Resilience and Vulnerability Mechanisms in the

Within-Day Pain Coping Process: Test of a Two-Factor Mediation Model

By

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ABSTRACT

Current models of pain coping typically focus on how pain contributes to poor physical and psychological functioning. Researchers have argued that this focus on the negative consequences is too narrow and does not account for times when individuals are able to maintain meaningful functioning despite their pain. Thus, the current study sought to investigate the day-to-day processes that both help and hinder recovery from pain and persistence towards daily goals. Specifically, the present study tested: a) a two-factor model of risk and resilience "factors" that capture key processes across affective, cognitive and social dimensions of functioning, and b) whether the relation between morning pain and end-of-day physical disability is mediated by increases in these afternoon risk and resilience factors. Within-day study measures were collected for 21 days via an automated phone system from 220 participants with Fibromyalgia. The results of multi-level confirmatory factor analysis indicated that, consistent with prediction, risk and resilience do constitute two factors. Findings from multilevel structural equation models also showed resilience factor mediated the link between late morning increases in pain and end-of-day disability, in line with hypotheses. Although the vulnerability factor as a whole did not mediate the within-day link between pain and disability, pain-catastrophizing individually did serve as a significant mediator of this relation. This study was the first to empirically test a within-day latent factor model of resilience and vulnerability and the first to capture the multidimensional nature of the pain experience by examining mechanisms across affective, cognitive and social domains of functioning. The findings of the current study suggest that in addition to studying the processes by which pain has a negative influence on the lives of pain sufferers, our

understanding of the pain adaptation process can be further improved by concurrently examining mechanisms that motivate individuals to overcome the urge to avoid pain and to function meaningfully despite it.

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INTRODUCTION

Chronic pain is a burdensome and complex medical condition that is characterized by considerable physical dysfunction, psychological distress and negative social consequences. In addition to the unpleasant physical sensations, the persistent and often unpredictable nature of pain in these conditions also evokes maladaptive affective and cognitive responses that disrupt daily life activities and pursuit of valued goals. The disabling nature of chronic pain contributes to substantial costs at the personal and the societal level in the form of loss of employment and income for individuals living with chronic pain, and an estimated $100 billion annual loss in productivity among active US workers (Gaskin & Richard, 2012). Although the aversive sensory aspect of pain may be the most acutely distressing aspect of living with chronic pain, the day-to-day functional impairments and disability often reported by individuals with various pain conditions may be a more significant contributor to lower overall quality of life (Rupp et al., 2006; Huisstede et all, 2008; Picavet & Hoeymans, 2004). Despite the well-established association between chronic pain and physical disability, relatively little is known about *how* an individual's day-to-day pain coping responses contribute to functional limitations (Wideman et al., 2013; Gheldof et al., 2010; Crombez et al., 2012).

Over the past three decades, researchers have come to recognize pain as a multidimensional construct, extending models of pain beyond the sensory-physical experience to incorporate the cognitive, affective and social components of living with chronic pain (Arewasikporn, Davis & Zautra, 2012; Zautra, 2014; Sturgeon & Zautra, 2016). Additionally, recent findings have highlighted the substantial within- and between-person variability in how individuals react to and recover from pain episodes on

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a daily basis (Zautra, Johnson & Davis, 2005; Gil et al., 2004; Holtzman & DeLongis, 2007; Sturgeon & Zautra, 2013). These studies show that although pain flares can contribute to impairments in physical, emotional and social functioning, many individuals with chronic pain are also able to successfully adapt to their pain and continue to participate in important activities and maintain social relationships. Therefore, identifying both adaptive and maladaptive day-to-day responses to pain across multiple domains of functioning, including affective, cognitive and social, is a step towards developing more effective intervention strategies to prevent daily disability and improve functional health of individuals living with chronic pain.

Resilience and Vulnerability as Distinct Processes

Research in individuals with chronic pain has traditionally focused on studying risk factors that are associated with poor adjustment to pain such as maladaptive thoughts and behaviors. Although this approach of studying detrimental factors has yielded important insights into the negative consequences of long-term pain, over the past decade, researchers have emphasized the importance of also studying resilience factors that contribute to positive adaptation in the face of pain and stress (Karoly & Ruehlman, 2006; Sturgeon & Zautra, 2010; Zautra, Johnson & Davis, 2005). Despite the aversive and intrusive nature of pain, many individuals are still able to successfully adapt and maintain functioning. By examining resilience processes, we may be able to determine whether adaptive factors that allow individuals to persist despite pain account for daily functional health independent of vulnerability factors that prevent people from performing daily activities.

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Although definitions vary, resilience is commonly referred to as the process of sustaining positive adaptation (e.g., maintaining relatively stable, healthy levels of physical and psychological functioning) despite the presence of significant adverse circumstances (Luthar & Cicchetti, 2000). For the purposes of the current study, resilience is defined as a construct reflecting processes that facilitate adaptive coping responses (e.g., positive affect recovery) and increase positive functioning (e.g., staying engaged in meaningful activities) despite the stressful aspects of the pain experience. Furthermore, resilience and vulnerability are often seen as dichotomous phenomena, such that each is defined as the absence of the other. However, more recent models of resilience and vulnerability suggest that these are two distinct factors that exist not on opposite ends of the same spectrum, but function as separate, yet inversely related dimensions (Rutter, 1987). This distinction is also paralleled in theories of approach and avoidance, which suggest that these are two separate motivational systems that facilitate emotions, cognitions, and behaviors that either move an individual towards positive experiences or away from aversive experiences, respectively (Carver & White, 1994; Davidson, 1992; Trew, 2011). Furthermore, Smith and Zautra (2008) found that these two constructs, resilience and vulnerability, are only moderately inversely correlated ($r = -.321$) and have largely independent relations with the affective, cognitive, and social dimensions of coping with pain. Therefore, there may be two independent vulnerability and resilience processes that incorporate different psychosocial dimensions in shaping an individual's response to the adversity of persistent pain.

In addition to independent contributions of resilience and vulnerability processes, recent models of pain adaptation have also emphasized the differential effects of stable

versus modifiable factors that facilitate adaptive and maladaptive coping responses. The Two-Factor framework, for example, delineates between resilience *resources*, which are stable, individual difference characteristics (e.g., optimism) that increase the likelihood of adaptive functioning and resilience *mechanisms*, which are time-varying factors that are utilized during a stressful experience (e.g., positive affect) to support adaptive coping (Smith & Zautra, 2008; Sturgeon & Zautra, 2010). A parallel resource-mechanism categorization can be made in the vulnerability domain. Stable personal characteristics such as pessimism and insecure attachment act as vulnerability *resources*, while maladaptive processes that activate at the time of a pain flare, such as negative affect and pain catastrophizing, serve as vulnerability *mechanisms* that interfere with effective pain coping. Sturgeon and Zautra (2013) proposed a conceptual model of the resource and mechanism framework depicting both resilience and vulnerability factors in the pain coping process. Expanding upon this framework, newer models such as the Stable-Modifiable Model of Vulnerability and Resilience Processes include resources and mechanisms that highlight the social context of pain coping, not just the *intra*-personal factors (e.g., strong social ties as a stable resilience resource and momentary positive social interactions as modifiable resilience mechanism) (Yeung, Arewasikporn & Zautra, 2012; Sturgeon, Zautra, & Arewasikporn, 2014; Sturgeon & Zautra, 2013). Although these frameworks emphasize the importance of both the stable and fluid elements that foster and/or hinder successful adjustment to pain, the researchers also suggest that the modifiable psychosocial processes (i.e., mechanisms) may be especially important to identify as they are more susceptible to the influences of psychosocial intervention than the more stable resources.

Importance of Social Context and Differential Levels of Pain Coping

A review of the literature on coping with chronic pain illustrates the predominant emphasis on internal states such as cognitions, moods, and perceptions of pain. Relatively fewer studies have accounted for the influence of external events on how individuals experience and regulate their pain, as well as accompanying emotions, cognitions and behavioral responses. However, the biopsychosocial model of chronic pain underlines the importance of the role that social environment plays in how pain is experienced and how individuals adapt to chronic pain (Keefe and France, 1999). Indeed, several researchers have suggested that studies must incorporate measures of the *inter*personal context in addition to the *intra*personal perceptions of pain and affective states because these do not exist independent of the external world (Zautra, Affleck, Tennen, Reich & Davis, 2005; Karoly & Ruehlman, 2006; Davis, Affleck, Zautra & Tennen, 2006; Zautra & Sturgeon, 2016). For instance, studies have shown that individuals with chronic pain are able to increase their levels of positive affect through positive social interactions (Smith & Zautra, 2008; Davis et al., 2010). Similarly, the presence of stressful social experiences also has implications for internal states such as increased negative affect (Finan et al., 2010), depressed mood (Nezlek & Allen, 2006) and fatigue (Parrish, Zautra, & Davis, 2008). Therefore, greater attention to both the positive and the negative social interactions will enable researchers to develop a more accurate understanding of the complexity of the process of coping with chronic pain.

In addition to the importance of studying both resilience and vulnerability processes across multiple domains of inter- and intra-personal functioning, a great deal of research on pain adaptation have also noted that affective (Zautra, Johnson & Davis,

2005), cognitive (Sturgeon & Zautra, 2013b) and social (Finan et al., 2010) constructs fluctuate considerably across the day. Usually, psychosocial constructs are examined in terms of magnitude and with single-measure retrospective accounts covering weeks or months. Such measurements not only introduce recall biases, but also weaken our understanding of the dynamic processes underlying an unstable experience such as pain (Csikszentmihalyi & Larson, 2014). Instead, examining day-to-day or moment-to-moment accounts allow us to capture a richer account of the variability in the daily experiences of individuals with chronic pain. For example, within-day fluctuations in pain catastrophizing have been shown to have a pronounced and unique relation with an individuals' ability to cope with pain, leading researchers to argue for the importance of considering the consequences of within-person variation in pain catastrophizing independent of stable average levels of catastrophizing (Sturgeon & Zautra, 2013b; Campbell et al., 2010). Furthermore, examining daily ("state") fluctuations in psychosocial responses to pain allows us to detect times *when* individuals are vulnerable or resilient to the pain experience rather than identifying people *who* are vulnerable or resilient due to stable person-level ("trait") differences. Lastly, researchers have also argued for the need for daily process studies to address questions concerning sequential relations between or temporal ordering of daily fluctuations in pain intensity, pain response processes and pain-related outcomes (Turner, Mancl & Aaron, 2004). Overall, the current understanding of pain adaptation can be further improved by examining not just how pain begins to interfere with meaningful functioning, but also the day-to-day processes that enable people to persist despite pain. The following section will review three vulnerability and resilience mechanisms within each of the domains of

affective, cognitive and social functioning that support or obstruct adaptive functioning.

The factors reviewed are by no means exhaustive, but serve as the most promising

mechanisms to examine empirical work based on evidence found in the current literature

on adaptive coping in individuals with chronic pain (Yeung, Arewasikporn, & Zautra,

2012; Sturgeon & Zautra, 2013; Sturgeon & Zautra, 2016).

Vulnerability pathways contributing to disability

Pain Catastrophizing

Pain-related catastrophizing is the tendency to magnify perception of pain as

being worse than it is, or making exaggerated predictions about its damaging

consequences (Sullivan, Bishop, & Pilvik, 1995; Rosenstiel & Keefe, 1983). A

propensity to catastrophize about pain has been associated with poor psychological and

physical outcomes, including higher levels of negative affect (Hirsh, George, Riley, &

Robinson, 2007), increased risk of depression (Lee, Chan, & Berven, 2007; Sullivan,

Rodgers, & Kirsch, 2001; Keefe et al., 1991), greater anxiety (Sullivan, Bishop, & Pivik,

1995) and overall emotional distress (Moldovan, Onac, Vantu, Szentagotai, & Onac,

2009). Functional disability has also been consistently correlated with pain

catastrophizing in several chronic pain conditions including fibromyalgia (Nicassio,

Schoenfeld-Smith, Radojevic, & Schuman, 1995; Martin et al., 1996), rheumatoid

arthritis (Keefe, Brown, Wallston, & Caldwell, 1989; Parker et al., 1989), and low back

pain (Smeets et al., 2006), with the association between pain catastrophizing and

increased disability often present even after controlling for depression, anxiety,

neuroticism, and disease and pain severity (Sullivan, Stanish, Waite, Sullivan, & Tripp,

1998; Martin et al., 1996). The consistent nature of these findings across various pain

populations illustrates the significance of pain-catastrophizing for key pain-related outcomes.

The association of pain catastrophizing with increased disability may be due, in part, to high versus low pain catastrophizers focusing more attention and coping efforts on pain. Studies have shown that high pain catastrophizing is strongly predictive of hypervigilance to the threat of pain and greater difficulty disengaging from pain signals (Crombez, Eccleston, Van, Goubert & Van Houdenhove, 2004; Goubert, Crombez, & Van Damme, 2004; Van Damme, Crombez, Eccleston, 2004). Low catastrophizers, on the other hand, view anticipated pain as less threatening and are able to re-direct attention to other environmental stimuli. These studies support the fear-avoidance model- a theoretical framework explaining how catastrophic interpretation of pain contributes to pain-related fear and promotes avoidance behaviors (Vlaeyen & Linton, 2000; Leeuw et al., 2007; Buer & Linton, 2002). In brief, this model posits that although avoidance may be adaptive in the acute pain stage by preventing further injury, for chronic pain sufferers, fear of pain may lead to consistent avoidance of important daily activities. Thus, the heightened attention to pain, difficulty disengaging from the threat of pain, worry, and avoidance behaviors may explain the longer term process through which pain catastrophizing has a deleterious effect on physical functioning.

Negative Affect

Another key feature of maladaptive pain coping in individuals with chronic pain is negative affect. Several studies have established a close relation between chronic pain and a range of negative emotional states, including higher prevalence of depression, anxiety, and anger (Burns et al., 2016; Tan et al., 2008; Wade et al., 1996). Negative

affect emerging in response to pain is not surprising. Pain may inspire feelings of helplessness and frustration, limit engagement in enjoyable activities, and increase a sense of loss. In addition to correlational studies examining the associations between pain and negative mood states, studies have also evaluated negative affective reactivity in response to painful episodes. Notably, Zautra and colleagues (1995) found that on days of higher than usual pain, individuals with chronic pain report increased negative affect and greater decreases in positive affect. A number of investigators using similar diary methodology have reported comparable within-day findings (Crombez et al., 2013; Hamilton et al., 2008; Affleck, Tennen, Urrows, & Higgins, 1991). Such episodes of increased pain and concomitant negative affect may lead to repeated attempts to escape or avoid the unpleasant physical and emotional experiences. Although these avoidance efforts may lead to relief in the short term, they also do not move a person closer to resolving challenges or towards valued goals. Rather, individuals may perseverate on the unattainable goal of achieving long-lasting escape from pain and distress. Repeated failures to achieve this relief may further increase negative affect and maladaptive cognitions (a sense of helplessness, poor self-image), and contribute to disability by compromising successful goal pursuit.

In addition to contributing to avoidance goals, negative affect may also contribute to poor adaptation by inhibiting positive affect. Several theories about the structure of affect have suggested that positive and negative affect are independent and uniquely modified by life experiences (Tellegen, Watson, & Clark, 1999; Davis, Zautra, & Smith, 2004; Cacioppo, Gardner, & Bernston, 1999). The Dynamic Model of Affect proposes that under stressful circumstances, affective space is narrowed, and positive and negative

affect form a single, bipolar dimension (Reich, Zautra, & Davis, 2003; Davis, Zautra, &

Smith, 2004). According to this theory, affect becomes polarized under threatening

conditions to enable quicker and more efficient processing of affective information,

which would allow for faster judgments in adaptation to a threat. Evidence for this model

has been found in multiple studies, including laboratory-induced stress (Zautra, Reich,

Davis, Potter & Nicolson, 2000) and in investigations of stress in daily life (Zautra, et al.,

2000; Zautra, Berkhof, & Nicolson, 2002). Thus, when an individual experiences a

stressor, the presence of increased negative affect reduces the likelihood of positive affect

(and vice-versa). The degree of affective differentiation maintained during times of

stress may be particularly relevant for individuals with chronic pain because the

experience of ongoing pain and the uncertainty of it function as chronic stressors. Thus,

acute episodes of pain in the context of chronic pain, and resulting negative affect may

contribute to a narrowing of affective space, and with it the potential for a broader range

of adaptive coping responses (Davis et al., 2004).

Interpersonal Stress

To develop a more accurate understanding of the complexity of chronic pain,

there has been growing attention for the contribution of social context to the process of

adapting to chronic pain on a day-to-day basis, which includes the transactional relations

between interpersonal relations, the pain experience, and coping efforts. Among

individuals with chronic pain, interpersonal stressors such as increases in daily negative

interpersonal events have been associated with poorer same-day functional and emotional

outcomes (Parrish, Zautra, & Davis, 2008; Finan et al., 2010). There may be several

processes by which psychosocial stressors lead to poorer illness course in individuals

with chronic pain. Studies have shown that changes in daily stressful interpersonal experiences are associated with reduced activity engagement (Schanberg et al., 2000). For example, in a study examining the role of stressful interpersonal interactions in an experimental setting, Schwartz, Slater, and Birchler (1994) randomized individuals with chronic pain and their spouses to either a stressful interpersonal interview or a neutral talking task, followed by a physical activity task. The researchers found that among the individuals with pain, those who were assigned to the stress interaction condition were significantly more likely to terminate the physical activity task compared to those assigned to the control condition. Similar to within-day increases in pain catastrophizing and negative affect, the detrimental impact of daily psychosocial stressors on outcomes, therefore, may occur via the influence on pain behaviors such as activity avoidance and withdrawal.

Researchers have also proposed that chronic pain may be associated with deficiencies in the reward circuitry of the central nervous system (Sturgeon, Finan & Zautra, 2016). In a review of psychological processes in chronic pain, Simons and colleagues (2014) suggest that in the pursuit of relief from pain, individuals with chronic pain may engage in fewer positive affective and rewarding experiences such as enjoyable interpersonal experiences, which over time, potentially leads to a reward-processing deficit. Repeated exposure to a chronic stressor like pain may cause impairment in the neural pathways that are implicated in reinforcement learning, thereby contributing to a diminished ability to modify behaviors based on reinforcing social experiences (Pizzagalli, 2014). Taken together, it is also possible that social vulnerability in individuals with chronic pain may be due to reduced sensitivity to rewarding experiences

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(including social reward), reduced expectation of future reward, and/or at the behavioral level, reduced motivation to pursue rewarding experiences.

A negative social context may also make an individual with chronic pain more vulnerable to poor outcomes by exacerbating affective, cognitive, and physiological difficulties. As noted, an increase in daily negative interpersonal events has been shown to predict same-day increases in negative affect (Finan et al., 2010), depressed mood (Nezlek & Allen, 2006) and fatigue (Parrish, Zautra, & Davis, 2008). In studies of individuals with rheumatoid arthritis, weeks (Zautra et al., 1997) and months (Davis et al., 2008) of increased interpersonal stress contributed to increased inflammatory response, which may exacerbate fatigue. Thus, by increasing behavioral avoidance, fatigue and negative affect, day-to-day social stressors may further diminish the adaptive capacity of people already burdened by the adversity of chronic pain.

Resilience pathways contributing to adaptive functioning

Pain Acceptance

Among the numerous psychosocial factors that influence adjustment to chronic pain conditions, pain acceptance has proven to be an important predictor of positive outcomes for individuals with chronic pain, including mitigating the damaging effects of pain on emotional and physical functioning (Wright et al., 2011; Ramirez-Maestre, Esteve & Lopez-Martinez, 2014). McCracken and colleagues (2004) define pain acceptance as the willingness to engage in activities despite the experience of pain. Due to the persistent nature of pain in individuals with chronic pain conditions, efforts to avoid or remedy it are often counterproductive as they can magnify the distress associated with this stressor. Instead, when individuals adopt a willingness approach to coping with pain, they

acknowledge its aversive nature, halt exaggerated predictions about its damaging

consequences, and disengage from unsuccessful attempts to avoid or eliminate it. By

giving up efforts to control the pain experience, acceptance frees emotional and cognitive

resources that can instead be invested into the pursuit of more attainable and meaningful

goals (McCracken & Eccleston, 2005; McCracken, 2010).

Research on the consequences of pain acceptance has almost exclusively utilized

cross-sectional models with single measures of trait level acceptance. Such studies have

shown that greater levels of pain acceptance are not only associated with lower levels of

pain catastrophizing, but also can help protect against the harmful effects of

catastrophizing about pain on physical and emotional dysfunction (Weiss et al., 2013;

Vowles, McCracken & Eccleston, 2008; Crombez, Eccleston, Van Hamme & De Vlieger,

2008). Researchers have theorized that pain acceptance may combat the narrowing of

attention to pain-related fear and the rigid response patterns that occur with

catastrophizing by freeing up cognitive resources to consider broader coping resources

and respond more flexibly during times of greater pain (Sturgeon & Zautra, 2010;

Eccleston, Crombez, Aldrich & Stannard, 2001). Additionally, pain acceptance may also

contribute to emotional resilience through increases in positive affect and dampening

negative affect during pain flares (Kratz, Davis, & Zautra, 2007). Moreover, acceptance-

based approaches to coping with the pain experience have also been shown to be

associated with increased self-efficacy for coping with pain and stress (Wallace,

Harbeck-Weber, Whiteside, & Harrison, 2011; Davis & Zautra, 2013; Zautra et al.,

2008). Due to its implications for enabling more resilient response to persistent pain, this

cognitive construct has been identified as an important potential target for interventions

in chronic pain (Baranoff et al., 2015; Banstetter-Rost, Cushing & Douleh, 2009;

Cederberg et al., 2015; Davis & Zautra, 2013).

Positive Affect

A growing body of research in chronic pain consistently points to the role of positive

affect as an important resilience mechanism that aids in recovery from pain and stress.

Fredrickson's (1998) broaden-and-build model suggests that positive emotions broaden

people's thoughts and actions, rather than narrow responses to specific action tendencies

(e.g., fight-or-flight). In other words, when people experience positive emotions, they

have a broader range of thoughts and see a greater number of potential courses of action

to pursue. In this way, positive affect can facilitate flexible coping by highlighting

various affective, cognitive, social and physical resources that may be used to cope

during times of stress (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008). The restorative

effect of positive affect on undoing stress has been found among individuals who have

high average levels of positive affect (Zautra, Smith, Affleck, & Tennen, 2001; Zautra,

Johnson, & Davis, 2005), as well as with day-to-day momentary increases in positive

affect (Finan, Quartana, & Smith, 2013; Litt, Shafer, Ibanez, Kreutzer, & Tawfik-

Yonkers, 2009).

Another important implication of the broaden-and-build model is that positive

emotions have an undoing effect on negative emotions (Fredrickson, Mancuso, Branigan,

& Tugade, 2000). By broadening the thought-action repertoire and loosening the hold of

negative emotions, positive emotions can protect against the disruptive effects of negative

affective states on daily functioning. In fact, studies have shown that negative affect in

response to daily stressors is weakened when positive affect is high (McHugh, Kaufman,

Frost, Fitzmau-rice, & Weiss, 2013; Zautra, Affleck, Tennen, Reich, & Davis, 2005).

Furthermore, an experimental study also found that inducing positive affect following an interpersonal stressor was effective in fostering pain and positive mood recovery among depressed individuals with chronic pain (Davis, Thummala & Zautra, 2014). The extent to which an individual can experience both positive and negative emotions under conditions of stress is called affective complexity (Davis, Zautra, & Smith, 2004), and it has been identified as a significant contributor to adaptive pain coping (van Puymbroeck, Zautra, & Harakas, 2007).

The degree of affective differentiation maintained during times of stress may be particularly relevant for individuals with chronic pain because the experience and the uncertainty of pain function as chronic stressors. In fact, studies have found a strong inverse relation between positive and negative affects during times of increased pain and stress (Davis, Zautra, & Smith, 2004). Additionally, it has been well established that episodes of pain increase negative affect (Affleck, Tennen, Urrows, & Higgins, 1991; Zautra, Burleson, et al., 1995). Thus, the episodes of pain and stress contribute to a narrowing of affective space, and with it the narrowed perception of available coping responses (Davis et al., 2004). However, when individuals experience more positive emotions, the association between their current pain and negative affect is diminished. In this regard, positive affect may be thought to buffer the effects of pain on negative emotion (Strand et al., 2006). Zautra and colleagues (2005) also found that during weeks of elevated pain, individuals with rheumatoid arthritis who report high levels of positive affect also report significantly lower levels of negative affect. Overall, building the

capacity to sustain positive affect during pain or stress may promote resilience by limiting the detrimental effects on negative affect on disability.

Interpersonal Enjoyment

Positive social exchanges have been shown to be a source of resilience for individuals in pain and can have a powerful effect on how individuals cope with their chronic pain. Researchers have suggested several processes by which enjoyable interpersonal experiences may lead to improved outcomes in individuals with pain. For example, positive interpersonal events may serve as a distraction from pain and reduce the importance given to it (Katz, Ritvo, Irvine, & Jackson, 1996). Additionally, satisfying interpersonal relationships may serve as a buffer by supplying individuals with resources to cope with the illness and by increasing their self-efficacy. For instance, an intervention that aimed to increase positive social experiences in women with chronic pain found that enhancing positive social engagements contributed to improvements in emotional functioning, belief in one's ability to cope with pain, and also reduced disease activities such as pain, fatigue and stiffness (Zautra, Hamilton, & Yocum, 2000). Moreover, a positive social context in the form of social support has also been identified as an important factor in successful adaptation to pain (Ferreira & Sherman, 2007; Montoya, Larbig & Braun, 2004). Receiving pain-relevant social support can have a stress-buffering effect and protect against psychological distress (Brown, Wallston & Nicassio, 1989; Kerns, Rosenberg, & Otis, 2002). A lack of social support, on the other hand, can contribute to the etiology of depression in individuals with chronic pain (Creed & Ash, 1992).

On a daily basis, how might positive interpersonal relations facilitate optimal functioning in individuals with chronic pain? One possibility is that increases in positive relations may limit pain related increases in maladaptive cognitions such as catastrophizing and/or interrupt the harmful effects of catastrophizing on self-efficacy for coping with pain. A daily diary study by Taylor and colleagues (2013) showed that on days of increased pain, individuals with the support of a loved one tended to use more adaptive pain coping strategies, had higher pain coping efficacy, and lower pain-related disability compared to unpartnered or unhappily partnered individuals. Similarly, another within-day study found that when individuals report increased satisfaction with spousal support, the negative effect of catastrophizing on pain-related outcomes was attenuated (Holtzman & DeLongis, 2007). Diary studies have also found that increases in daily positive social interactions contribute to better same-day outcomes such as higher levels of positive affect and lower levels of fatigue (Zautra, Affleck, Tennen, Reich, & Davis, 2005; Parrish, Zautra, & Davis, 2008; Yeung, Aiken, MacKinnon, & Davis, 2014). Overall, given the many day-to-day challenges of dealing with persistent pain, engaging in enjoyable and meaningful social relationships, even during painful episodes, can enhance resilience to this stressor and be an important contributor to successful daily adaptation.

Goals of the current study

The majority of studies that have examined physical disability, an important outcome for individuals with chronic pain, have relied on cross-sectional models with single observations of pain, pain-related predictors and outcomes. Rarely have studies utilized methods with repeated measurements at different time points during the day that

may allow researchers to capture the within-day relations and test the temporal ordering of relations between these variables. Therefore, the current paper proposes a model of pain adaptation that will examine the within-day process of how morning increases in pain contribute to physical disability by the end of the day. Furthermore, models of pain coping also typically focus on how pain contributes to poor physical and psychological functioning. Researchers have argued that this focus on the negative consequences is too narrow and does not account for times when individuals are able to maintain meaningful functioning despite their pain. However, even when pain researchers have proposed frameworks capturing both resilience and vulnerability factors (Smith & Zautra, 2008; Yeung, Arewasikporn & Zautra; Sturgeon & Zautra, 2013), these models have often been comprised of person-level characteristics such as personality traits (e.g., optimism, pessimism), coping style (e.g., active coping, avoidance), and stable clinical attributes (e.g., anxiety, depression). This has lead researchers to suggest that beyond these static contributors to pain adaptation (i.e., *resources*), it is also important to identify the dynamic factors that are activated during times of pain and stress (i.e., *mechanisms*) that either help or hinder recovery (Sturgeon & Zautra, 2013, 2016). In other words, under what conditions do individuals become debilitated by the pain experience and when are they able to recover in order to pursue daily life activities despite the pain? Thus, another aim of the current study is to look further into the day-to-day adaptive and maladaptive processes that are activated in response to pain and to test if these processes map on to a two-factor model of resilience and vulnerability, respectively. Such a two-factor model may be useful for understanding how the positive and negative domains subsequently enhance or hinder clinically relevant outcomes such as daily physical functioning.

Lastly, despite the growing recognition of the strong role that social interactions play in the pain adaptation process, studies are often constrained to only examining the influences of cognitive and affective states that reside within a person. Hence, in addition to affective and cognitive processes, the current study will also incorporate both enjoyable and stressful interpersonal experiences to examine the consequences of changes in the social context for generating vulnerable or resilient times in the daily lives of individuals with pain. Overall, the purpose of this study is to empirically test a two-factor model focusing on day-to-day adaptive and maladaptive mechanisms across multiple dimensions of functioning with the aim of gaining further insight into the wide-ranging and complex nature of coping with chronic pain.

Specific Hypotheses

1. Hypothesis 1 (See Figure 1): Multi-level confirmatory factor analysis will be used to determine if particular affective, cognitive and social mechanisms assessed in the afternoon will load on the two proposed latent factors: 1a) positive affect, pain acceptance and enjoyable social interactions on a resilience factor, and 1b) negative affect, pain catastrophizing, and stressful social experiences on a vulnerability factor.

2. Hypothesis 2a (See Figure 2): Higher-than-usual morning pain will be predictive of decreased levels of resilience mechanisms within those domains (i.e., decreased positive affect, acceptance and social enjoyment, respectively) that afternoon.

   Hypothesis 2b: Higher-than-usual morning pain will be predictive of increased

levels of afternoon affective, cognitive, and social vulnerability mechanisms (i.e., increased negative affect, catastrophizing and interpersonal stress, respectively).

3. Hypothesis 3a: On days of increased resilience mechanisms in the afternoon, individuals with FMS will report lower physical disability at the end-of-day. Hypothesis 3b: On the contrary, on days of increased vulnerability mechanisms in the afternoon, individuals will report higher physical disability at the end-of-day.

4. Hypothesis 4: The relation between the increases in morning pain and end-of-day physical disability is expected to be partly mediated by centered afternoon resilience and vulnerability factors. Note that the correlation between the two mediators (resilience and vulnerability factors) will be modeled in the mediation analyses.

METHODS

Participants

Participants were recruited in the Phoenix metropolitan area through physician referrals, fibromyalgia support groups, and print and online advertisements in order to participate in a larger treatment outcome study for fibromyalgia. Inclusionary criteria included: 1) being 18 to 72 years of age, 2) self-reported pain, either, a) lasting three months or longer in at least three of the four quadrants of the body, or b) lasting three months or longer in at least two of the four quadrants of the body with significant fatigue and sleep disturbance, and 3) passing a tender point assessment conducted by a licensed nurse to verify FM diagnosis according to American College of Rheumatology criteria (Wolfe et al., 1990). Exclusionary criteria included: 1) diagnosis of an autoimmune or

neuropathic pain disorder; 2) involvement in litigation related to their pain condition, and 3) currently participating in another research study, clinical trial, or counseling for pain or depression.

Procedure

Participants were initially screened for eligibility by telephone. Those who met criteria were visited at home by a registered nurse who administered a tender point exam to confirm FM diagnosis. Participants who met pain eligibility criteria were then consented and introduced to the study procedure, and completed (a) an initial questionnaire packet including measures of pain, physical health, and emotional health; (b) a phone interview assessing psychological health and life events; (c) a laboratory assessment of physiological and affective responses to pain and emotional stimuli; (d) pre-intervention questionnaires regarding current symptoms and physical and emotional functioning; and (e) diary reports regarding interpersonal events, pain, fatigue, sleep quality, mood, and coping for 21 days. Participants were then randomly assigned to one of three 7-week treatment conditions. Following the treatment, participants completed six- and twelve-month follow-up questionnaires, as well as post-intervention assessments that matched those in pre-treatment.

The current study used data from the pre-intervention diary potion of the larger project. Diary data from 220 participants will be included in the study. The diaries assessed the participants' daily physical symptoms, functional health, pain cognitions and coping efforts, interpersonal events, and affective states. Participants were trained by a member of the research team on how to complete the diaries using a cell phone provided by the study. Participants were then prompted four times per day to complete daily

reports for up to 21 days. An automated phone system was used to call each of the participants at the four time points daily. Participants were called 20 minutes following his/her specified wake up time for the morning interview, at 11 a.m. for the late-morning interview, at 4 p.m. for the afternoon interview, and within 30 minutes of bedtime for the end-of-day interview. If the participant missed the call, s/he could complete the diary by calling the system within two and a half hours following the missed call. Participants were encouraged to call our staff immediately if a problem occurred with the phone system, and diary completions and progress were routinely monitored. Participants were paid $2 for each day they completed diaries, and an additional $1/day for rates of completion that met or exceeded 50%.

Gathering data with multiple assessments across the day enables a closer look at the fluctuations among study variables within participants from morning to evening. The temporal ordering of variables in the daily diaries allows for examination of questions such as, "Does higher than usual pain intensity in the morning predict higher physical disability at the end of the day?" and "Does higher than usual positive affect mediate the detrimental effects of morning pain intensity on end-of-day physical disability?" Therefore, the main hypotheses for this study draw on morning reports of pain intensity, afternoon reports of pain-catastrophizing, pain acceptance, positive/negative affect, interpersonal enjoyment/stress, and end-day-reports of physical disability.

Measures

A copy of all study measures are included in the Appendix.

11a.m. Morning Pain Intensity. Daily average pain was measured in the dairy on a 101-point numerical rating scale (Jensen, Karoly, & Braver, 1986). Participants were asked,

"What was your overall level of pain? Enter a number between 0 and 100 that best describes your pain level. A zero would mean 'no pain' and a one hundred (100) would mean 'pain as bad as it can be.'"

4p.m. Afternoon Pain Catastrophizing. Daily pain catastrophizing was assessed with an item drawn from the Pain Catastrophizing subscale (PC) of the Coping Strategies Questionnaire (Keefe et al., 1989), which assesses the extent to which an individual engages in negative self-statements and overly negative thoughts about their pain. Participants were asked to rate the statement, "You felt your pain was so bad you couldn't stand it anymore" using a scale of 1 to 5, with 1 meaning "Not at all" and 5 meaning "completely."

4p.m. Afternoon Pain Acceptance. Daily pain acceptance was assessed with an item drawn from the Kentucky Inventory of Mindfulness Skills (Baer, Smith, & Allen, 2004), which assesses the extent to which one can accept their experience without judgment. Participants were asked to rate the statement, "How much have you told yourself that you shouldn't be feeling the way you're feeling?" using a using a scale of 1 to 5, with 1 meaning "Not at all" and 5 meaning "completely." The item was reverse coded such that higher values reflect greater willingness to experience pain, or more exactly, less *un*willingness to experience pain.

4p.m. Afternoon Pain Control. This served as an alternate resilience item coded in the positive direction to assess daily perceived control over pain. Greater perceived ability to control or manage one's pain has been shown to mediate improvements in psychological and physical functioning following pain-related treatments (Turner, Holtzman, & Mancl, 2007; Nielson & Jensen, 2004). Participants were asked to rate the statement, "You were

able to control your pain" (Affleck, Tennen, & Apter, 2001), using a using a scale of 1 to 5, with 1 meaning "Not at all" and 5 meaning "completely."

4p.m. Afternoon appraisal of interpersonal events. Participants rated their perceived interpersonal stress and perceived interpersonal enjoyment using ratings from the Inventory of Small Life Events (ISLE; Zautra, Guarnaccia, & Dohrenwend, 1986). Participants were asked to respond to the statement, "During the past 2-3 hours, how stressful (or enjoyable) were your relations with your spouse or partner (friends, family, co-workers), on a scale of 1 to 5?" using a scale of 1 to 5, with 1 meaning "not at all" and 5 meaning "completely." The perceived stress and enjoyment measures were formed as the average of 2 ratings of the stressfulness and enjoyment that followed inquiries into the daily occurrence of interpersonal events in each of these two domains: (1) spouse or partner; (2) others (family, friends, co-workers).

4p.m. Afternoon Affect Ratings. Positive and negative affects were measured using 4 items (each) drawn from the Positive and Negative Affect Schedule-Expanded Form (PANAS-X; Watson & Clark, 1994). Participants rated the extent to which they experienced each of 4 items using a 5-point scale from 1 (not at all) to 5 (completely). Examples of positive affect items include, "How cheerful did you feel?" and "How energetic did you feel?" Examples of negative affect items include, "How sad did you feel?" and "How angry did you feel?" Daily positive and negative affect scores were computed by averaging the four affect items for each.

End-of-day Physical Disability. Functional limitations due to physical problems were assessed in the dairy using the 4-item Role Physical (RP) subscale from the SF-36 health survey (Ware, Snow, Kosinski & Gnadek, 1993). On a scale of 1 to 3, with 1 meaning

"no" and 3 meaning "very much", participants were asked to rate statements such as "Did you have difficulty performing work or other activities?" and "Were you limited in the kind of work or other activities you did?" Daily physical disability scores were computed by averaging the four items.

Data Analytic Strategy

Centering, Interclass Correlations, and Handling Missing Data

This study investigated the within-day relations among morning pain and end-of-day disability and if this relation is mediated by daily increases in afternoon vulnerability and/or resilience mechanisms. A multilevel modeling approach was used for analysis as the data are structured such that each participant provided multiple daily reports across a 21-day period. The study has two levels consisting of days (Level 1 or within-person) nested within individuals (Level 2, person-level, or between-person). The first level (within-person) is comprised of an individual's daily reports that ask participants about their experiences during the day. To disaggregate the between-person from the within-person variation included in the daily reports, these reports were centered within-person. Specifically, each participant's daily score was subtracted from his/her mean score for that variable over all days of assessment; therefore, each centered score is Level 1 and signifies each day's deviations from an individual's mean across all their days of assessment. This process of centering around each individual's own average allows for the investigation of phenomena "when" they are occurring. As an example of the two levels, centered pain-catastrophizing reflects the level 1 day-to-day deviations from an individual's average pain-catastrophizing score (i.e., "when" someone is catastrophizing), whereas mean pain-catastrophizing across the 21 days represents the level 2 between-

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person variable of catastrophizing (i.e., a person is a catastrophizer). Level 1 person-centered scores are uncorrelated with Level 2 score on the same variable, facilitating interpretation of effects (Enders & Tofighi, 2007).

Intraclass correlation coefficients (ICC) were computed using unconditional multilevel models to quantify the proportion of variance at the between-person level relative to the total variance. The ICC values provide information regarding the extent to which variables are stable over time, which higher values reflecting greater stability (Kaplan, Kim & Kim, 2009).

Participants differed in the number of measures they completed each day, which resulted in different cluster sizes. Full information maximum likelihood (FIML) estimator with an accelerated EM algorithm procedure in M*plus* version 7 was used to estimate models with missing data. This procedure is robust to non-normality, missing data and unbalanced cluster sizes in data (Muthen & Asparouhov, 2008; Preacher, Zyphur, & Zhang, 2010).

Multilevel Confirmatory Factor Analysis

The first set of analyses utilized multilevel confirmatory factor analysis (MCFA) to determine whether the resilience and vulnerability mechanisms assessed in the afternoon loaded on two latent variables as hypothesized (see Figure 1): pain acceptance, positive affect, and interpersonal enjoyment on the resilience factor, and pain catastrophizing, negative affect, and interpersonal stress on the vulnerability factor. The Multilevel CFA analysis performed using MPlus version 7 (Muthen & Muthen, 1999-2012) accounts for the non-independence of observations in nested data by partitioning the between- and within-person variance and modeling each as unique sources of

covariance (Hox & Maas, 2001). This two-factor structure was tested to determine if the affective, cognitive and social mechanisms within each of the vulnerability and resilience clusters were best represented as two factors. Model fit was evaluated according to the loadings and established fit guidelines for multiple fit indices including the comparative fit index, the root mean square error of approximation, and the within- and between-group standardized root mean square residuals (Hu & Bentler, 1999).

Mediation in Multilevel Structural Equation Model

The next set of analyses examined if the relation between increases in morning pain and end-of-day physical disability is mediated by the hypothesized latent structures of the vulnerability and resilience factors. The mediation models were estimated using multi-level structural equation modeling techniques (MSEM), again using MPlus version 7 (Muthen & Muthen, 1999-2012). These MSEM (Preacher et al., 2010) models account for variation at both the within-person (Level 1) and between-person (Level 2) levels by modeling variables at both levels simultaneously. A multilevel structural two-mediator model was estimated to assess: a) the relations between morning pain and both afternoon mediators: resilience and vulnerability factors (paths a_1 and a_2, respectively, in Figure 2); b) the relations between afternoon resilience and vulnerability factors and the outcome variable, evening physical disability (paths b_1 and b_2, respectively, in Figure 2); and c) the roles of the vulnerability and resilience factors as statistical mediators of the relation between late morning pain and evening pain. The mediating (indirect) effects of the vulnerability and the resilience factor were calculated by taking the product of the coefficients of the paths between the predictor and the mediators (*a* paths) and the paths between the mediators and the outcome (*b* paths). RMediation was employed to estimate

asymmetric 95% confidence limits for the mediated effects (Tofighi & MacKinnon, 2011)), which accounts for the correlations between the *a* and *b* paths (Kenny, Korchmaros, & Bolger, 2003).

RESULTS

Sample Characteristics, Intraclass correlations and Intercorrelations

Table 1 shows the sample demographic characteristics. Participants comprising the sample were largely female (87%), Caucasian (78%), and employed (50.7%). They reported an average age of 51 years (*SD*= 11.02 ; range = 19-72), being married or living with a romantic partner (55%), attending at least some college (68%), and a median annual household income range between $30,000-$39,999. Table 2 shows the ranges, means, standard deviations, response rates, skewness, kurtosis and intraclass correlations (ICCs) of the raw daily scores for morning pain, afternoon variables including pain catastrophizing, negative affect, interpersonal stress, pain acceptance, pain control, positive affect and interpersonal enjoyment, and end-of-day physical disability. In general, individuals in the current sample reported experiencing lower levels of vulnerability factors such as negative affect and social stress compared to resilience factors such as positive affect and social enjoyment. The ICC values for the measures used in the study ranged from .24 to .75 in the current sample (see Table 2). These ICC values suggest that there is substantial within-person variability, and that the two sources of variability (i.e., within- and between-person) can are best modeled within a multi-level framework (Kaplan, Kim & Kim, 2009).

Table 3 presents the means, standard deviations, skew, kurtosis, and intercorrelations for the between-person level of the multilevel model. Based on the average scores in the sample as a whole, both positive and negative relational qualities were unrelated to chronic physical disability, and relational stress was also unrelated to chronic pain. Next, table 4 presents the standard deviation, skew, kurtosis and intercorrelations for the within-person level of the measures. At the within-person level, daily elevations in morning pain intensity were positively correlated with pain catastrophizing, negative affect, interpersonal stress and physical disability, but negatively correlated with pain acceptance, pain control, positive affect and interpersonal joy. Similarly, within-person end-of-day physical disability levels were also related to an increase in the vulnerability factors such as catastrophizing, negative affect and social stress and to a decrease in the resilience factors of pain acceptance, pain control, positive affect and social joy. Lastly, daily elevations in interpersonal stress was unrelated to daily changes in pain control.

Multilevel Confirmatory Factor Analysis

As the first step in the data analytic plan, a 2-factor multilevel CFA was fit from the six measured variables: positive affect, pain acceptance, and interpersonal joy loading onto the resilience mechanism factor, and negative affect, pain catastrophizing, and interpersonal stress scores loading onto the vulnerability mechanism factor. Results of this analysis indicated that the two-factor model based on the hypothesized six indicators proved to be a poor fit to the data. Importantly, the covariance between the two factors was found to be not positive definite, which may suggest a model misspecification error

either due to a lack of two distinct factors or due to linear dependency among two or more variables in the model.

Closer inspection of the indicators suggested that the reverse coding technique used to create the pain acceptance item in the current study may actually reflect a "non-rejecting" stance towards one's pain rather than being an accurate measure of "acceptance" towards one's pain experience. To address the conceptual and analytic issues raised by the pain acceptance indicator, a decision was made to replace the pain acceptance variable in the MCFA model with a different indicator of resilient pain coping cognition, pain control. Pain control is both conceptually and empirically related to pain acceptance, and is highly related to the other resilience indicators in the current study (see Tables 3 and 4). Moreover, it is scored in a positive direction, indicating that higher scores reflect greater perceived pain control. Thus, the multilevel CFA analyses were repeated with pain control replacing pain acceptance as the measure loading on to the resilience mechanism factor. Results of this analysis, presented in Figure 3, are consistent with a two-factor structure of resilience and vulnerability factors. Examination of the fit indices indicated an overall adequate fit using Hu and Bentler (1999) standards for RMSEA (RMSEA =.068), CFI (CFI = .832), and both the between-model and within-model SRMR (SRMR$_{within}$ = .080, SRMR$_{between}$ = .108).

At the within-person level, items showed good loading onto each factor score (standardized factor loadings ranged from .250 to .774), with all factor loadings significant at $p<.001$. The between-personal model also showed good fit for all loadings on both factors (standardized factor loadings ranged from .510 to .979), with all factor loadings significant at $p<.001$. Overall, these results indicated that the theoretical factor

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structure imposed on the outcomes were a good fit at both the within and between-person

level (Hu & Bentler, 1999).

Mediation in Multilevel Structural Equation Model

The next set of analyses utilized a multilevel structural mediator model to

estimate: 1) the relations between late morning pain and both afternoon resilience and

vulnerability (paths a_1 and a_2, respectively, in Figure 2); 2) the relations between

afternoon vulnerability and resilience mechanisms and end-of-day physical disability

(paths b_1 and b_2, respectively, in Figure 2); and 3) the roles of the afternoon vulnerability

and resilience mechanisms as the statistical mediators of the relation between late

morning increases in pain and end-of-day physical disability. The first mediation model

tested included both mediators, resilience and vulnerability latent factors, simultaneously

in the multi-level model, while allowing the two mediators to co-vary. However, this

model failed to converge, indicating a misspecified model. Next, the resilience and

vulnerability factors were each tested in individual multi-level mediation models.

Resilience Mechanism as a Mediator

A multi-level model was tested with the resilience mechanism as a single

mediator of the morning pain to end-of-day disability.

Within-level

The results of multilevel resilience mediation model are presented in Table 5.

The findings indicate that, as hypothesized, a within-day increase in late morning pain

predicted a decrease in the afternoon resilience (path a_1) and that an increase in resilience

in the afternoon predicted lower end-of-day disability (path b_1). Paths a_1 and b_1 are

significant (*p*s< .05) and shown in row 1 of Tables 5. Moreover, consistent with

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hypothesis, the resilience mechanism did significantly mediate the link between an increase in late morning pain and end-of-day physical disability. The asymmetric confidence interval for the a_1b_1 path was .004 to .007.

Between-level

Although the hypotheses for the mediation analyses were at the within-person level, MPlus also simultaneously estimates the results at the between-person level. Consistent with the within-person level results, people who reported higher mean level of late-morning pain also reported lower levels of afternoon resilience (path a_1), which, in turn, predicted their higher levels of end-of-day disability (path b_1), both paths significant at $p < .01$. Furthermore, afternoon resilience "mechanism" was shown to significantly mediate the link between late morning pain and end-of-day physical disability at the between-person level. The asymmetric confidence interval for this a_1b_1 path was .003 to .007. The results of the estimation of the between-person level of analysis are presented in row 2 Table 5.

Vulnerability Mechanism as a Mediator

The multi-level model testing the vulnerability mechanism as a single mediator of the morning pain to end-of-day disability path failed to converge indicating a misspecified model. To probe this error further, the three vulnerability indicators- pain catastrophizing, negative affect and interpersonal stress- were modeled together as three single indicator multi-level meditational paths.

Within-level

The analyses of the mediation model with the each vulnerability indicator modeled separately showed that negative affect and interpersonal stress did not mediate

the within-day pain-disability relation. However, a within-day increase in late morning

pain predicted an increase in the afternoon levels of pain catastrophizing (path a_2), which,

in turn, predicted higher end-of-day disability (path b_2), both paths significant at $p < .01$.

Moreover, within-day increases in afternoon pain-catastrophizing levels did significantly

mediate the link between an increase in late morning pain and end-of-day physical

disability (Table 6). The asymmetric confidence interval for the a_2b_2 path was .001 to

.003.

Between-level

At the between level, modeling each of the three vulnerability indicators

separately revealed that none serve as mediators of the morning pain and end-of-day

disability relation at the between level.

Summary

The findings indicate that within-person fluctuations in cognitive-affective-social

resilience and vulnerability factors are highly inversely related. Moreover, at both the

within- and between-person levels, a parallel mediator model linking more morning pain

with evening disability does not fit the data. Rather, it is the resilience factor, not

vulnerability as a whole, which mediates the relation between morning pain and evening

disability. However, the exploratory analyses revealed that among the vulnerability

factors, it is pain catastrophizing that appears to mediate the detrimental effects of

morning of increased pain on end-of-day disability.

DISCUSSION

The current study sought to investigate the day-to-day processes that keep people with fibromyalgia in a cycle of pain and disability, as well as those that enable individuals to endure exacerbation in their pain and persist towards daily goals. This was the first study to use an empirical approach to test a dual-factor model of risk and resilience incorporating affective, cognitive and social aspects of functioning. It was also novel in its investigation of how these resilience and vulnerability factors unfold in daily life to either protect individuals from or exacerbate their risk for disability in the face of pain. The findings that risk and resilience do constitute two factors, as predicted: 1) a resilience factor encompassing shared variance from positive affect, pain control and interpersonal enjoyment, and 2) a vulnerability factor encompassing shared variance from negative affect, pain catastrophizing and interpersonal stress. Findings also suggested that the resilience factor mediated the link between late morning increases in pain and end-of-day disability, in line with hypotheses. Although the vulnerability factor as a whole did not mediate the within-day link between pain and disability, pain-catastrophizing individually did serve as a significant mediator of this relation.

Capturing Resilience as a Within-Day Latent and Mediating Factor

Several scholars have presented theoretical models of risk and resilience "factors" that aim to capture key processes that guide pain adaptation (e.g., Sturgeon & Zautra, 2013; Goubert & Trompetter, 2017; Yeung, Arewasikporn & Zautra, 2012). The Two-Factor model, for example, suggests that in addition to identifying stable trait-like characteristics of resilient and vulnerable individuals (e.g., dispositional optimism,

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recurrent depression, etc.), investigators need to identify fluctuating or "modifiable" mechanisms that explain adaptive functioning in the presence of pain. Identifying modifiable dimensions of functioning has special relevance for the field, as these mechanisms are better targets for intervention than dispositional traits. Thus, the literature on resilience in the context of chronic pain and stress guided the focus on the current study on development of a resilience "factor" that captured key processes across affective, cognitive and social domains of functioning.

The results of the current study revealed that all three within-day resilience indicators (i.e., positive affect, pain control, and interpersonal joy) loaded significantly onto the resilience latent factor. Of note, the indicator with the highest loading was positive affect, a finding that is aligned with prior evidence. The role of positive affect is often emphasized in the resilience literature as a key contributor to adaptive stress coping responses. Under the broaden and build theory of positive emotions, while a stressor like pain narrows attention, positive affect facilitates the reversal of this cognitive narrowing, fosters expansion of attention, and increases access to wider range of thoughts and information (Fredrickson, 1998; Fredrickson et al., 2008; Garland et al., 2010). Experimental tests of this theory in healthy individuals have shown that positive affect enhances creative problem solving, broadens scope of attention and prompt them to pursue a wider range of thoughts and actions (Fredrickson & Branigan, 2005; Rowe, Hirsh & Anderson, 2007; Isen, Daubman & Nowicki, 1987). In chronic pain patients, a similar pattern of findings emerges. For example, positive affect has been shown to enhance self-efficacy beliefs for coping with pain and protect against pain-related activity interference among individuals with chronic pain (Park & Sonty, 2010). In a healthy

sample, positive affect was also shown to produce faster cardiovascular recovery following a stress-induction task (Fredickson, Mancuso, Branigan & Tugade, 2000). Thus, in addition to promoting more adaptive cognitive and behavioral coping responses, positive affect may also serve a protective function by promoting physiological self-regulation following stress.

Pain control, or perception of the ability to effectively decrease and manage pain, was the second highest loading indicator to the latent resilience factor. Higher state and trait levels of perceived control over pain have been associated with several adaptive outcomes, including lower levels of pain intensity and physical disability (State- Grant, Long, & Willms, 2002; Trait- Mohr, Leyendecker, Petersen & Helmchen, 2012; Tsai, Chu, Lai & Chen, 2008; Beckham et al., 1991). Given that the aversive and unpleasant nature of pain can cause individuals to feel helpless and handicapped, daily increases in pain control belief may enhance resilience in the face of significant pain by boosting confidence in the ability to manage the pain episode. Thus, the extent to which individuals have confidence in their ability effectively control their pain will allow them to view the pain as less threatening and unpleasant, which in turn may allow them to persisting in activities despite it (Turner, Holtzman & Mancl, 2007).

Several authors have argued that the systematic study of resilience requires consideration of the social-contextual factors concurrently with intrapersonal components to fully account for the variability in the pain adaptation process (Sturgeon & Zautra, 2015; Montoya et al., 2004; Arewasikporn, Davis & Zautra, 2013; Karoly & Ruehlman, 2006). Consistent with this proposition, daily interpersonal enjoyment in the current study was a key contributor to the latent resilience factor. In other words, sustaining

engagement in positive social relationships with spouse, family, friends and coworkers aided in interrupting the effects of a pain flare on exacerbating disability. The role of a positive interpersonal context in facilitating resilient functioning may unfold through multiple adaptive processes, including by dampening the stress associated with pain (Hostinar, Sullivan & Gunnar, 2014; Finan, Okun, et al., 2010), boosting positive emotions (Smith & Zautra, 2008), enhancing the use of adaptive behavioral and cognitive coping strategies (Manne & Zautra, 1989), reducing fatigue (Yeung, Davis, Aiken & Tennen, 2014), and ultimately preserving physical and psychological functioning despite increased pain (Taylor, Davis & Zautra, 2013).

Thus, the role of each of the three resilience processes have both theoretical and empirical support for how they may enable individuals to function well despite the presence of pain. However, what does the shared variance among these three unique mechanisms captured by the latent factor of "resilience" reflect? Traditionally, empirical studies of resilience in the chronic pain literature have presented resilience as a trait-level variable focusing on individual difference level cognitive and personality factors. For example, Karoly and Ruelman (2006) identified a subgroup of individuals with chronic pain as *resilient* if they demonstrated low average levels of pain interference and emotional burden despite reporting high average levels of pain severity. This resilient group also reported higher adaptive coping responses such as more positive self-talk and greater task persistence, and fewer maladaptive coping responses such as catastrophizing, pain-related fear and functional disability. The latent resilience factor as modeled in this study is similar to previous studies in that it reflects adaptive affective, cognitive and

social functioning in the context of pain, but it is unique in that it captures a state-level or momentary *increase in* adaptive coping response in the context of *increased* pain.

The results of the mediation analyses provide support for resilience as a *state* that reflects an individual's momentary adaptive response to an adverse event such as a pain flare. In the current study, on days when individuals had higher than usual pain in the morning, they experienced subsequent reductions in situational resilience and had greater pain-related functional disability by the end of the day. Conversely, when individuals were able to sustain increased resilience processes in the afternoon, they reported less end-of-day disability on days with increased morning pain. Thus, increased resilience in the afternoon was a significant mediator of the link between morning increases in pain and end-of-day disability. These results indicate that state resilience is a mechanism that can protect individuals from poor daily outcomes following intense morning pain.

The latent resilience factor, which captures the common variance among increases in positive affectivity, greater sense of control over one's ability to cope with pain and sustained engagement in positive social experiences, may interrupt the effects of heightened pain on disability by activation of an approach-oriented coping process. Gray (1994) proposed a behavioral approach system (BAS) that reflects emotions, cognitions, and behaviors aimed at moving an individual towards positive stimuli and possibilities. Thus, by sustaining approach motivation, the resilience processes in this study may serve a protective role by orienting individuals towards opportunities in the environment, positive goal-oriented cognitions and behaviors, and with that, the likelihood of persisting in adaptive activities despite significant pain.

Capturing Vulnerability as a Within-Day Latent and Mediating Factor

In the current study, not only did a latent resilience factor identify conditions under which individuals are able to sustain adaptive functioning despite exacerbations in pain, but also a latent vulnerability factor that captured processes that leave individuals at risk for poor outcomes in the face of increased pain. Previous empirical studies looking to identify a category of individuals vulnerable to poor outcomes have largely focused on individual difference characteristics. Smith and Zautra (2008), for example, identified a vulnerability factor among chronic pain individuals that was comprised of trait level anxiety, depression, high emotionality, interpersonal sensitivity, and pessimism. Karoly and Ruehlman (2006) identified a "non-resilient" group who showed higher trait levels of emotional burden, catastrophizing, pain interference, and greater reliance on prescription pain medication compared to resilient individuals. The modeling of vulnerability in the current study was unique in that it captured fluctuations in affective, cognitive, and social within-day processes that predict increased disability risk during the day-to-day pain coping process.

Among the risk processes, an increase in pain-catastrophizing had the highest loading on to the vulnerability latent factor. This result is unsurprising given the abundance of previous research supporting the role of pain-catastrophizing in daily pain adaptation. Pain catastrophizing has been shown to be an important mediator of affective, behavioral, and social dysfunction during the pain experience. For example, daily diary studies of state-level pain catastrophizing have shown that it contributes to emotional dysregulation (i.e., greater decreases in positive affect and increases in negative affect) following pain episodes (Sturgeon, Zautra, and Arewasikporn, 2014; Grant, Long, & William, 2002). It has also been shown to mediate the effects of increased pain on social

dysfunction by increasing social withdrawal and ineffective communication in the face of increased pain (Shelby et al., 2009). Behaviorally, pain catastrophizing predicts increased vigilance for pain, difficulty disengaging from signals of pain, and avoidance of key activities of daily life (Goubert, Crombez & Van Damme, 2004; Buer & Linton, 2002; Van Damme, Crombez & Eccleston, 2004).

Daily fluctuations in negative affect and interpersonal stress also significantly contributed to the vulnerability latent factor. Individuals with chronic pain are more vulnerable to experiencing negative affect more frequently and more intensely than those without pain (Staud et al., 2003). Activation of negative affective states such as increased sadness, fear and anger may contribute to daily dysfunction by modifying an individual's willingness to function under painful conditions and instead orient them towards behaviors focused on achieving relief from pain and emotional distress. While these defensive self-regulatory efforts may lead to relief in the short term, it does not move an individual closer to towards pursuing valued goals and activities. Similarly, a stressful interpersonal context may also exert a negative influence on day-to-day pain adaptation by disrupting affective, behavioral, and social functioning. Studies with repeated measures have shown that within-person increases in interpersonal stress can exacerbate emotional dysregulation (Finan et al., 2010), fatigue (Parrish, Zautra, & Davis, 2008), and behavioral avoidance (Schanberg et al., 2000).

Thus, similar to the resilience processes, the role of each of the three vulnerability processes also have both theoretical and empirical support for how they may influence daily adaptation in the presence of pain. The vulnerability latent factor is also unique in that it captures fluctuating, within-day processes that confer increased risk in the pain

coping process. However, unlike the resilience latent factor, it did not mediate the within-day pain intensity to disability relationship. Follow-up analyses examining the mediating role of each of the three vulnerability processes individually revealed that daily increases in afternoon pain-catastrophizing was the only one to mediate the pain to disability process. Specifically, results of the study showed that higher than usual morning pain contributes to subsequent functional disability partially through increases in afternoon pain catastrophizing.

In the face of intense pain, catastrophic thoughts about pain and one's ability to cope with it may make an individual vulnerable to functional impairments by activating an avoidance motivational system (Vlaeyen & Linton, 2012). As previously discussed, resilience processes may protect individuals from disability by increasing approach motivation and orienting them towards goal-directed behaviors despite the stress of pain. In contrast to the approach motivation that is activated by resilience processes, the avoidance motive activates self-regulatory strategies focused on escape from aversive or threatening stimuli. When catastrophizing about their pain, individuals interpret their pain as threatening, experience increased pain-related fear, and are more vigilant to pain-related cues (Goubert, Crombez, & Van Damme, 2004; Van Damme, Crombez, & Eccleston, 2004). Such hypervigilance to the threat of pain entraps individuals in a maladaptive cycle, where pain-related catastrophizing leads to greater levels of sustained vigilance and fear of pain, which in turn prompts the use of avoidant coping strategies due to fear of exacerbating pain during the accomplishment of daily activities (Vlaeyen & Linton, 2000; Vlaeyen, Crombez, & Linton, 2009). Therefore, the disabling consequence of pain catastrophizing emerges in the context of competing goals, when the goal to avoid

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pain is pursued over engagement in meaningful daily activities (Roy, 2010; Schrooten & Vlaeyen, 2010; Vlaeyen & Morley, 2004).

Follow-up analyses showed that the other two vulnerability processes of negative affect and interpersonal stress did not mediate the within day pain to disability relation. In the current study, morning increases in pain intensity predicted increased negative affect in the afternoon (a-path). This finding is line with previous studies have shown an increase in negative affect following episodes of pain (Affleck, Tennen, Urrows, & Higgins, 1991; Zautra, Burleson, et al., 1995). However, daily fluctuations in afternoon negative affect did not predict poor physical functioning at the end of the day (b-path). This finding indicates that when people are suffering from pain, although they may feel more emotionally distressed, negative affectivity on its own did not have profound negative consequences for maintaining daily physical functioning. For interpersonal stress on the other hand, increased morning pain did not lead to more negative social interactions in the afternoon (a-path). However, higher than usual interpersonal stress in the afternoon did lead to functional impairments at the end of the day (b-path). This suggests that increased pain may not make individuals more vulnerable to experience more negative social interactions, but when overwhelmed by stressful social experiences, they have difficulty sustaining progress towards day-to-day functional goals.

Two-Dimensional Structure of Resilience and Vulnerability Latent Factors

Although the resilience and vulnerability processes emerged as two latent factors in the current study, they were also highly inversely correlated at the within- and between-person levels, suggesting that they may not be two distinct constructs, contrary to prediction. Thus, follow-up analyses were conducted to test an alternate single-factor

model including all of the indicators. However, this model did not converge making it difficult to assess whether a one-factor model was a better fit of the six indicators compared to a two-factor model. However, a review of the existing evidence on models of risk and resilience provides some clues regarding how these two factors may be related at the state and trait levels.

Despite the considerable amount of variability in the literature on how "resilience" and "vulnerability" latent factors are operationalized and measured, several studies exploring a two-dimensional representation of adaptive and maladaptive attributes have found that these constructs share a high degree of common variance. For example, Wright, Zautra and Going (2008) predicted a two-factor model of risk and resilience, and found a high inverse correlation (r=-0.70) among these factors (risk factor indicated by trait neuroticism, depressive symptoms and negative affect; resilience factor indicated by trait extraversion, vitality and positive affect). Similarly, in a non-pain chronic illness sample, Gallo and colleagues (2012) identified two distinct but highly related factors (r=-0.80) for their resilience and risk latent model (resilience was comprised of trait self-esteem, social support, life engagement and low pessimism; risk was comprised of trait anxiety, depression, hopelessness, hostility and loneliness). Lastly, a study of women with a chronic health condition also found a strong inverse latent correlation (r=-.88) among resilient resource and psychosocial vulnerability factors (resilience measured by trait optimism, mastery, self-esteem and ego resiliency; vulnerability measured by trait neuroticism, perceived stigma and illness uncertainty) (Driscoll et al., 2016).

Thus, at the between-person level, the correlation between the resilience and vulnerability latent factors (r=-0.70) in the current study is similar to previous studies of

using trait-level predictors to test latent models of risk and resilience. Moreover, although a model testing a single-factor structure did not converge in the current study, prior studies have shown that despite the high correlation among these latent factors, a two-factor solution revealed to be a better fit when compared to a single-factor model (Driscoll et al., 2015; Wright, Zautra & Going, 2008). This suggests that although the risk and resilience constructs may share common variance, there is unique variance to each factor not accounted for by the single-factor structure.

However, given the higher correlation at the within person level (r=-0.99), there is a strong indication for the non-independence of these latent factors when resilience and vulnerability processes are at work at the same time. The persistent and unpredictable nature of pain creates an environment of constant stress and uncertainty for individuals living with chronic pain. Under these conditions, based on the Dynamic Model of Affect, risk and resilience processes may become less differentiated and converge on a single bipolar dimension, reflecting the high inverse relation between these two constructs. Studies have found that positive and negative affect become more polarized and less differentiated under conditions of increased stress and pain (Reich, Zautra, & Davis, 2003; Davis, Zautra, & Smith, 2004). Similarly, when individuals with fibromyalgia experienced increased negative events with their partners, they perceived lower levels of love and support from their spouse (Davis, Zautra & Smith, 2004). Thus, at the within person-level, individuals may have difficulty sustaining affective, cognitive and social complexity in moments when they are stressed by increased pain. Instead, the boundaries between the positive and negative systems may collapse to enable individuals to more

rapidly appraise stressors and adopt coping behaviors that alleviate the distress in that situation.

Limitations of the Current Study

This study has some important limitations that deserve mention. First, the resilience and vulnerability cognitive indicators (pain catastrophizing, pain acceptance and pain control) were measured using only one item each, which may not capture the multidimensional nature of these constructs. For example, while some researchers (Rosenstiel and Keefe, 1983) have conceptualized pain catastrophizing in terms of feeling helpless and unable to cope with pain, others (Sullivan et al., 2001) have reported that pain catastrophizing appears to have a more complex factor structure comprised of three separate dimensions, including rumination, magnification, and helplessness. Pain catastrophizing was measured in the current study with participant ratings of the statement "you felt your pain was so bad that you couldn't stand it anymore," which was not a comprehensive representation of the different dimensions of this construct. Thus, using a multidimensional scale of pain-catastrophizing could provide a more nuanced evaluation of this negative appraisal's relevance for pain management. However, the use of fewer items to assess these cognitions reduced participant burden when completing daily diaries and allowed for more frequent daily assessments to evaluate the impact of fluctuating levels of these constructs across the day.

The measurement of pain acceptance in the current study also proved to be problematic. Recent definitions of pain acceptance have suggested that this construct has two distinct components that impact the pain-coping process: a willingness to experience pain and engagement in valued activities despite the presence of pain (McCracken, 2010).

The pain acceptance variable utilized in the current study was constructed by reverse coding an item representing an "unwillingness" to experience pain ("How much have you told yourself that you shouldn't be feeling the way you're feeling?"). Thus, the reverse coded score of this item was thought to reflect willingness to experience pain, one of the two dimensions of pain acceptance. However, this reverse score may more strongly reflect a "non-rejecting" stance towards one's pain rather than capturing "acceptance" towards one's pain experience. Given the wealth of prior evidence indicating that pain acceptance is an important predictor of individual adaptation to pain (e.g., McCracken & Eccleston, 2005; Vowles, McCracken, & Eccleston, 2008), the lack of findings related to pain acceptance in the current study should be interpreted with caution as this construct may not have been completely represented in our assessment.

Some additional potential limitations also deserve comment. All the participants in this study had fibromyalgia and had volunteered to take part in a larger treatment outcome study. Thus, the extent to which the current findings generalize to other chronic pain populations and to non-treatment seeking individuals remains to be seen. Next, given the correlational nature of the data, the relation between the study variables should not be viewed as causal. Although the temporal ordering of variables may provide support for a theorized causal direction of the effects, only experimental manipulation of pain or the within-day affective, cognitive and social processes can establish a true causal relation between these and subsequent physical functioning. Lastly, as is typical of relations among variables in daily diary studies, the association among the within-day factors in the study was overall quite small. However, as experiences occur on a daily

basis, their effects may accrue over time, and the compounded effects could potentially have meaningful long-term impact.

Strengths and Future Directions

The results of the current study provide some potentially valuable implications for future studies. Researchers have called for the development of more complex models that provide a nuanced representation of adaptive and maladaptive multidimensional processes governing the day-to-day pain experience. Although several studies have presented risk and resilience models of trait level factors, to the author's knowledge, no study has examined whether state level risk and resilience factors exist. The within-day findings presented in the current study suggest that there is a time-varying component to these factors, and including them in future models of pain coping is necessary for a more complete representation of processes that predict greater resilience and vulnerability to pain. Understanding the within-day fluctuating relations between pain, coping processes and clinically relevant outcomes is also valuable for identifying meaningful targets for psychosocial pain interventions. For example, the findings from the current study indicate that in the face of pain, resilience and vulnerability processes become highly inversely correlated and collapse into a single dimension. This suggests that it would be valuable for interventions to target processes on either side (i.e., increase resilience processes or decrease vulnerability) to support one's ability maintain cognitive, affective, and social complexity and prevent them from withdrawing from valued activities during pain episodes.

Furthermore, evidence for the within-day latent structure of resilience and

vulnerability factors indicates the risk and resilience processes may be linked such the whole cluster may be activated in response to a stimulus such as pain. This may suggest that when individuals experience an increase in one of type of adaptive process, positive affect for example, they are more likely to report an increase in the other resilience-promoting processes. In other words, when experiencing increased positive affect, they may perceive their social experiences and ability to control their pain more positively. It is also possible that an increase in one resilience process may promote an increase in the experience (rather than just the perception) of the other processes. For example, when individuals experiencing more positive affect, they may also feel more in control of their pain symptoms and engage in more positive social experiences.

Another particularly unique aspect of this study was that it attempted to more accurately reflect individuals' real life experiences by modeling adaptive and maladaptive processes across multiple dimensions of functioning. Although the indicators in the current study were chosen based on theoretic and empirical support from the pain literature, only a limited number of cognitive, affective, and social processes were included. Future investigations might expand the model to include additional risk and resilience mechanisms across different domains that have been shown to influence the within-day pain cycle, including daily fluctuations in fatigue (Yeung et al., 2015), sleep quality (Kothari et al., 2015), pain expectancy (Mun et al., 2017), and loneliness (Wolf et al., 2015). Additionally, it is possible that in the current study, negative affect and interpersonal stress vulnerability processes did not mediate the within-day pain to disability relation because, unlike pain catastrophizing, these variables were not specifically related to the pain experience. Thus, more pain-focused maladaptive

affective (e.g., pain-related fear or anger) and interpersonal (pain-related spousal criticism or rejection) processes may hold more weight in explaining increased vulnerability to pain.

The mediating role of the resilience latent factor and pain catastrophizing were theorized to reflect approach and avoidance motivational processes. However, more targeted self-report measures of approach and avoidance tendencies (e.g., translating trait level measure such as the BIS/BAS scale to a state level measure) are needed to accurately understand how underlying motivational systems are activated and influence coping responses during times of intense pain (BIS/BAS Scale- Carver & White, 1994). However, given the potential biases in studies utilizing self-report measures, motivational aspects of coping may be best clarified in a laboratory setting. Studies experimentally manipulating pain and the risk/resilience mechanisms (i.e., affect, cognitions and interpersonal events) can more firmly establish their effect on modifying the willingness of an individual to approach or avoid engagement in a task. For example, the within-day model in the current study may be replicated in a laboratory environment using a paradigm where pain is experimentally induced (e.g., a cold-pressor task) followed by positive mood induction (or, interpersonal stress, cognitive-reappraisal tasks, etc.) to test their effects on an individual's persistence or discontinuation during a challenging task (e.g., stressful mental arithmetic or painful finger pressing tasks).

The current study provides some useful insights into mechanisms that allow individuals with chronic pain to persevere towards daily goals despite the stress of increased pain. Future studies may examine if these resilience mechanisms are also

applicable to individuals coping with non-pain related chronic stress. Resilience has been traditionally defined as sustaining positive functioning despite the presence of chronic, long-term stressors (e.g., Luthar, Cicchetti, & Becker, 2000; Cicchetti & Blender, 2006). Individuals may suffer from prolonged stress due to various causes such as other types of chronic illnesses, persistent insomnia, caregiving for a terminally ill family member or even socio-environment stressors like poverty. The chronic, fluctuating and uncontrollable nature of stress in these populations may make them vulnerable to poor day-to-day physical and emotional outcomes. While researchers have examined factors that contribute to trait level resilience in individuals facing non-pain related adversity (for reviews, see Aburn, Gott & Hoare, 2016 and Mukherjee & Kumar, 2017), few have explored how individuals may adapt to their stressor through the course of their daily lives. Thus, it may be useful to determine if the resilience mechanism identified in the current study are protective against poor daily functioning in other chronically stressed populations.

Conclusion

The current findings showed that the relation between morning pain flares and end-of-day physical disability is mediated by increases in pain catastrophizing and the resilience latent factor. Although negative thinking about pain increased vulnerability to poor functional outcomes, positive affect, feeling in control of one's pain and positive social experiences protected individuals from become further disability during days of increased pain. This study was the first to empirically test a within-day latent factor model of resilience and vulnerability and the first to capture the multidimensional nature

of the pain experience by examining mechanisms across affective, cognitive and social domains of functioning. The findings of the current study suggest that in addition to studying the processes by which pain has a negative influence on the lives of pain sufferers, our understanding of the pain adaptation process can be further improved by concurrently examining mechanisms that motivate individuals to overcome the urge to avoid pain and to function meaningfully despite it. A better understanding of the diverse ways in which individuals cope with the daily challenges of pain will allow further refinement and improvement of models of pain coping and prove useful in directing future interventions for chronic pain.

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Table 1
Sample Characteristics (*N*=220)

Measures	Mean or % (SD)
Age	51.25 (11.02)
Gender	
Male	11.2
Female	87.0
Education	
Not completed high school	2.2
Completed high school	13.0
Some College/business/trade	46.6
4 years of college	17.5
Post graduate	17.0
Marital Status	
Never married	8.1
Married/Living with Partner	55.3
Divorced/Widowed/ Separated	34.6
Employment	
Working Full-Time	23.3
Working Part-Time	27.4
Not working	47.1
Race/Ethnicity	
Caucasian	78.0
Black/African American	2.7
Asian	1.3
Hispanic	14.3
Native American	4.0
Native Hawaiian/Pacific Islander	0.9
Other	3.6
Income	
Under $3,000-$20,999	25.6
$21,000-$39,999	22.0
$40,000-$59,999	17.9
$60,000-$99,999	19.7
$100,000 and over	8.1

Table 2

Descriptive Statistics Of Between-person Variables Across All Days.
Range, mean, standard deviation, skewness, kurtosis, and intraclass correlation
coefficient (ICC) of measures used for the 220 participants. Computations are based on
individual daily diary raw scores of all participants.

Repeated Measure	Range	M(SD)	Number of Obs*	Response Rate^	Skew	Kurtosis	ICC
Pain	1-100	48.74(24.30)	3939	84.87%	-0.09	-0.80	0.50
Catas.	1-5	2.15(1.07)	4206	90.62%	0.58	-0.62	0.54
Neg. Affect	1-5	1.64(0.81)	4201	90.51%	1.47	1.64	0.65
Inter. Stress	1-5	1.67(1.04)	1628	59.04%	1.64	1.98	0.25
Acceptance	1-5	3.76(1.34)	4204	90.58%	-0.76	-0.69	0.75
Pain Cont	1-5	3.09(1.08)	4205	90.60%	0.02	-0.60	0.53
Pos. Affect	1-5	2.66(0.83)	4202	90.60%	0.23	-0.31	0.59
Inter. Joy	1-5	3.44(1.16)	1628	59.08%	-0.36	-0.69	0.43
Disability	1-3	2.00(0.63)	3767	81.17%	0.05	-1.05	0.37

*Number of observations is the number of individual daily diary scores aggregated
across all participants.
^Response rates were calculated based on 4620 possible daily reports that would
have been collected had participants provided responses on all 21 days of daily
diary protocol.

Table 3
Between-Person Correlations of the Study Variables for 220 Participants

	M(SD)	Pain	Catas.	Neg. Affect	Inter. Stress	Accept.	Pain Cont	Pos. Affect	Inter. Joy	Disability
Pain	48.79(17.81)	-								
Catas.	2.17(0.81)	0.74**	-							
Neg. Affect	1.67(0.67)	0.38**	0.54**	-						
Inter. Stress	1.67(0.58)	0.03	0.19**	0.44**	-					
Acceptance	3.75(1.16)	-0.39**	-0.57**	-0.43**	-0.27**	-				
Pain Cont	3.07(0.83)	-0.37**	-0.40**	-0.30**	-0.10**	0.25**	-			
Pos. Affect	2.64(0.66)	-0.42**	-0.49**	-0.46**	-0.28**	0.37**	0.65**	-		
Inter. Joy	3.40(0.81)	-0.11**	-0.10**	-0.34**	-0.57**	0.07**	0.28**	0.47**	-	
Disability	2.00(0.41)	0.34**	0.36**	0.28**	0.03	-0.16**	-0.35**	-0.47**	-0.01	-

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

Table 4
Within-Person Correlations of the Study Variables

	Std. Dev.	Pain	Catas.	Neg. Affect	Inter. Stress	Accept.	Pain Cont	Pos. Affect	Inter. Joy	Disability
Pain	16.87	-								
Catas.	0.71	0.50**	-							
Neg. Affect	0.47	0.23**	0.28**	-						
Inter. Stress	0.87	0.07**	0.09**	0.32**	-					
Acceptance	0.66	-0.21**	-0.27**	-0.29**	-0.09**	-				
Pain Cont	0.72	-0.35**	-0.40**	-0.21**	-0.04	0.17**	-			
Pos. Affect	0.52	-0.33**	-0.49**	-0.44**	-0.15**	0.24**	0.41**	-		
Inter. Joy	0.85	-0.16**	-0.09**	-0.28**	-0.35**	0.12**	0.12**	0.33**	-	
Disability	0.48	0.18**	0.24**	0.12**	0.07**	-0.09**	-0.19**	-0.30**	-0.09**	-

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

Table 5

Mediation model examining the role of afternoon resilience factor in mediating the relation between morning pain and end-of-day disability.

Model	a_1 path	b_1 path	$a_1 b_1$ path	Correlation	Asymmetric Confidence
	B (SE B)	B (SE B)	B (SE B)	of a_1 and b_1	Interval
1. Within-person	-.011***(.001)	-.535***(.048)	.006***(.001)	-.017	[.004, .007]
2. Between-person	-.017***(.003)	-.279***(.047)	.005***(.001)	.054	[.003, .007]

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

Table 6

Mediation model examining the role of afternoon pain catastrophizing in mediating the relation between morning pain and end-of-day disability.

Model	a_1 path	b_1 path	$a_1 b_1$ path	Correlation	Asymmetric Confidence
	B (SE B)	B (SE B)	B (SE B)	of a_1 and b_1	Interval
1. Within-person	.021***(.001)	.138***(.017)	.003***(.001)	.117	[.001, .003]
2. Between-person	.034***(.002)	.110(.068)	.004(.002)	.086	[0, .008]

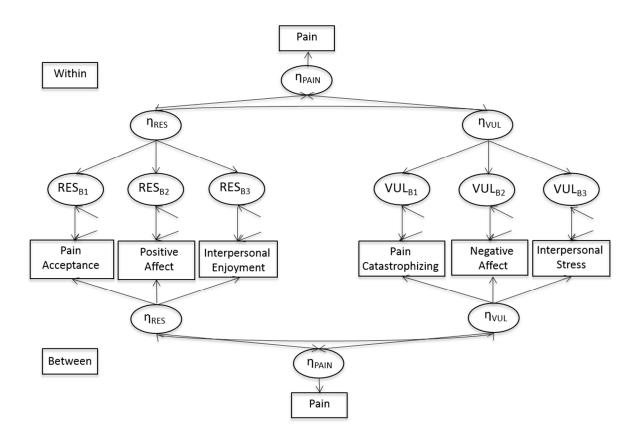† p <.10. * p < .05. ** p <.01. *** p < .001.

Figure 1. Model depicting the hypothesized two-factor multilevel confirmatory factor analysis. All pathways with arrows were estimated, though the factor structure and outcome are hypothesized at the within-person level. The small arrows in the center of the model indicate residuals. VUL = Vulnerability Mechanisms. RES = Resilience Mechanisms.
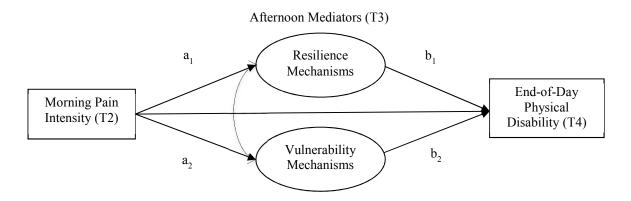
Afternoon Mediators (T3)

```
                    Afternoon Mediators (T3)

         a₁          ╭─────────────╮          b₁
                     │  Resilience  │
                     │  Mechanisms  │
                     ╰─────────────╯
  ┌──────────────┐                      ┌──────────────┐
  │ Morning Pain │                      │  End-of-Day  │
  │Intensity (T2)│─────────────────────▶│   Physical   │
  └──────────────┘                      │Disability (T4)│
                                         └──────────────┘
         a₂          ╭─────────────╮          b₂
                     │ Vulnerability│
                     │  Mechanisms  │
                     ╰─────────────╯
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Figure 2. Heuristic mediation model demonstrating the hypotheses to be tested. T2 = Time 2, Morning 11:00 AM. T3 = Time 3, Afternoon 4:00 PM. T4 = Time 4, End-of-Day 7:00 PM. Resilience Mechanisms = Positive affect, Pain Acceptance, and Positive Interpersonal Appraisals. Vulnerability Mechanisms = Negative affect, Pain Catastrophizing, and Negative Interpersonal Appraisals.
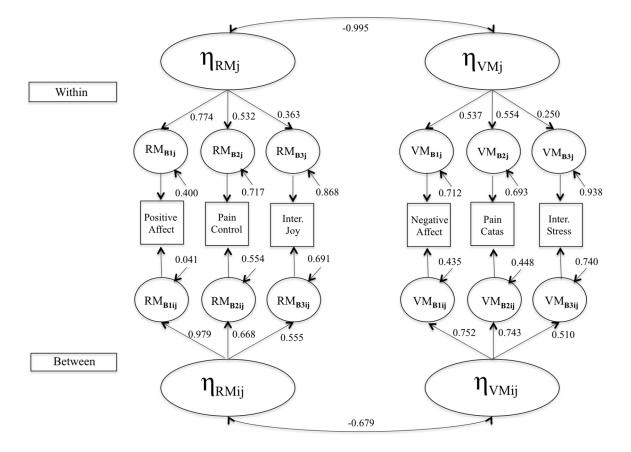
Figure 3. Confirmatory factor analytic structure for the resilience and vulnerability mechanisms. RM = Resilience Mechanisms, #1 = Positive Affect, #2 = Pain Control, #3 = Interpersonal Joy. VM = Vulnerability Mechanisms, #1 = Negative Affect, #2 = Pain Catastrophizing, #3 = Interpersonal Stress.
Note: Factor loadings reported in the figure are standardized and significant at *p*<.001, Smaller diagonal arrows towards the center represent residual variances for indicated variables.

APPENDIX A

MEASURE ITEMS AND RESPONSE SCALE

1. Physical Pain Item: What was your overall level of pain?
    Response Scale:
    Enter a number between 0 and 100 that best describes your pain level. A zero would mean "no pain" and a one hundred (100) would mean "pain as bad as it can be". Please enter your answer now. Remember all your answers should be followed by the # key.

2. Pain Catastrophizing Item: Have you felt your pain was so bad you couldn't stand it anymore?
    Response Scale:
    Please enter an answer on a scale of 1 to 5.
    1, not at all
    2, a little
    3, some
    4, quite a bit, or
    5, completely

3. Pain Acceptance Item: How much have you told yourself that you shouldn't be feeling the way you're feeling?
    Response Scale:
    Please enter an answer on a scale of 1 to 5.
    1, not at all
    2, a little
    3, some
    4, quite a bit, or
    5, completely

4. Perceived Control Over Pain Item: You were able to control your pain.
    Response Scale:
    Please enter an answer on a scale of 1 to 5.
    1, not at all
    2, a little
    3, some
    4, quite a bit, or
    5, completely

5. Negative Affect Items:
    a. How sad do you feel?
    b. How afraid do you feel?
    c. How lonely do you feel?
    d. How angry do you feel?
    Response Scale:
    Please rate each item on a scale of 1 to 5.
    1, not at all
    2, a little

3, some
4, quite a bit
5, completely

6. Positive Affect Items:
   a. How cheerful do you feel?
   b. How calm do you feel?
   c. How energetic do you feel?
   d. How much were you at ease about your emotions?
   Response Scale:
   Please rate each item on a scale of 1 to 5.
   1, not at all
   2, a little
   3, some
   4, quite a bit
   5, completely

7. Physical Disability Items:
   a. Did you cut down on the amount of time spent on work or other activities?
   b. Today did you accomplish less than you would have liked?
   c. Were you limited in the kind of work or other activities you did?
   d. Did you have difficulty performing work or other activities?
   Response Scale:
   Please rate each item on a scale of 1 to 3.
   1, no
   2, yes slightly
   3, yes very much

8. Interpersonal Event Items:

   Enjoyable Event Items: During the past 2-3 hours, how enjoyable were your relations with your spouse or partner (friends, family, co-workers) today?
   Response Scale:
   Please enter an answer on a scale of 1 to 5.
   1, not at all
   2, a little
   3, some
   4, quite a bit
   5, completely

   Stressful Event Items: During the past 2-3 hours, how enjoyable were your relations with your spouse or partner (friends, family, co-workers) today?
   Response Scale:
   Please enter an answer on a scale of 1 to 5.
   1, not at all

2, a little
3, some
4, quite a bit
5, completely