highlights the neurobiological, psychological, and social connections between emotions and pain. Research has shown that emotional stress (Koopman et al., 1998) and limited emotional awareness (Mehling & Krause, 2005) are related to greater experiences of chronic and cancer-related pain. Additional evidence suggests that emotional awareness and the capacity to regulate negative emotions play a critical role in chronic pain management (Lumley et al., 2017).

The Function of Emotions in Adaptation

The ability to identify and distinguish between the various emotions that accompany pain and other aversive experiences may impact the precision of an individual's regulatory and coping efforts. According to the affect-as-information perspective, specific affective states function as a source of information, whereby different emotions provide different types of information (Schwarz & Clore, 1983).

While positive emotions can motivate an individual to approach a situation or continue engaging in an activity (Fredrickson, 1998), negative emotions and their interconnected biological signals can indicate a need to alter one's current state or activity (Pratto & John, 1991; Coifman et al., 2016). A critical aspect of choosing an optimal response is that the individual is able to successfully identify an emotional state (Barret et al., 2001). Furthermore, within the context of health communications, affect may influence information processes, judgments, and decision-making relating to the management of chronic pain conditions (Peters et al., 2006).

Negative Emotion Differentiation

Negative emotion differentiation (NED), or the ability to differentiate negative affective experiences into discrete categories (Barrett et al., 2001), may be one possible mechanism by which individuals can facilitate adaptive functioning in the presence of chronic pain. Whereas emotional awareness is a multifaceted cognitive process that involves understanding, describing, and attending to one's emotional experience (Mankus et al, 2016; Lane & Shwartz, 1987), NED is a component of emotional awareness that emphasizes the ability to have a more precise understanding of the nuances of the experience of negative emotions. Individuals who are high in NED tend to respond to emotion-eliciting events with a wider range of emotion words than low differentiators (Barrett et al., 2001). For example, on a particularly stressful day, low differentiators may condense their emotional experiences into a simplified summary like "bad" or "terrible," whereas high differentiators with similar experiences would identify a wider and more nuanced range of emotions, such as "irritating, unsettling, and tiring." To the extent that

individuals can make fine distinctions between negative emotion states, they may be better able to select optimal responses to help manage a stressful experience, including pain.

Prior research has examined emotion differentiation using laboratory-based tasks (Erbas, et al., 2013), self-reported measures (Kang & Shaver, 2004), and most commonly, experience-sampling methods (*e.g.,* Carstensen et al., 2000; Pond et al., 2012; Kashdan et al., 2010). Laboratory-based studies of emotion differentiation typically expose individuals to standardized emotion-eliciting stimuli and then evaluate the extent to which they display emotion differentiation (Erbas et al., 2013). For example, Erbas and colleagues (2013) used a laboratory setting to examine whether individuals with autism spectrum disorder (ASD) differentiate less than typically developing individuals by presenting them with a set of 20 standardized emotional photographs and asking them to report on their experienced emotions using a Likert scale. In conjunction with another task, they found that while individuals with ASD differentiate less than typically developing individuals, both groups gave similar meaning to emotions. Although laboratory-based studies on emotion differentiation have the benefit of utilizing standardized stimuli to elicit various emotional reactions, they rely on measurements over a relatively short period of time and may not generalize to real world experiences (Erbas et al., 2013; Erbas et al., 2014). Self-report measures of emotion differentiation (e.g., Kang & Shaver, 2004) ask respondents to reflect on their emotional experiences using global terms (e.g., "I usually experience a wide range of emotions") and have been used to identify emotion differentiation as a possible mediator in the relationship between

alexithymia and emotion regulation (da Silva et al., 2017). Similar to other laboratory-based studies, self-report measures of emotion differentiation are less time intensive, yet these global self-report measures tend to reflect trait levels that may be biased by the individuals' beliefs about themselves (Kashdan et al., 2015).

The experience-sampling approach allows researchers to gather repeated measurements on emotional experiences over a long period of time and to assess how close the different emotional states are to each other (Lindquist & Barrett, 2008). This approach also provides information that is less sensitive to validity issues associated with self-report methodology (Smidt & Suvak, 2015) and more ecologically valid than laboratory-based assessments. Assessment durations vary from days to weeks and include ecological momentary assessments, which prompt individuals to respond in the moment (e.g., Dasch et al., 2010; Kashdan et al., 2010), and daily diary assessments, which include standard reporting times for responses (e.g., Lundh, L. G., & Simonsson-Sarnecki, 2001).

To measure emotion differentiation using the experience-sampling approach, intra-class correlations (ICC) are used to distinguish the strength of the correlations between like-valanced emotions across time for each individual. High correlations therefore indicate less discernment and nuance in how individuals identify emotions to describe how they feel (Barret et al., 2001; Erbas et al., 2014). More simply, high ICCs indicate lower emotion differentiation, whereas low ICCs reflect a stronger ability to differentiate. Some of the most compelling studies have used experience-sampling assessments, including that of Kalokerinos and colleagues (2019), which showed that in a

sample of university students, low negative emotion differentiation was associated with ineffective use of emotion-regulation strategies.

NED and Psychological Functioning

The ability to identify emotional experiences in a more nuanced manner has been linked to better psychological functioning. In a study assessing emotion differentiation in a sample of participants with major depressive disorder (MDD), Demiralp and colleagues (2012) found that individuals with MDD had lower levels of NED than healthy participants. Research also suggests that across different contexts (e.g., random moments, face-to-face interactions, and end-of-day reflections), individuals with social anxiety disorder display less NED than healthy individuals (Kashdan & Farmer, 2014). Additionally, results from a longitudinal study examining within-subjects associations of daily stress exposure and daily changes in depressed mood in a sample of veterans found that low NED predicted stronger reactivity to daily negative events (Starr et al., 2017). Furthermore, for individuals low on neuroticism, NED significantly predicted better health, suggesting the importance of between-subject differences (Oh & Tong, 2020). These studies provide broad support for the importance of NED on mental health and well-being; yet there is a dearth of knowledge on how NED may affect individuals with various types of chronic pain.

Pain and Stress

Stress often accompanies the experience of chronic pain. Not only can stress contribute to the onset of chronic pain (Macfarlane, 2016) and pain flares (Zautra et al.,

1997), but being in pain can be particularly stressful. For example, a lack of control and feelings of helplessness associated with chronic pain can contribute to elevated stress (Turk et al., 2013). Additionally, the experience of chronic pain can be stressful in that pain can interfere with sleep, exercise, work, and other daily activities (Widerström-Noga et al., 2001). Chronic pain has also been shown to be associated with interpersonal stress. For example, chronic pain has shown to contribute added stress among spouses, resulting in decreased marital and sexual satisfaction (Flor et al., 1987). Other studies have shown that increased muscle tenderness and reduced pain thresholds are correlated with daily hassles, suggesting that pain may have an impact on the number of negative events one experiences (Cathcart & Pritchard, 2007; Affleck et al., 1997). Although much of the literature supports the relationship between pain and stress (Gil et al., 2004), the strength of the relationship might differ among pain conditions. For example, in a daily diary study spanning 75 days, researchers found that individuals with rheumatoid arthritis did not show consistent relationships among same-day pain, next-day pain, and daily stressors (Affleck et al., 1994). Additionally, in a study comparing women with either OA or FMS, it was found that although both groups experienced similar levels of stress, those with FMS that experienced higher levels of stress reported more pain (Zautra et al., 1999). Given that chronic pain patients have been shown to be more vulnerable to stress (Davis et al., 2001), it is especially important to investigate resilience traits that might buffer the effects of chronic pain on levels of stress.

NED as a Resilience Trait

The ability to accurately distinguish between various emotional experiences may provide valuable information in the maintenance of chronic pain. By having a more attuned understanding of one's emotional states, it is possible that individuals may better understand the underlying cause of an emotional experience, the context from which it arose, as well as bodily sensations that may accompany the emotion (Barret et al., 2001). A more refined or differentiated mastery of one's daily emotional experiences could better equip people with the skills necessary to adaptively respond (Erbas et al., 2014). More specifically, high levels of trait NED may function as a protective mechanism in the relationship between pain and stress. Prior research indicates that individuals with higher levels of NED utilize a wider range of negative emotion regulation strategies (Kalokerinos et al., 2019), especially at higher levels of emotional intensity (Barrett et al., 2001). Given that pain and stress are often accompanied by increased emotional intensity, it is possible that higher levels of trait NED may elicit the use of more precise emotion regulations strategies. However, the ability to utilize NED and its effectiveness among various chronic pain conditions has not been investigated.

Fibromyalgia and Osteoarthritis

Chronic pain conditions can vary widely in symptomatology, pain severity, and how they affect an individual's physical and emotional functioning. Furthermore, different aspects of pain such as unpredictability, increased negative emotion, and low social support may be particularly relevant to an individual's ability to differentiate negative emotions, and understanding the extent to which NED differentially impacts functioning across chronic pain conditions can provide useful information for chronic

pain management. Research on musculoskeletal pain commonly compares fibromyalgia syndrome (FMS) with osteoarthritis (OA) (Lopez-Ruiz et al., 2019; Reich et al., 2006; Kleinman et al., 2009), primarily because the conditions differ on important dimensions, many of which may have implications for NED. For example, OA is considered a predictable and normative chronic pain condition with known pathology that can be linked to specific tissue damage and inflammation in the joints (Lumley et al., 2011). FMS, on the other hand, is a less common multisymptomatic pain condition characterized by widespread, unpredictable soft tissue pain and fatigue of unknown origin and an uncertain course (Clauw, 2014; Lumley et al., 2011; Reich et al., 2006; Wolfe et al., 1990).

In a study comparing women with either FMS or OA who were scheduled for knee surgery, Davis and colleagues (2001) found that both groups reported similar levels of bodily pain. However, those with FMS reported worse overall functioning including poorer emotional and physical health, and a poorer social environment. In the same study, women with FMS also experienced more prolonged pain following a stress induction. Furthermore, research has shown that individuals with FMS tend to report higher levels of negative emotions (Middendorp et al., 2008; Galvez-Sanchez et al., 2008) and more avoidant coping compared to groups with OA (Davis et al., 2001) and community-based controls (Middendorp et al., 2008). Additional comparisons suggest that in contrast to patients with OA, patients with FMS are more likely to negatively rate their relationship satisfaction on days when they experience poorer physical functioning and greater illness uncertainty (Reich et al., 2006). These findings suggest that not only do individuals with

FMS experience worse functioning than those with OA, but FMS may also affect their social and emotional experiences and subsequent regulatory efforts. These differences in physical and emotional functioning may impact the extent to which NED may be differentially valuable for individuals with FMS or OA.

NED as Possible Explanation for Differences Between Functioning

Emotion differentiation has been linked with emotional and behavioral outcomes, yet there is a dearth of research examining ways in which NED may be a valuable resource for individuals with chronic pain. It is possible that NED may moderate the effects of daily pain on stress for patients with chronic pain in general, but it may also be differentially important depending on the nature of the pain condition. For example, it is possible that the poor functioning associated with FMS is a reflection of emotional disturbances that could be mitigated by higher levels of NED.

Research Questions and Hypotheses

The current study aims to use daily diary reports to examine the moderating effect of trait NED on the relationship between pain and daily stress in 259 patients diagnosed with OA or FMS. The study aims to expand the literature on adults with chronic pain conditions to understand the protective capacity that may be conferred by NED (Figure 1). Further, the study aims to evaluate whether NED is differentially protective against pain-related increases in daily experiences of stress for individuals with chronic pain due to OA versus FMS (Figure 2). Using OA as a comparison group will help identify if there

are differences among various types of chronic pain conditions and whether NED operates differently across groups.

The study aims and hypotheses are as follows:

Aim 1: The first aim is to assess the buffering effects of NED on the relationship between pain and stress across the two pain conditions.

Hypothesis 1: I hypothesize that daily increases in pain will result in higher reports of stress, averaging over levels of NED.

Hypothesis 2: I hypothesize that for individuals with higher levels of NED, reports of stress will be lower, averaging over levels of pain.

Hypothesis 3: I hypothesize that across groups, on days when individuals experience increased pain, those with higher versus lower levels of NED will show less pronounced increases in stress.

Aim 2: The second aim of this study is to examine group differences in the moderating effects of NED between individuals with FMS and OA. I will examine if NED differentially buffers the relations between increases in daily pain and same-day stress depending on the type of chronic pain. Due to the novel nature of these analyses, hypotheses are exploratory.

Method

Participants

Participants for the current study are 259 women with a physician-confirmed diagnosis of either FMS (n = 154) or OA (n = 105) recruited to participate in a longitudinal study of risk and protective factors that predict better adjustment among individuals with chronic pain. Participants were recruited from physicians' offices, senior citizen groups, mailings to members of the Arthritis Foundation, and advertisements around the Phoenix, Arizona metropolitan area. Eligibility requirements included being aged 18 or older and having a pain rating of >20 on a 0 to 100 scale, no diagnosed autoimmune disorder, and no involvement in litigation regarding their condition.

Procedure

Recruitment into the study took place between June 5, 2002 and March 28, 2008. All participants disclosed their diagnosis to the research staff and signed a Health Insurance Portability and Accountability Act (HIPAA) release form. The research staff then obtained a written confirmation of the participant's stated diagnosis and confirmed that the participant had no diagnoses of other autoimmune disorders. Participants were initially screened and later visited by a study clinician to verify FMS diagnosis by administering a tender point assessment. During a laboratory visit, participants were trained by a research assistant to complete daily diaries using a laptop computer loaned to them by the project. Participants were instructed to complete the diaries at the end of each day for 30 consecutive days. To ensure that data were only able to be entered on the correct day, date-checking software was installed on the laptop computers. The participants were provided with a phone number to reach laboratory staff in the case that a technical issue arose. If a laptop computer malfunctioned, a research assistant traveled

to the participant's home and provided a replacement. At the end of the 30-day period, a clinician visited the participants to debrief them and collected the laptop computers. Compensation of up to $90 was given to the participants for completion of the diary. Completion rates were high, with 92.5% of the participants completing 30 days of the daily diary.

Measures

Negative Emotion Differentiation

Negative affect was measured via an expanded version of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) as a part of the daily diary. Participants were asked to rate 16 negative affective states on a 5-point Likert scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*). General negative affective states assessed were hostile, irritable, ashamed, guilty, distressed, upset, scared, afraid, jittery, and nervous. Additional negative affective states included two items from the PANAS-X (Watson & Clark, 1994) sadness subscale (*i.e.*, sad, blue) and four items comprising the fatigue subscale (*i.e.*, sluggish, sleepy, drowsy, tired). An index of NED was obtained by computing the intraclass correlation coefficient (ICC) measuring the consistency of negative affect ratings for each individual across observations (Erbas et al., 2014). High intraclass correlations between negative affective states indicate low NED and low intraclass correlations indicate high NED. NED values were grand mean centered by subtracting the NED mean across the entire sample from each individual's NED score. Additionally, ICCs were not calculated when participants

reported *no* variance in negative emotions; for similar procedures, see Demiralp et al. (2012).

Negative Emotion Differentiation Composite

The Negative Emotion Differentiation Composite (NED composite) measure was calculated in a similar method to the aforementioned NED measure. However, prior to calculating ICCs, mean composite subscale scores were formed for synonymous affect terms. These composites are represented in Appendix C. 'Hostility' and 'irritability' were averaged and labeled as the Hostility subscale composite. 'Ashamed' and 'guilty' were averaged for the Guilt subscale composite. 'Scared', 'afraid', 'jittery', and 'nervous' were averaged together for the Fear subscale composite. The Sadness subscale composite was an average of 'sad' and 'blue'. The Fatigue subscale composite was a mean score of 'sluggish', 'sleepy', 'drowsy', and 'tired' and the General Negative Affect subscale composite was a mean score of 'distressed' and 'upset'.

Average Pain

Average pain was assessed daily in the diary component of the study. Participants were asked to "choose a number between 0 (*no pain*) and 100 (*pain as bad as it can be*) that best describes the average level of pain you have experienced today due to your Fibromyalgia syndrome or Osteoarthritis" (Jensen et al., 1986).

Negative Interpersonal Events

Negative interpersonal events were measured using 22 items from the Inventory of Small Life Events (ISLE; Zautra et al., 1986). At the end of each day, participants were asked to indicate which of the events from a list of discrete, small stressful events from within four interpersonal domains (spouse or significant other, friends, family members, and coworkers) they experienced that day. Study participants were able to select options stating that they did not have a spouse/partner or that they did not work/volunteer that day. See Appendix A for a list of items used. Each day, scores were summed to provide total number of negative life events per day, and then an average score for each participant across days was computed. For each individual observation, the participant's mean was subtracted from the daily score, providing a person-centered daily score that indexed within-person daily deviations in the occurrence of negative interpersonal events.

Perceived Interpersonal Stress

Perceived interpersonal stress was assessed using 4 items from the Inventory of Small Life Events (ISLE; Zautra et al., 1986). At the end of each day, participants were asked to rate the stressfulness of their social relationships in four interpersonal domains (spouse or significant other, friends, family members, and coworkers). For each domain, response options included 1 (*not at all*), 2 (*a little*), 3 (*moderately*), 4 (*extremely*), or "*no contact with (spouse/family or friends/coworkers*)". See Appendix B for a list of items used. Mean scores were computed to provide an average of perceived interpersonal stress across domains and days. For each individual observation, the participant's mean was

subtracted from the daily score, providing a person-centered daily score that indexed within-person daily deviations in perceived interpersonal stress.

Depressive Symptoms

Scores for depressive symptoms were measured using 9 items from The Hamilton Depression Inventory (Reynolds & Kobak, 1995). Participants were asked to report on the symptom of psychological aspects of depression over the past two weeks. Responses ranged from 0 (*not at all or rarely*) to 4 (*almost all the time*). Sum scores were calculated with higher scores indicating higher levels of depressive symptomatology.

Data Analytic Strategy

The distributional properties of key study variables and potential covariates (e.g., age, income, education, levels of depression) were examined prior to analyses. Skewed and kurtotic variables (skewness > 2; kurtosis > 7) were transformed prior to analyses and covariate variables were controlled for throughout analyses.

The repeated daily measurements included in this study formed a hierarchical nested data structure, with up to 30 daily observations (Level 1) nested within each participant (Level 2). Due to this design, multilevel analyses were conducted using SAS PROC MIXED Version 9.4, as recommended by Littell and colleagues (1998), to evaluate whether NED, daily pain, and their interaction predicted same-day negative interpersonal events and perceived interpersonal stress. This procedure is a useful approach for daily diary analyses with varying amounts of missing data because it omits missing data points without omitting cases. It also uses restricted maximum likelihood to

estimate model fit when data points are unbalanced between participants. Multilevel modeling also partitions the variance into two components: differences between persons in their average levels of the variables (Level 2), and differences within persons in their daily reports over time (Level 1). For each person, an average score for pain was computed across the 30 days for pain. Each person's average pain score was then subtracted from each of their daily pain scores, resulting in a set of up to 30 *deviation* scores for pain (Singer, 1998). These deviation scores, also termed person-centered scores, represent day-to-day within-person *change in pain* relative to an individual's average level of pain. Deviation scores are denoted hereafter by the Greek letter Δ. The primary Level 2 predictor variable of interest in the current analyses was NED (assessed in two ways: original scoring of ICCs based on procedures used in previous studies on NED (Matt et al., 2016; Seah et al., 2020) and scoring of ICCs using composites composed of items that are synonymous). The latter approach was used to assess whether the similarities among negative emotion items were influencing ICCs and their relation to other variables. NED variables were grand-mean centered, such that the sample NED means were subtracted from each person's NED scores.

To illustrate the analytic approach to test study hypotheses, the basic equation evaluating whether NED moderated the relation between pain-related changes in daily negative interpersonal events was as follows:

Negative interpersonal events = $b0 + b1$ (NED) + $b2$ (ΔPain) + $b3$ (NED X ΔPain) + r.

*b*0 represents an estimate of the intercept for negative interpersonal events. Coefficients b1-3 provide slope estimates of predictor variables, with slopes b1 testing between-person effects on negative interpersonal events, b2 the within-person effects on negative interpersonal events, and b3 differences in the pain-negative interpersonal events relations based on NED scores, respectively. The *r* indexes the within-person residual.

All multilevel analyses were conducted using the SAS (version 9.4) PROC MIXED software, which furnished parameters in the form of unstandardized restricted maximum likelihood estimates (β coefficients). These are partial correlations, adjusted for between-unit differences, which serve as useful effect size estimations of magnitude and direction of changes in dependent variables associated with changes in independent variables. For all analyses, intercepts were allowed to vary randomly, thereby allowing us to generalize the findings to the population of persons from which the sample was drawn and the populations of observations from which their daily reports were sampled. Autocorrelated residuals are a common consequence of equally spaced observations and can bias standard errors and significance levels; thus, a first order autoregressive term [i.e., AR(1)] was included in all models.

To test Aim 2, regarding the moderating effects of OA vs FMS status on the moderating effects of NED on the daily pain-stress relation, three-way multilevel interactions were tested. To probe the three-way interaction of pain (high vs low) x NED (high vs low) x diagnosis type (OA vs FMS) in association with same-day stress, I tested the simple slope of levels of pain (+/- 1 SD) across values of NED within the OA group

and the FMS group. This was conducted individually for each of the measures of stress (*i.e.*, total daily negative events and perceived interpersonal stress).

Finally, to assure that NED effects were not confounded with depressive symptomatology, the initial models were modified to include the main effects of depression as well as the interaction between depression and pain in the prediction of both negative interpersonal events and perceived interpersonal stress.

Results

Participants

The sample was entirely female, and the majority were Caucasian (89%), with an average age of approximately 57 years (*SD* = 8.38, range 37 to 72). Of the 259 participants, 154 (59%) were diagnosed with FMS and 105 (41%) were diagnosed with OA. Although some participants did not complete high school (2%), the majority of participants graduated from high school (15%), attended trade school (13%) or college (32%), graduated from college (12%) or obtained a post-graduate degree (23%). The average annual family income of the sample was between $25,000 and $29,999. The FMS and OA participants were comparable in income, education, relationship status and employment status (*t*s < -.04, *p*s > .97), but OA participants were older (*t*s > 4.54, *p*s < .001). The average age of participants with FMS was 55.36 years (*SD* = 8.23 years), while those with OA were 60.07 years old (*SD* = 7.77 years).

Descriptive Statistics and Intercorrelations Among Study Variables

Table 1 shows the general descriptive statistics of all Level 2 variables used in the analyses. Variables were normally distributed, except for negative interpersonal events which was slightly skewed. On average, people reported .79 negative interpersonal events daily and rated their daily level of perceived interpersonal stress as an average of 1.49 out of 4 over the course of the 30 days of diaries. Additionally, participants reported an average pain rating of 54.47 out of 100 daily over the course of the 30 days of diaries.

Table 2 shows all the intercorrelations among Level 2 variables used in the analyses. As expected, NED and the NED composite measure were positively correlated (r = .87, p < .01). NED was also positively correlated with Average Daily Pain (r = .13, p < .05) and negatively correlated with Average Daily Negative Events (r = -.15, p < .05). Similarly, the NED subscale measure was also negative correlated with Average Daily Negative Events (r = -.18, p < .01) and Average Perceived Stress (r = -.16, p < .05). Additionally, diagnosis type (0 = OA, 1 = FMS) was positively correlated with Average Daily Pain (r =.37, p < .01), Average Perceived Stress (r =.19, p < .01), and Average Daily Negative Events (r = .19, p < .01). Age was positively correlated with NED (r = .18, p <.01) and the NED composite measure (r = .22, p < .01) and negatively correlated with the remaining variables (rs between -.13 and -.37, ps < .05). Additionally, depression was correlated with all variables except the average number of negative interpersonal events (See Table 2 for correlations and p-values).

Table 3 depicts the intercorrelations among Level 1 variables. Findings showed that average daily pain was not correlated with the average number of negative interpersonal events, but was positively correlated with perceived interpersonal stress (r =

.08, p <.01). Furthermore, perceived interpersonal stress and negative interpersonal events were positively correlated with each other (r = .38, p < .01).

Preliminary analyses included mixed model regressions to account for the nesting of days within individual to identify potential covariates (age, income, education, and employment status) and each stress type (*i.e.,* Daily Negative Events and Daily Perceived Stress). Based on correlational analyses, age, income, education, diagnosis type, and levels of depression were controlled for in all analyses.

NED as a Moderator of Pain-related Changes in Number of Daily Negative Events

It was hypothesized that levels of NED would interact with changes in daily pain to predict changes in the number of daily negative interpersonal events, such that those with higher versus lower levels of NED would show smaller increases in negative interpersonal events on days of elevated pain. Findings are depicted in Table 4, Model 1. Results indicated that daily deviations in same-day pain did not significantly predict same-day negative interpersonal events $F(1, 6330) < 0.001$, $p = 0.95$, nor did levels of NED $F(1, 230) = -0.44$, $p = 0.09$. Similarly, the interaction between same-day pain and NED did not significantly predict same-day negative interpersonal events $F(1, 6330) = -0.006$, $p = 0.22$.

The second aim of the study sought to examine whether levels of NED would interact with changes in daily pain and diagnosis to predict changes in same-day stress. Results of exploratory analyses predicting the number of daily negative interpersonal events are depicted in Table 4, Model 2. Findings showed that the interaction between

levels of NED, daily pain, and diagnosis did not predict changes in the number of daily negative interpersonal events $F(1, 6328) = -0.006$, $p = 0.48$.

NED as a Moderator of Pain-related Changes in Levels of Perceived Stress

Next, analyses were conducted to test whether levels of NED interacted with changes in daily pain to predict changes in perceived interpersonal stress, such that those with higher versus lower levels of NED would show smaller increases in perceived interpersonal stress on days of elevated pain. Findings are reported in Table 5, Model 5. Results indicated that daily deviations in same-day pain significantly predicted same-day perceived stress $F(1, 6129) = 0.002$, $p < 0.0001$. However, levels of NED did not significantly predict same-day perceived stress $F(1, 230) = -0.137$, $p = 0.27$, nor did the interaction between same-day pain and levels of NED $F(1, 6129) = -0.002$, $p = 0.28$.

Furthermore, it was predicted that levels of NED would interact with changes in daily pain and diagnosis to predict changes in levels of perceived interpersonal stress, such that the buffering effects of NED on pain-related changes in levels of perceived stress would be stronger for those with FM versus OA. Findings are depicted in Table 5, Model 6. Findings indicated that the interaction between levels of NED, daily pain, and diagnosis did not significantly predict changes in levels of perceived stress $F(1, 6127) = -0.003$, $p = 0.51$.

In sum, findings were not consistent with study hypotheses. With regard to daily negative interpersonal events, NED did not predict daily negative interpersonal events, did not interact with changes in daily pain to predict negative events, and did not interact

with both daily pain and diagnosis to predict daily negative events. Similarly, with regard to daily perceived interpersonal stress, NED did not predict daily perceived interpersonal stress, did not interact with changes in daily pain to predict daily perceived interpersonal stress, and did not interact with both daily pain and diagnosis to predict daily perceived interpersonal stress.

NED Composite as a Moderator of Pain-related Changes in Number of Daily Negative Events

Similar to hypotheses involving the standard NED measure, it was predicted that levels of the NED composite score would interact with changes in daily pain to predict changes in the number of daily negative interpersonal events, such that those with higher versus lower levels of NED composite score would show smaller increases in negative interpersonal events on days of elevated pain. Findings are depicted in Table 4, Model 3. Results indicated that daily deviations in same-day pain did not significantly predict same-day negative interpersonal events $F(1, 6330) = 0.00$, $p = 0.82$. However, levels of the NED composite did significantly predict same-day negative interpersonal events $F(1, 230) = -0.44$, $p = 0.03$, such that those with higher NED composite scores reported fewer negative interpersonal events over the course of the 30 daily diaries. Contrary to prediction, the interaction between same-day pain and the NED composite did not significantly predict same-day negative interpersonal events $F(1, 6330) = -0.005$, $p = 0.11$.

It was also predicted that levels of the NED composite would interact with changes in daily pain and diagnosis to predict changes in the number of daily negative interpersonal events, such that the buffering effects of the NED composite on pain-related changes in negative interpersonal events would be stronger for those with FM versus OA. Results are depicted in Table 4, Model 4. Findings showed that the interaction between levels of the NED composite measure, daily pain, and diagnosis did not significantly predict changes in the number of daily negative interpersonal events $F(1, 6328) = -0.005$ $p = 0.48$.

NED Composite as a Moderator of Pain-related Changes in Levels of Perceived Stress

Next, I examined whether levels of the NED composite score would interact with changes in daily pain to predict changes in perceived interpersonal stress, such that those with higher versus lower levels of the NED composite would show smaller increases in perceived interpersonal stress on days of elevated pain. Findings are reported in Table 5, Model 7. Consistent with our hypotheses, results demonstrated that daily deviations in same-day pain significantly predicted same-day perceived stress $F(1, 6129) = 0.002$, $p < 0.0001$, as did levels of the NED composite $F(1, 230) = -0.282$, $p = 0.01$. Additionally, the interaction between same-day pain and levels of the NED composite was significant, indicating that levels of NED significantly moderated the relationship between same-day pain and same-day perceived interpersonal stress $F(1, 6129) = -0.005$, $p < 0.01$. The interaction is depicted in Figure 3, which shows that individuals with higher vs lower

levels of the NED composite reported lower levels of perceived interpersonal stress on days of higher-than-average pain.

Moreover, it was predicted that levels of the NED composite would interact with changes in daily pain and diagnosis to predict changes in levels of perceived stress, such that the buffering effects of the NED composite on pain-related changes in levels of perceived stress would be stronger for those with FM versus OA. Findings are depicted in Table 5, Model 8. Although daily pain $F(1, 6127) = 0.002$, $p = 0.01$ and diagnosis-type $F(1, 229) = 0.106$, $p = 0.04$ independently predicted changes in levels of perceived stress, results indicated that the interaction between levels of the NED composite, daily pain, and diagnosis did not significantly predict changes in levels of perceived stress $F(1, 6127) = -0.001$, $p = 0.83$.

In summary, the findings of analyses that employed the NED composite differed from those employing the traditional approach to computing NED scores. Specifically, the NED measure computed according to the traditional approach did not significantly predict negative interpersonal events or perceived interpersonal stress. Similarly, the interactions between the traditional NED measure and daily pain did not significantly predict negative interpersonal events or perceived interpersonal stress. However, the NED composite measure significantly predicted both negative interpersonal events and perceived interpersonal stress. Although the NED composite measure did not interact with daily pain to predict negative interpersonal events, the interaction did significantly predict perceived interpersonal stress.

Evaluating the Specificity of NED Effects Distinct from Depression

Post-hoc analyses were conducted to investigate whether NED was simply a confound for depression or if the effects conferred by NED were distinct from depression. First, analyses were conducted using the standard NED measure, depression, same-day pain and the number of total negative interpersonal events. Results are reported in Table 6 Model 9. In this model there were no significant main effects or interactions. Next, a similar model was constructed to examine whether the effects of the NED composite were distinct from depression in predicting negative interpersonal events. See Table 6 Model 10. Similar to Model 9, there were no significant main effects or interactions.

Analyses were also assessed using the standard NED measure, depression, same-day pain and levels of perceived interpersonal stress. See Table 7 Model 11 for results. Findings indicate significant main effects of depression $F(1, 223) = 0.029$, $p < 0.0001$ and pain $F(1, 6002) = 0.002$, $p < 0.0001$, but not NED $F(1, 223) = 0.044$, $p = 0.73$. Furthermore, the interactions between depression and pain $F(1, 6002) = 0.000$, $p = 0.19$ and same-day pain and NED $F(1, 223) = -0.001$, $p = 0.67$ were both non-significant. Similarly, when examining the same relationships using the NED composite measure (see Table 7 Model 12), the main effects of depression $F(1, 223) = 0.029$, $p < .0001$ and pain $F(1,6002) = 0.002$, $p < .0001$ were both significant. However, the depression by pain interaction was non-significant $F(1, 6002) = 0.000$, $p = 0.75$, whereas, contrary to analyses conducted using the standard NED measure, the pain by NED composite interaction significantly predicted changes in levels of perceived interpersonal stress $F(1,$

6002) = -0.004, p = 0.01. This suggests that although depression was a significant covariate, the NED composite significantly moderated the relationship between daily pain and same-day levels of perceived interpersonal stress such that those higher vs lower in levels of the NED composite reported lower levels of perceived interpersonal stress on days of higher-than-average pain.

Discussion

General Summary of Findings

This study aimed to evaluate the relation between NED and daily interpersonal stress. More specifically, this study tested whether NED buffers pain-related increases in same-day stress among women with chronic pain due to either FMS or OA. The findings presented in this study are consistent with a growing body of research in support of NED functioning as a protective factor (Zaki et al., 2013; Seah et al., 2020). Within-person differences were examined to look at the relation between daily experiences of chronic pain and stress, while between-person differences were probed to investigate the moderating effects of NED on the relationship between daily pain and same-day stress. Consistent with hypotheses, results indicated that among individuals with chronic pain due to FMS or OA, NED (assessed using affective composites) was associated with lower average levels of daily negative events and perceived interpersonal stress across the 30 daily diaries and buffered within-day associations between pain flares and perceived interpersonal stress. Contrary to expectation, NED (assessed via traditional scoring) was not associated with average number of negative interpersonal events over 30 days of

diaries and did not buffer pain-related increases in daily negative interpersonal events. Additional exploratory analyses comparing the NED buffering effects for women with FMS versus OA yielded no differences between groups. Finally, the buffering effects of NED on the pain-stress relation were not accounted for by levels of depressive symptoms.

Main Effects of NED

Consistent with prior studies, results from the current study revealed that NED significantly predicted psychosocial functioning (Israelashvili et al., 2019). Although the standard NED measure was not significantly predictive of either stress type, the NED composite measure significantly predicted both average daily negative interpersonal events and perceived interpersonal stress, such that those who were high (vs low) in the NED composite reported less interpersonal stress. High NED is generally understood to reflect an individual's ability to discern their own emotional experience, but it has also been shown to be related to better reading of emotions in others (Israelashvili et al., 2019). It is possible that higher levels of NED attenuate negative interpersonal experiences because the individual can not only identify their own emotions and regulate appropriately, but they can better understand the emotions of people around them. As such, it is possible that they are better able to validate others' experiences and deescalate conflict in doing so. Although it could be argued that being more attuned with others' emotional experiences could lead to negative outcomes (e.g., compassion fatigue), someone who is high in NED should, theoretically, still be able to identify and accurately regulate those negative emotional experiences, thus limiting the spill-over effect onto

interpersonal interactions. Moreover, it is also possible that experiencing higher levels of stress limits one's ability to differentiate their emotional experiences in the moment. For example, studies have shown that stress is associated with reduced cognitive resources such as impaired memory retrieval of affective terms (Kuhlmann et al., 2005) and a reduced working memory capacity (Klein & Boals, 2001). Additionally, Erbas and colleagues (2018) examined the effects of stress on NED and found that stress significantly predicted lower levels of state emotion differentiation in the following day. Unfortunately, those results did not replicate when examined over longer time periods, suggesting that more research is needed on the relevance of time on the relationship between stress and NED. However, it is possible that those with high *trait* NED may have the capacity to respond to pain and stress with higher *state* NED and, in turn, limit additional stress from arising.

Moreover, the NED composite measure showed to be more important for perceived interpersonal stress than it was for negative interpersonal events. This may be due to the specific negative interpersonal events that were captured in the Inventory of Small Life Events (ISLE). The ISLE focuses primarily on events over which the individual would have very little control (e.g., not being invited to a party given by friends, needing to work overtime when you didn't want to, having a friend/acquaintance not show up on time). Research has shown that perceived controllability influences the extent to which someone is negatively impacted by stressors (Peters et al., 1998). As such, it is possible that for a daily pain flare within the context of chronic pain, NED may

not be an effective buffer against interpersonal conflict events with which the individual has little control over.

Interaction Effects Pain x NED

Results showed that the NED composite measure significantly moderated the relationship between daily flares of pain and perceived interpersonal stress, such that on days of higher-than-average pain, those who were high (vs low) in NED reported lower levels of perceived interpersonal stress. This finding is consistent with those in the extant literature suggesting that NED may function as a protective trait. However, it remains unclear exactly how NED buffers the effects of pain-related increases in stress. One possible explanation is that NED may function on a neurocognitive level. For example, research has linked changes in emotion regulation mechanisms with increased ratings of pain affect, such that after a negative mood induction, activation in the inferior frontal gyrus and amygdala linked negative mood regulation with pain processing (Berna et al., 2010). It is possible that when pain and negative emotions increase, NED helps the individual discern whether the negative emotion is due to pain or other stimuli in the environment, such as interpersonal conflict.

Furthermore, higher levels of NED are related to lower levels of depressive symptoms (Starr et al., 2017) and it is possible that NED functions in a way that allows the individual to discern their negative emotions so that they do not fall into common thinking errors such as black-and-white thinking and rumination that might otherwise lead to negative interpersonal interactions. In fact, Zaki and colleagues (2013) found that

NED was protective against maladaptive coping behaviors in that it decreased rumination. This might also allow individuals to utilize more effective strategies to deal with their pain, as opposed to avoiding the pain entirely and potentially exacerbating it. Indeed, research has shown that lower levels of NED is related to ineffective use of emotion regulation strategies (Erbas et al., 2014), while high levels of NED are associated with less use of disengagement coping strategies such as avoidance (Brown et al., 2021). Moreover, in the context of chronic pain, research has shown that affective regulation buffers the effects of pain on negative and positive affect (Hamilton et al., 2005) and it is possible that NED functions in a similar way to affective regulation when buffering against pain-related increases in stress. For example, it has been shown that affective regulation is related to quicker recovery from negative affect (Hamilton et al., 2005) and it is possible that by better understanding one's negative experiences (e.g., pain or interpersonal stress), one can regulate their affect to produce similar positive outcomes. Likewise, it is possible that NED functions similarly to mood clarity, or the extent to which one believes that they are clear about their feelings, in that it may assist preservation of positive affect in a way that maintains positive engagement with interpersonal relationships despite experiencing pain flares (Zautra et al., 2001).

Pain and Stress

This study supports evidence showing that pain is related to stress (Friborg et al., 2006). More specifically, results indicated that pain significantly predicted perceived interpersonal stress. This may be due to the shared commonalities among physical and social pain. For example, Sturgeon and Zautra (2016) created a conceptual model of

shared mechanisms between social pain (e.g., alienation, criticism, exclusion) and physical pain (acute and chronic) and related both types of pain to such mechanisms as neural activation, affective states, cognitive behavioral responses, and social relationships. Given this overlap of social and physical pain, it is plausible that pain is related to perceived interpersonal stress. Moreover, given the cognitive, neural, and affective mechanisms, one could predict that the relationship between pain and stress would be particularly strong for perceived stress, in that the perception of such experiences would also involve similar mechanisms.

However, it is also important to note than average daily pain was not significantly related to negative interpersonal events. This may be due to the fact that this sample reported relatively few negative events each day, with the majority of participants reporting less than one negative interpersonal event each day. Prior research suggests that chronic pain populations experience increased stress relative to individuals without chronic pain (Cathcart & Pritchard, 2008; Benedittis & Lorenzetti, 1992; Lampe et al., 2003); however, people generally do not report a substantial number of interpersonal events on a day-to-day basis (Chiang et al., 2018). This study focused on interpersonal events, which tend to be the most meaningful for people. However, it is possible that the measure of negative interpersonal events was too specific and did not capture all possible experiences of daily hassles such as traffic, bills, or home maintenance. Furthermore, this finding supports prior research indicating that subjective reports of stress (*i.e.*, perceptions of stressfulness) might be more important than objective measures (*e.g.*,

occurrence of stressful events) in the context of psychosocial functioning (Lakey & Cassady, 1990).

Moderation Effects of Diagnosis

The exploratory analyses evaluating whether the buffering effects of NED were differentially important depending on the chronic pain condition yielded nonsignificant results. Since there is little literature on NED as a buffer against the negative effect of pain flares, including those experienced by individuals with FMS or OA, no hypotheses were proposed regarding which chronic pain condition would be more impacted by the effects of NED. Nevertheless, these two pain conditions are associated with differences in social and psychological functioning. For example, studies suggest that difficulties in psychological functioning for those with FMS might be due to deficits in emotional processing (Kashikar-Zuck et al., 2008), highlighting the possibility of a stronger need for NED among FMS versus OA sufferers. These functional differences are also evidenced in additional studies. For example, in a study inducing negative mood, researchers found that women with FMS are more vulnerable to negative effects of interpersonal stress than women with OA (Davis et al., 2001). More specifically, that study found that women with FMS experienced higher stress-related increases in pain and stronger decreases in positive affect during the induction, than women with OA. Similarly, women with FMS reported more frequent use of avoidant coping with pain and experienced perceived deficits in their social environment, such that they reported having fewer individuals in their social network and experienced greater negative social interactions (Davis et al., 2001) Additionally, compared to women with OA, women with

FMS also tend to experience greater deficits in positive affect overall and exhibit a lower ability to sustain positive affect from day to day (Finan et al., 2009). In line with previous findings, the current study showed that FMS was significantly related to stress and depressive symptoms, such that those with FMS reported more stress and more depressive symptoms. This may be due to a deficit in positive affect for those with FMS as evidenced in prior research (Zautra et al. 2005). This deficit may suggest that although NED is equally relevant for negative affective states in FMS and OA, for those with FMS there may be a larger problem due to positive affective system deficits that may be better explained by examining positive emotion differentiation or outcomes of positive affect. Moreover, the current results evidenced that NED was not significantly related to diagnosis-type. Although NED may be equally relevant for those with FMS and OA in regard to buffering pain-related negative affective experiences, such as interpersonal stress, it is possible that NED may be more relevant for maintaining positive affect in the context of chronic pain and future research would benefit from examining such relations.

NED Main Effects in Context of Age

Lifespan studies have shown that NED changes throughout the lifespan (Nook et al., 2018), with higher levels of NED in childhood and adulthood, but dips in adolescence. Furthermore, studies also suggest that emotion differentiation in adulthood tends to increase with age (Carstensen et al., 2000). Consistent with prior studies, preliminary analyses suggested that age was positively related to NED, suggesting that adults get more differentiated in their negative emotion experiences as they age. As such, age was included in all analyses. Furthermore, all models showed that age significantly

predicted stress, such that those who were older reported less perceived interpersonal stress and fewer negative interpersonal events. These findings are consistent with the socioemotional selectivity theory (Carstensen et al., 2003), which suggests that as individuals age, they become more selective of their social networks and surround themselves with fewer relationships to which they can devote more emotional resources to. As a result, older individuals are typically surrounded by fewer stressful relationships, which provides a plausible explanation for why the older individuals in this sample reported less stress. Similarly, results also indicated that the NED composite negatively predicted both negative interpersonal events and perceived interpersonal stress, suggesting that those who are higher in the NED composite reported less stress, in terms of observable negative events and the perception of stressful interpersonal experiences. Together, these findings provide a plausible explanation for how socioemotional selectivity theory may function. For example, it may be that age-related increases in levels of emotion differentiation allow individuals to better understand their emotional experiences and more precisely select who they engage with interpersonally. Although our results are not able to empirically support this idea, future research using longitudinal designs would provide the opportunity to examine whether NED mediates the relationship between age and interpersonal stress.

Finally, additional analyses were conducted to examine whether NED was simply a proxy for depression, since preliminary analyses showed that NED was negatively correlated with depression. These correlations were also consistent with the literature suggesting that those with low NED tend to experience more depressive symptoms (Starr

et al., 2017; Demiralp et al., 2012). Results indicated that when adding depressive symptoms into the model, depressive symptoms significantly predicted perceived interpersonal stress, while the NED composite measure no longer significantly predicted perceived interpersonal stress. This suggests that at the between-person level, the relation between NED and perceived interpersonal stress appear to be due to depressive symptoms. However, the buffering effects of NED were still maintained in the pain-NED composite interaction despite including depressive symptoms and the depressive symptoms X pain term in the models. This suggests that when people have chronic pain flares, NED, independent of depressive symptoms, is able to buffer against pain-related increases in perceived interpersonal stress. As such, this demonstrates that although NED and depression overlap, NED is able to make unique contributions to within-day regulation of interpersonal stress for those with chronic pain.

Limitations

This study has many strengths including 1) assessing a sample of women with pain from two distinct pain conditions and from diverse backgrounds (e.g., SES, education obtainment); 2) the use of two stress measures, one capturing discrete interpersonal events and the other measuring perception of general interpersonal stress; 3) ecologically-valid assessments of within-person processes over 30 days; and 4) high compliance with diary assessments. However, the study is not without some limitations. For example, although the daily diaries are more reliable because they were obtained over the course of 30 days, the data are still based on self-reports and thus influenced by individual biases. Similarly, depressive symptoms were assessed via self-reports using

only 9 items, which does not capture diagnosed depression. However, there is evidence to suggest that subjective appraisals are more important than objective measures when trying to assess psychosocial functioning (Lakey & Cassady, 1990). Additionally, pain was only assessed at one time per day, thus, it is possible that the responses were impacted by recall bias and/or the current state of pain when completing the daily diary. Furthermore, although the diary assessments span up to 30 days, the data are still cross-sectional and the results are unable to determine causal effects.

There are also limitations in the measurements of NED used in this study. For example, negative emotions were only rated once a day, whereas many studies using ecological momentary assessments for NED typically obtain multiple reports each day (Lindquist & Barrett, 2008; Smidt & Suvak, 2015; Dasch et al., 2010; Kashdan et al., 2010). Although assessing emotion at multiple time-points within each day may provide a slightly more nuanced report, various studies examining emotion differentiation have utilized the methodology applied in the current study (Willroth et al., 2020, Pond et al., 2012). Furthermore, Schneider and colleagues (2020) compared ecological momentary assessments and end-of-day reports of emotions and found that the two methodologies demonstrated moderate-to-high correspondence for emotion levels, variability, instability, and mixed emotions.

Additionally, this is the first time, to my knowledge, that NED has been calculated using mean composite scores prior to running ICCs. Although conceptually there is nothing to suggest that the two measures are examining separate constructs, it is possible that the NED composite measure is tapping into something slightly different.

However, when examining differences between the two NED measures it is apparent that both measures behave in similar manners. For example, both measures were negatively related to perceived interpersonal stress, negative interpersonal events, and depressive symptoms with similar strengths. Similarly, the main effects of both NED measures on perceived interpersonal stress and negative interpersonal events were in the same direction and of similar magnitude. The only difference is that the NED composite measure was a better predictor of stress in that it more often reached significance. This suggests that the NED composite measure may be a more reliable measure overall due to the mean composite scores being more internally reliable and therefore eliciting more power to detect significant effects.

Additionally, this sample consisted primarily of white, middle-class women which might further limit the generalizability of the study's findings. However, chronic pain prevalence rates have shown to exhibit sex differences (Mogil, 2012), with studies suggesting that 80-90% of fibromyalgia diagnoses occur in women (Wolfe et al. 2018, Yunus, 2001). Moreover, in a review of gender differences in clinical pain, Unruh (1996) found that women tend to report higher pain severity, more frequent pain, and longer pain duration than do men. Gender may also impact the utilization of pain coping strategies, with women reporting greater use of efforts to seek out social support, palliative behaviors, positive self-statements, and problem solving than do men (Unruh et al., 1999). Additionally, survey reports indicate that 46% of individuals surveyed with fibromyalgia consulted with three to six healthcare providers prior to receiving a diagnosis (Annemans et al., 2009). Given the time and resources necessary to access such

a large number of healthcare providers, it is possible that our affluent sample simply had sufficient resources to obtain a physician-confirmed diagnosis, a requirement necessary for inclusion in the study.

Moreover, the analytic approach involved multiple analyses (i.e., analyses for NED and NED composite measures), raising concerns about familywise error. The extent to which the findings are replicable remains to be determined. Nevertheless, although the analyses were repeated with two similar moderators, results involving both moderators displayed effects in the same directions as expected. Even though the majority of the analyses involving the standard NED measure did not yield significant effects, there is still a trend of negative relationships, such that those with higher NED tended to report lower levels of interpersonal stress.

Finally, the effect sizes exhibited in this study are relatively small. However, it is important to note that these analyses were on the daily level. It is possible that NED may have a small buffering effect on day-to-day life, but these small influences over many years may result in a stronger impact. This would be in-line with the theory of allostatic load (Goldstein & McEwen, 2002), in that stress over time can create more wear and tear on the body. Similarly, it is possible that the buffering effects of NED overtime may prevent negative outcomes associated with allostatic load (e.g., cardiovascular disease, functional decline). In support of this idea, Seeman and colleagues (2002) longitudinally followed adults and found that positive relationship experiences overtime was associated with lower allostatic load.

Future Directions

Results from the current study suggest that NED is a protective factor for individuals with FMS and OA in relation to interpersonal stress. To my knowledge, no other studies have examined the buffering effects of NED for those with chronic pain. Since two very different chronic pain conditions benefitted from NED similarly, it is reasonable to assume that other chronic pain conditions will also benefit from these effects. However, it is also plausible that not all chronic pain conditions would be impacted by NED in the same way. For example, it is possible that the periodic experience of chronic migraines may benefit more from a refined in-the-moment discernment of pain versus negative emotions than a more continuous experience of pain such as chronic back pain. As such, future studies may compare other types of pain conditions (e.g., migraine headaches, chronic back pain, cancer-related pain, neurogenic pain) to see if NED differentially impacts physical and/or psychosocial functioning. Additionally, studies could build upon the findings of this study by seeing if NED is important for other non-self-report measures of stress. For example, studies could look at objective measures of physiological stress such as cortisol and heart rate variability to examine whether the buffering effects of NED go beyond the subjective experiences of interpersonal stress. Moreover, the literature on NED would benefit from examining whether NED impacts other types of stress, such as financial stress or discrimination. Furthermore, NED may differentially impact various relation types and future research could compare whether interpersonal stress stemming from work relationships differed from interpersonal stress among spouses and/or friendships. Future studies could also

build upon this study design by utilizing cross-lagged effects to see if NED is also protective for next-day experiences of stress. Future studies may also build upon current literature on emotion differentiation interventions which suggest that NED is malleable and capable of increasing (Van der Gucht et al., 2019; Widdershoven et al., 2019; Hoemann et al., 2021) by seeing the extent to which these findings apply to chronic pain populations. Future interventions could also emphasize learning to better discern negative emotions due to stress versus pain flares for those with chronic pain. Finally, this study only examined whether NED impacted negative indicators of well-being and future studies with chronic pain populations might consider whether positive indicators, such as daily experiences of positive affect, would also benefit from NED. These findings would enrich the NED literature by providing insight into whether NED also has implications for thriving.

In conclusion, NED may be beneficial for chronic pain patients when experiencing pain flares in that it buffers the effects of pain flares on same-day interpersonal stress. However, these findings are not unique to FMS or OA. Future work is required to further specify the impact of NED on other outcomes of well-being for those with chronic pain.

Table 1. *Descriptive Statistics and Participant Demographics*

		n	*%*	*M*	*SD*	*Skew*	*Kurtosis*
NED		258		0.36	0.21	0.95	0.33
NED Composite		258		0.56	0.25	0.22	-1.08
Daily Perceived Stress		253		1.49	0.61	1.47	2.11
Total Negative Events		259		0.79	0.82	2.18	5.98
Average Daily Pain		259		54.47	17.42	-0.36	0.12
Depressive Symptoms		250		8.30	5.36	0.94	0.43
Age		250		57.34	8.38	-0.26	-0.68
Education		249					
	5-8 years	2	0.8				
	High school incomplete	2	0.8				
	High school complete	38	15.3				
	Post high school	34	13.7				
	1-3 years college	82	32.9				
	4 years college	32	12.9				
	Post graduate college	59	23.7				
Marital Status		252					
	Never Married	11	4.4				
	Married	140	55.6				
	Widowed	30	11.9				
	Divorced	62	24.6				
	Separated	2	0.8				
	Romantic partner	7	2.8				
Employment		251					
	Full-time	78	31.1				
	Part-time	62	24.7				
	Unemployed/retired	111	44.2				
Income		241					
	Less than $15,000	34	14.1				
	$15,000 – 24,999	29	12.0				
	$25,000 – 49,999	78	32.4				
	$50,000 – 69,999	43	17.8				
	$70,000 or more	57	23.7				
Ethnicity (*N* = 249)							
	Caucasian	222					
	Black	8					
	Asian	0					
	Hispanic	9					
	Native American	0					
	Pacific Islander	0					
	Multiracial/Other	10					

Table 2. *Intercorrelations Among Between-person (Level 2) Variables*

	1	2	3	4	5	6	7	8	9
1. NED	-								
2. NED Composite	.87**	-							
3. Daily Pain	.13*	-.02	-						
4. Perceived Stress	-.09	-.16*	.20**	-					
5. Negative Events	-.15*	-.18**	.06	.32*	-				
6. Diagnosis	-.01	-.03	.37**	.19**	.19**	-			
7. Income	-.09	-.02	-.09	-.13*	.13*	.00	-		
8. Age	.18**	.22**	-.15*	-.13*	-.37**	-.27**	-.14*	-	
9. Education	-.04	.01	-.10	.04	.12*	-.03	.19**	-.12	-
10. Depressive Symptoms	-.21**	-.31**	.38**	.25**	.12	.28**	-.21**	-.13*	-.19**

Note. * $p < .05$. ** $p < .01$. NED (Negative Emotion Differentiation) = Intraclass correlation coefficients representing the proportion of variance at the within-person level. NED composite = Intraclass correlation coefficients using composite means. Daily Pain = mean scores of daily pain, averaged across diary days. Perceived Stress = mean scores of daily perceived stress, averaged across diary days. Negative Events = mean scores of daily negative interpersonal events, averaged across diary days. Diagnosis was coded 0 = osteoarthritis and 1 = fibromyalgia. The sample size ranged from 235 to 250 for correlations due to missing data.

Table 3. *Intercorrelations Among Within-person (Level 1) Variables*

	1	2	3
1. Δ Daily Pain	-		
2. Δ Negative Events	.00	-	
3. Δ Perceived Stress	.08**	.38**	-

Note. * $p < .05$. ** $p < .01$. Δ Daily Pain = person-centered scores of average daily pain. ΔNegative Events = person-centered scores of daily negative interpersonal events. ΔPerceived Stress = person-centered scores of daily perceived stress. The number of observations used for correlations ranged between 6944 and 7134.

Table 4. *Standardized estimates of effects of predictors and covariates on same-day negative interpersonal events.*

	Variable	β	*SE*	DF	t Value	*p*
Model 1						
	Intercept	2.074	0.510	230	4.07	<.0001
	Pain	0.000	0.000	6330	0.06	0.95
	NED	-0.443	0.257	230	-1.73	0.09
	Pain x NED	-0.006	0.005	6330	-1.23	0.22
	DX	0.169	0.108	230	1.57	0.12
	Age	**-0.031**	0.007	230	-4.71	**<.0001**
	Education	0.037	0.037	230	1.00	0.32
	Income	0.013	0.012	230	1.07	0.29
Model 2						
	Intercept	2.070	0.510	229	4.05	<.0001
	Pain	0.000	0.001	6328	-0.19	0.85
	NED	-0.360	0.400	229	-0.91	0.36
	DX	0.169	0.108	229	1.57	0.12
	Pain x NED	-0.002	0.006	6328	-0.34	0.74
	Pain x DX	0.000	0.002	6328	0.26	0.79
	NED x DX	-0.141	0.512	229	-0.27	0.78
	Pain x NED x DX	-0.006	0.009	6328	-0.71	0.48
	Age	**-0.031**	0.007	229	-4.70	**<.0001**
	Education	0.037	0.037	229	0.99	0.32
	Income	0.014	0.013	229	1.09	0.28
Model 3						
	Intercept	1.972	0.514	230	3.84	<.001
	Pain	0.000	0.000	6330	0.23	0.82
	NED composite	**-0.443**	0.209	230	-2.12	**0.03**
	Pain x NED composite	-0.005	0.003	6330	-1.59	0.11
	DX	0.169	0.107	230	1.58	0.12
	Age	**-0.030**	0.007	230	-4.51	**<.0001**
	Education	0.040	0.037	230	1.08	0.28
	Income	0.015	0.012	230	1.21	0.23
Model 4						
	Intercept	1.978	0.516	229	3.81	<.001
	Pain	0.000	0.001	6328	-0.09	0.93
	NED composite	-0.410	0.302	229	-1.36	0.18
	DX	0.170	0.107	229	1.58	0.12
	Pain x NED composite	-0.003	0.005	6328	-0.63	0.53
	Pain x DX	0.000	0.002	6328	0.26	0.79
	NED composite x DX	-0.063	0.409	229	-0.15	0.88
	Pain x NED composite x DX	-0.005	0.007	6328	-0.71	0.48
	Age	**-0.030**	0.007	229	-4.49	**<.0001**
	Education	0.040	0.037	229	1.07	0.29
	Income	0.015	0.012	229	1.22	0.22

Table 5. *Standardized estimates of effects of predictors and covariates on same-day perceived interpersonal stress.*

	Variable	β	*SE*	DF	t Value	*p*
Model 5						
	Intercept	2.151	0.247	230	8.72	<.0001
	Pain	**0.002**	0.000	6129	5.50	**<.0001**
	NED	-0.137	0.124	230	-1.10	0.27
	Pain x NED	-0.002	0.002	6129	-1.09	0.28
	DX	0.102	0.052	230	1.96	0.06
	Age	**-0.010**	0.003	230	-3.16	**0.002**
	Education	0.006	0.018	230	0.36	0.72
	Income	**-0.016**	0.006	230	-2.59	**0.01**
Model 6						
	Intercept	2.150	0.247	229	8.69	<.0001
	Pain	**0.002**	0.001	6127	2.52	**0.01**
	NED	-0.121	0.192	229	-0.63	0.53
	DX	0.102	0.052	229	1.95	0.06
	Pain x NED	0.001	0.003	6127	-0.21	0.83
	Pain x DX	0.001	0.001	6127	1.61	0.11
	NED x DX	-0.028	0.248	229	-0.11	0.91
	Pain x NED x DX	-0.003	0.004	6127	-0.66	0.51
	Age	**-0.010**	0.003	229	-3.15	**<0.01**
	Education	0.006	0.018	229	0.36	0.72
	Income	**-0.016**	0.006	229	-2.56	**0.01**
Model 7						
	Intercept	2.047	0.246	230	8.32	<.0001
	Pain	**0.002**	0.000	6129	5.73	**<.0001**
	NED composite	**-0.282**	0.100	230	-2.82	**0.01**
	Pain x NED composite	**-0.005**	0.002	6129	-3.03	**<0.01**
	DX	**0.105**	0.051	230	2.05	**0.04**
	Age	**-0.009**	0.003	230	-2.73	**<0.01**
	Education	0.009	0.018	230	0.49	0.62
	Income	**-0.015**	0.006	230	-2.52	**0.01**
Model 8						
	Intercept	2.043	0.247	229	8.28	<.0001
	Pain	**0.002**	0.001	6127	2.76	**0.01**
	NED composite	-0.249	0.144	229	-1.72	0.09
	DX	**0.106**	0.051	229	2.05	**0.04**
	Pain x NED composite	-0.004	0.002	6127	-1.92	0.06
	Pain x DX	0.001	0.001	6127	1.43	0.15
	NED composite x DX	-0.063	0.196	229	-0.32	0.75
	Pain x NED composite x DX	-0.001	0.003	6127	-0.21	0.83
	Age	**-0.009**	0.003	229	-2.70	**0.01**
	Education	0.009	0.018	229	0.48	0.63
	Income	**-0.015**	0.006	229	-2.47	**0.01**

Table 6. *Standardized estimates of effects of predictors including depression and covariates on same-day negative interpersonal events.*

	Variable	β	*SE*	DF	t Value	*p*
Model 9						
	Intercept	1.973	0.523	223	3.77	0.0002
	Depressive Symptoms	0.009	0.011	223	0.86	0.39
	Pain	0.000	0.001	6195	0.01	0.99
	NED	-0.405	0.274	223	-1.48	0.14
	Depression x Pain	0.000	0.000	6195	-0.23	0.82
	Pain x NED	-0.006	0.005	6195	-1.31	0.19
	DX	0.143	0.114	223	1.26	0.21
	Age	**-0.030**	0.007	223	-4.51	**<.0001**
	Education	0.044	0.038	223	1.16	0.25
	Income	0.015	0.013	223	1.17	0.24
Model 10						
	Intercept	1.902	0.525	223	3.62	<0.001
	Depressive Symptoms	0.007	0.011	223	0.63	0.53
	Pain	0.000	0.001	6195	0.19	0.85
	NED composite	-0.410	0.224	223	-1.83	0.07
	Depression x Pain	0.000	0.000	6195	-0.52	0.60
	Pain x NED composite	-0.006	0.004	6195	-1.69	0.09
	DX	0.149	0.113	223	1.32	0.19
	Age	**-0.029**	0.007	223	-4.36	**<.0001**
	Education	0.046	0.038	223	1.20	0.23
	Income	0.016	0.013	223	1.25	0.21

Table 7. *Standardized estimates of effects of predictors including depression and covariates on same-day perceived interpersonal stress.*

	Variable	β	*SE*	DF	t Value	*p*
Model 11						
	Intercept	1.911	0.238	223	8.03	<.0001
	Depression	**0.029**	0.005	223	5.66	**<.0001**
	Pain	**0.002**	0.000	6002	5.64	**<.0001**
	NED	-0.044	0.125	223	0.35	0.73
	Depression x Pain	0.000	0.000	6002	1.32	0.19
	Pain x NED	-0.001	0.002	6002	-0.43	0.67
	DX	0.022	0.052	223	0.43	0.67
	Age	**-0.008**	0.003	223	-2.76	**0.01**
	Education	0.022	0.017	223	1.24	0.22
	Income	-0.008	0.006	223	-1.28	0.20
Model 12						
	Intercept	1.863	0.239	223	7.79	<.0001
	Depression	**0.026**	0.005	223	5.12	**<.0001**
	Pain	**0.002**	0.000	6002	5.73	**<.0001**
	NED composite	-0.117	0.102	223	-1.14	0.25
	Depression x Pain	0.000	0.000	6002	0.32	0.75
	Pain x NED composite	**-0.004**	0.002	6002	-2.51	**0.01**
	DX	0.031	0.052	223	0.61	0.54
	Age	**-0.008**	0.003	223	-2.47	**0.01**
	Education	0.022	0.017	223	1.25	0.21
	Income	-0.008	0.006	223	-1.40	0.16

Figure 1. *Model A Examining the Moderating Effects of NED on the Relationship Between Pain and Stress*

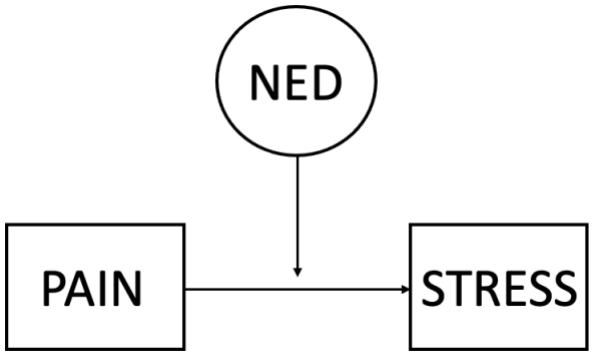


Figure 2. *Model B Examining Group Differences (Diagnosis Type) in the Moderating Effects of NED*

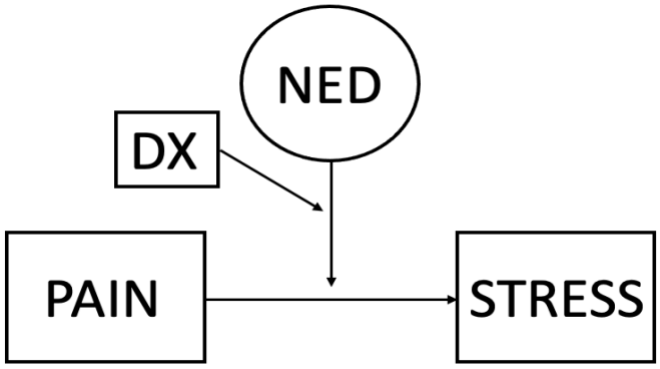
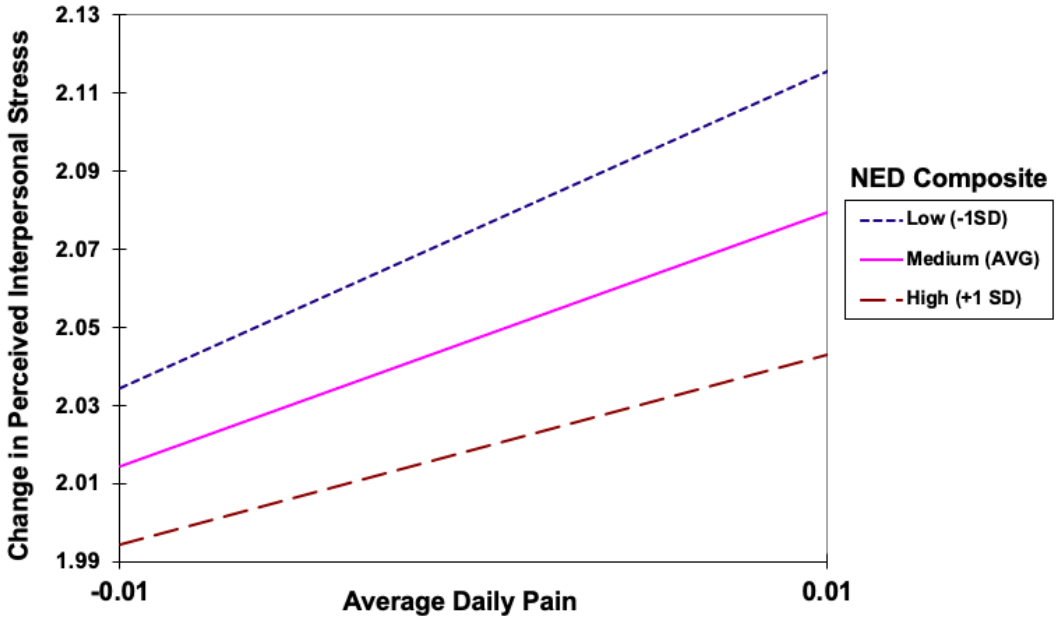


Figure 3. *Plot of NED Composite by Daily Pain Interaction in the Prediction of Perceived Stress*



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APPENDIX A

ITEMS USED FOR NEGATIVE INTERPERSONAL EVENTS

Appendix A: Items used for *Negative Interpersonal Events*

Have you…

Had a friend/acquaintance not return your call	Yes	No
Had a friend/acquaintance not show up on time	Yes	No
Been criticized by friend/acquaintance	Yes	No
Argued with friend/acquaintance	Yes	No
Met an unfriendly or rude person	Yes	No
Not been invited to party given by friends	Yes	No
Argued with a spouse/partner	Yes	No
Been critical of spouse/partner	Yes	No
Been criticized by spouse/partner	Yes	No
Had your spouse/partner stopped being affectionate	Yes	No
Been criticized or blamed for something by a family member	Yes	No
Had an argument with a family member	Yes	No
Had to work overtime when you didn't want to	Yes	No
Had people under your supervision failed to get work done	Yes	No
Been criticized by your superior at work	Yes	No
Had added pressure to work harder and faster	Yes	No
Disagreed with others about your job assignments	Yes	No
Gotten negative feedback about job performance review	Yes	No

APPENDIX B

ITEMS USED FOR PERCEIVED INTERPERSONAL STRESS

Appendix B: Items used for *Perceived Interpersonal Stress*

Overall, how stressful were your relations with your friends today?	Not at all	A little	Moderately	Extremely	No contact with friends
Overall, how stressful were your relations with your spouse/partner today?	Not at all	A little	Moderately	Extremely	No contact with spouse/partner
Overall, how stressful were your relations with your family today?	Not at all	A little	Moderately	Extremely	No contact with family
Overall, how stressful were your relations with your co-workers today?	Not at all	A little	Moderately	Extremely	I did not work today

APPENDIX C

COMPOSITES USED IN THE CALCULATION OF THE NED COMPOSITE

Appendix C: *Composites used in the calculation of the NED composite*

"Hostility" composite
Hostile
Irritable
"Guilt" composite
Ashamed
Guilty
"General Negative Affect" composite
Distressed
Upset
"Fear" composite
Scared
Afraid
Jittery
Nervous
"Sadness" composite
Sad
Blue
"Fatigue" composite
Sluggish
Sleepy
Drowsy
Tired