Emotional and Social Reactivity among Individuals with Comorbid Posttraumatic Stress Disorder and Chronic Pain: A Multi-method Study of Dysregulation

by

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ABSTRACT

Comorbid posttraumatic stress disorder (PTSD) and chronic pain create a heavier symptom burden than does chronic pain alone. Individuals with both conditions may exhibit physiological and emotional reactivity that make them susceptible to distressing reactions to negative social-emotional stimuli as well as less able to capitalize on positive social-emotional experiences. The current study examined physiological and emotional reactivity to affective stimuli in a laboratory setting as well as social responses to changes in interpersonal events in daily life among individuals with fibromyalgia (FM) and a history of PTSD symptoms versus those with FM only. The impact of the type of traumatic event experienced was also examined. Participants' startle reflex responses and emotional reactions to affective stimuli in a laboratory setting and social stress and enjoyment responses to interpersonal events in daily diaries were collected. Results indicated that higher levels of past PTSD symptoms were associated with higher levels of bodily pain, social stress, depression, negative affect, and less positive affect. Higher levels of past PTSD symptoms did not affect physiological or social-emotional reactivity to stimuli either in the laboratory setting or in the daily diaries. Individuals with a history of PTSD symptoms from sexual trauma exhibited lower startle magnitudes to positive emotional stimuli in the laboratory compared to individuals with no trauma or a history of PTSD symptoms from of other types of trauma. There were no differences among trauma types in responsivity to negative stimuli in the laboratory or social-emotional responses in daily life. Findings suggest lasting and stable effects of past PTSD symptoms on physical and emotional health in chronic pain, rather than reactivity to

positive and negative changes in the environment. Findings indicate the need to assess for past trauma in pain patients and tailor treatments to account for specific traumas.

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Introduction

Effectively coping with a chronic health condition on a daily basis can be daunting. For people living with chronic pain, the struggle includes not only pain, but also other sequela including fatigue, depression, coping difficulties, and pain-related disability (Hamilton et al., 2008; Thieme, Turk, & Flor, 2004; Turner, Jensen, Warms, & Cardenas, 2002). A similar pattern is evident among people with posttraumatic stress disorder (PTSD). They struggle on a daily basis to manage the aftermath of exposure to trauma, including mood disturbance, physiological dysregulation, and disability (Ginzburg, Ein-Dor, & Solomon, 2009; Sareen et al., 2007; Shin, Rauch, & Pitman, 2006). Unfortunately, many individuals lead a life marked by both chronic pain and PTSD. The growing literature on chronic pain and PTSD demonstrates that experiencing both conditions simultaneously is common. Studies have found point prevalence rates of comorbid PTSD and chronic pain ranging from 7%-46% in the general population and chronic pain populations (Sareen et al., 2007, Liebschutz et al., 2007; Von Korff et al., 2005). Comorbid PTSD and chronic pain rates as high as 50-80% have been found among veteran populations (Beckham et al., 1997; Otis et al., 2010; Shipherd et al., 2007).

Coping with a life marked by chronic pain alone is overwhelming, but what is life like for individuals who are experiencing chronic pain *and* PTSD? Individuals with comorbid chronic pain and PTSD often experience depression and anxiety, poor physical and psychosocial functioning, physiological dysregulation, and significant disability (Jenewein, Moergeli, Wittmann, Büchi, Kraemer, & Schnyder, 2009; Moeller-Bertram,

Keltner, & Strigo, 2012; Otis, Pincus, & Keane, 2006; Palyo & Beck, 2005; Sullivan et al., 2009). In addition to physical and emotional challenges, interpersonal issues including mistrust, stigma, and poor communication are prevalent and can exacerbate already compromised functional health (Alschuler & Otis, 2013; Cloitre, Miranda, Stovall-McClough, & Han, 2005). These interpersonal challenges serve to impair intimacy in close relationships, creating a cycle of social problems that hinder recovery (McFarlane, Bookless, & Air, 2001; Monson, Taft, & Fredman, 2009).

Especially important are findings that individuals with both chronic pain and PTSD experience worsened outcomes than those with chronic pain alone (Moeller-Bertram et al., 2012). For example, individuals with both fibromyalgia (FM), a condition marked by widespread chronic pain (Wolfe et al., 1990) and PTSD report greater levels of pain, emotional distress, life interference, disability, and trouble coping than FM patients without PTSD (Sherman, Turk, & Okifuji, 2000). Similarly, individuals with musculoskeletal pain and posttraumatic stress report greater pain intensity, emotional distress, and disability than individuals with pain but no posttraumatic stress (Ruiz-Párraga & López-Martínez, 2013). Individuals with chronic pain and PTSD also experience greater affective disturbance and disability than individuals with pain but no PTSD (Geisser, Roth, Bachman, & Eckert, 1996). Further, individuals with comorbid chronic pain and PTSD experience worsened cognitive-emotional aspects of the pain experience itself, including higher levels of catastrophizing about pain, feeling they have less control over their pain, and feeling that their emotions have a greater impact on their pain compared to individuals with chronic pain but no significant PTSD symptoms (Alschuler & Otis, 2012).

Definition and Psychological Correlates of Chronic Pain

Chronic pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage" (Otis, Pincus, & Keane, 2006) that lasts beyond the expected healing time and has a detrimental effect on an individual's well-being or functioning (American Society of Anesthesiologists Task Force on Chronic Pain Management, 2010). National statistics indicate that at least 30% of individuals in the United States report chronic pain with half of those people experiencing pain on a daily basis, and many rating the severity of their average pain to be at least a 7 out of 10, which corresponds with a moderate to severe level of pain (Johannes, Kim Le, Zhou, Johnston, & Dworkin, 2010).

Chronic pain is distressing for individuals living with it on a daily basis. Despite knowing that some level of pain is consistently present, many individuals with chronic pain struggle with the unpredictable nature of the severity, and they catastrophize about pain-related disability (Turner et al., 2002). Unfortunately, catastrophizing about pain frequently exacerbates the pain experience through its association with psychological distress, pain intensity, and pain-related disability (Turner et al., 2002). Struggles are also evident in social domains among many pain populations, FM in particular, as there is a strong sense of stigma because pain is usually not visible (Åsbring & Närvänen, 2002; Kool & Geenen, 2012). Pain-related stigma frequently leads to social withdrawal and loneliness, especially among individuals with FM (Åsbring & Närvänen, 2002; Kool & Geenen, 2012).

Unsurprisingly, mood disturbances among individuals with chronic pain are highly prevalent, with reports of nearly half of individuals with chronic pain having a major depressive disorder (Elliot, Renier, & Palcher, 2003). In studies of FM, patients are nearly three times more likely to have a major depressive disorder and nearly seven times more likely to have an anxiety disorder compared to individuals without FM (i.e., healthy controls or individuals rheumatoid arthritis) (Arnold et al., 2006). Understanding the high prevalence of mood disorders in chronic pain is important as there is a strong cyclic link between negative affect and pain among individuals with chronic pain (Zautra, Johnson, & Davis, 2005). Pain not only increases negative affect, but also decreases positive affect among individuals with FM (e.g., Zautra, Smith, Affleck, & Tennen, 2001). Further, individuals experiencing both chronic pain and psychological distress frequently report the greatest pain severity and pain-related disability (Bair, Wu, Damush, Sutherland, & Kroenke, 2008). In sum, chronic pain is affected by underlying emotional distress that creates significant coping abilities for individuals living with pain on a daily basis.

Definition and Psychological Correlates of PTSD

Akin to chronic pain, individuals with PTSD symptoms must face the burden of coping with emotional changes and symptoms on a daily basis, following exposure to traumatic circumstances. Individuals may experience intrusion symptoms, in which they are plagued by frequent nightmares of the traumatic event, become extremely emotionally and physiologically distressed when they are reminded of the event, and may feel as if the event is happening again (i.e., flashbacks). Understandably, individuals with PTSD symptoms often want to avoid any reminders of the event. They may avoid social

gatherings, activities, or places that remind them of the event or that seem similar to the event and therefore are deemed unsafe. Changes in mood are also frequently experienced, as individuals may develop negative beliefs about what the traumatic event means about them as a person or what it means about their ability to lead a happy life. Relatedly, they may develop distressing emotions such as fear, anger, and guilt, or conversely, they may develop an inability to feel a wide range of emotions (i.e., emotional numbing). They may also become less interested in activities that were once enjoyable, leading to greater disconnection from other people. Individuals with PTSD symptoms may also display behavioral and physiological changes by becoming irritable or aggressive, acting recklessly, startling easily, having trouble concentrating, and developing trouble sleeping. Often, individuals with PTSD symptoms become hypervigilant for any sign of a potential threat that is linked with their traumatic experience as a way to prevent it from happening again. Unfortunately, this constant need to be on alert may keep individuals from enjoying pleasant activities with others and concentrating on more important life goals (5th ed.; *Diagnostic and statistical manual of mental disorders*; American Psychiatric Association, 2013).

According to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed., *DSM-V*), individuals meeting criteria for PTSD must have experienced a traumatic stressor that resulted in intrusion symptoms, avoidance of trauma-related stimuli, negative alterations in cognitions and mood, and alterations in arousal and reactivity associated with the event. Symptoms must last for at least one month and create significant impairment in the person's life. Criteria for the intrusion cluster include experiencing at least one symptom, such as recurrent memories, traumatic nightmares,

flashbacks, intense or prolonged distressed to reminders of the event, or marked physiological reactivity after exposure to event reminders. Within the avoidance cluster, individuals exhibit at least one symptom of either avoiding trauma-related thoughts or feelings or avoiding external reminders of the trauma (e.g., people, places, situations). The alterations in cognitions and mood cluster of symptoms includes experiencing at least two symptoms following the trauma such as negative beliefs about oneself or the world, persistent negative trauma-related emotions, markedly diminished interest in life activities, and feeling alienated from others. The alterations in arousal and reactivity cluster of symptoms includes experiencing at least two symptoms following the trauma such as irritability, self-destructive behavior, hypervigilance, exaggerated startle response, trouble concentrating, and sleep disturbance (5th ed., text rev.; *DSM-V*; American Psychiatric Association, 2013). PTSD affects approximately 6.8% of adults in the United States (Kessler et al., 2005). Rates may be even higher among medical patients. For example, an assessment of primary care patients found that 23% had PTSD symptoms, but only 11% had the diagnosis in their medical record (Liebschutz et al., 2007).

The eliciting traumatic events required for a PTSD diagnosis may vary significantly in terms of duration, age of exposure, and the type of trauma experienced. Events that produce PTSD symptoms are often grouped together as simply traumatic events. Such a generalized category of traumatic events overlooks the possibility that different types of events may have differential effects on subsequent psychological and physiological dysregulation. One important question for the trauma field is whether the aspects of a traumatic event matter or if all traumas produce similar outcomes. A study

of PTSD resulting from various traumas found that not only do different traumas produce diverse overall PTSD severity, but also the severity of specific symptoms varies by event type (Kelley et al., 2009). Sexual traumas, for example, involve not only aspects of physical assault and threats to one's safety, but also involve damage to self-identity, intimacy, and trust. Therefore, individuals who have been sexually traumatized may be unique compared to those who have experienced non-sexual traumas. For example, sexual and physical assault victims report greater PTSD symptomatology, including avoidance and hyperarousal, less posttraumatic growth, and poorer psychological health compared to those who experienced bereavement-related or non-interpersonal traumas such as motor vehicle accidents (MVAs) (Frans, Rimmö, Åberg, & Fredrikson, 2005; Kelley, Weathers, McDevitt-Murphy, Eakin, & Flood, 2009; Shakespeare-Finch & Armstrong, 2010). Further, symptoms related to emotional numbing, trouble connecting with others, and avoidance are more severe in sexual assault traumas compared to MVA traumas (Kelly et al., 2009). Also, symptoms involving fear, hypervigilance, and physiological symptoms are more abundant as a result of sexual assault and MVA traumas relative to other traumas (Kelley et al., 2009). Taken together, it seems that although PTSD can occur from a variety of traumas, events involving interpersonal trauma and violence (i.e., rape, assault) tend to generate more severe PTSD symptoms than do other types of trauma (e.g., accidents, natural disasters).

Like those in chronic pain, individuals who have experienced traumatic events may also face emotional and physiological challenges. For example, individuals with PTSD symptoms report psychological distress and disability, poor well-being, a high likelihood of suicide attempts (Sareen et al., 2007), and more difficulties with emotion

regulation (Ehring & Quack, 2010). It is also more common to experience comorbid PTSD, depression, and anxiety than it is to experience only PTSD, and this comorbidity is associated with more impaired functioning (Ginzburg et al., 2009). In sum, individuals with PTSD face a plethora of physiological, emotional, and cognitive symptoms that are exacerbated by psychosocial distress.

Potential Mechanisms Underlying Poor Outcomes in Comorbid PTSD and Chronic Pain

What are the mechanisms that account for poorer outcomes among individuals with comorbid chronic pain and PTSD compared to those with only chronic pain? Emotional and physiological regulation is commonly impaired in both chronic pain and PTSD (Cloitre et al., 2005; Ehring & Quack, 2010; Hamilton, Zautra, & Reich, 2005; Nes, Roach, & Segerstrom, 2009; Tull, Barrett, McMillan, & Roemer, 2007). In fact, physiological and emotional dysegulation in the face of aversive experiences, including stress and pain flares, is a hallmark of both chronic pain and PTSD (Moeller-Bertram et al., 2012). Yet little work has examined whether having *comorbid* chronic pain and PTSD produces a cumulative effect that puts individuals at greater risk for these maladaptive physiological and socio-emotional responses compared to those with only chronic pain.

Two aspects of impairment in self-regulation among individuals with comorbid chronic pain and PTSD may be 1) inappropriately exaggerated physiological and emotional responses to stressful experiences, and 2) dampened or negative physiological and emotional reactions to positive experiences. Two complementary approaches have

been used to examine responsivity to stress and positive experiences: exposure to standardized stimuli in a laboratory and daily diary assessments of responses to everyday experiences in the field. Thus, impairments associated with PTSD and chronic pain may be seen in the laboratory environment in which individuals with these comorbid conditions display exaggerated physiological reactions, such as increased startle responses, to negative emotional stimuli. Similarly, individuals with these comorbid conditions may be unable to reap the emotional benefits of positive emotional stimuli during laboratory tasks by displaying either dampened positive emotional ratings or reacting with exaggerated startle responses to positive emotional stimuli that pose no threat (Litz, Orsillo, Kaloupek, & Weathers, 2000; Rhudy et al., 2013).

Impaired self-regulation may also occur in daily life such that individuals with comorbid PTSD and chronic pain may have exaggerated negative emotional reactions to difficult social situations relative to nonsocial situations. Further, individuals with both conditions may also have less positive emotional responses to positive social experiences by finding pleasant interactions to be less enjoyable. Thus, individuals with comorbid PTSD and chronic pain may display greater negative reactions to stressful emotional and social experiences and benefit less from positive emotional and social experiences compared to individuals with chronic pain only.

Laboratory Approaches to Understanding Reactivity to Negative and Positive Emotional Stimuli in Chronic Pain and PTSD

Both PTSD and chronic pain are characterized by hypervigilance and strong physiological reactions to stressful stimuli, whether it is perceived threats or potential

pain (Sharp & Harvey, 2001). Much of the work done on physiological reactivity in PTSD and chronic pain has utilized the startle response paradigm. This paradigm is used frequently because it provides a noninvasive means of detecting unbiased, automatic physiological responses to threatening stimuli, and it can be used to measure the extent to which physiological reactions to startling stimuli are modulated by emotional context (Grillon & Baas, 2003). The startle response is an automatic, defensive reflex that results in a wave of movement throughout the body (i.e., the startle response) and is a complex process that involves activity in several brain areas. After individuals perceive threatening stimuli through sensory organs and that input travels to sensory-related brain areas, such as the thalamus, and is relayed to the amygdala. Stimuli perceived to be threatening activate networks in the brain associated with responding to aversive stimuli. The amygdala signals the nucleus reticularus pontis caudalis, which signals the body to create the observable startle reflex (Lang, Bradley, & Cuthbert, 1998). The primary assessment of the startle response involves the eyeblink reflex that is typically evoked by a sudden burst of white noise (Grillon & Baas, 2003). The eyeblink reflex is a defensive reflex meant to protect against potential organ injury incurred while facing a threat (Lang et al., 1998). One facet of the eyeblink startle response is the startle magnitude, the intensity of the eyeblink response. A second measure of the response is the startle latency, the amount of time it takes for the eyeblink response to occur following the burst of white noise.

Additional assessments of physiological reactions to emotional stimuli are obtained by facial electromyographic (EMG) responses, particularly activity of the zygomatic muscle and the corrugator muscle. Unlike the startle response, which is

reflexive, zygomatic and corrugator muscle activity are voluntary responses to stimuli. Photos evoking positive emotions typically increase zygomatic muscle activity such that lips move to form a smile (Dimberg, Thunberg, & Elmehed, 2000). Photos evoking negative emotions activate corrugator muscle activity in which the eyebrows come together during a frown (Dimberg et al., 2000).

Startle responses can be modulated by emotional states, such that magnitude and latency depend on whether the individual is in an aversive or appetitive state. If a person is in an aversive, threatened emotional state, the startle response will occur more quickly than if the person is in an appetitive, non-threatened state (Lang et al., 1998). This differentiation occurs because when individuals are in a threatened state, they are primed to be ready to react to a threat and will react more quickly. Conversely, when they are in a calm, non-threatened state that does not signal the need to be ready to protect oneself at any moment, their startle responses will be slower and less pronounced. Further, when individuals are in a positive and enjoyable emotional state that signals pleasure, individuals exhibit an even further muted startle response relative to neutral.

Laboratory-based startle probe data have shown that compared to those without PTSD, individuals with PTSD have exaggerated reactivity to negative stimuli, reflected in greater startle magnitude, as well as more negative reported emotion (Asmundson & Katz, 2009; Grillon et al., 2009; Pole et al., 2007). For example, traumatized individuals with PTSD who are highly vigilant to potential threats exhibit greater startle magnitude during exposure to photos of angry, threatening faces, compared to those without PTSD (Fani et al., 2011). Even in experimental study conditions where the risk of threat is low

(i.e., participants were told they would not be shocked until later), individuals with PTSD continue to react with greater startle magnitude than those without PTSD, suggesting they are unable to differentiate between safe and threatening situations (Pole, Neylan, Best, Orr, & Marmar, 2003).

Similar physiological dysregulation has also been found among individuals with chronic pain. For example, studies employing the startle probe have found that compared to healthy individuals, persons with chronic neck and back pain display greater and prolonged startle responses during exposure to pain-related words, and this is especially true for those who are highly fearful and anxious about pain (Carleton, Asmundson, Collimore, & Ellwanger, 2006). The data are not uniform across pain groups, however. An experimental study of patients with FM and healthy controls did not find any group differences in startle magnitude in response to negative, attack-related photos, although patients with FM did respond more defensively by displaying greater displeasure ratings and corrugator EMG responses, a marker of voluntary physiological reactivity (Bartley, Rhudy, & Williams, 2009). A similar study of patients with FM, rheumatoid arthritis, and healthy controls found that patients with FM startled less to mutilation photos than to neutral photos, a pattern that did not occur in the other groups (Rhudy et al., 2013). However, patients with FM displayed greater corrugator EMG activity to these photos than the rheumatoid arthritis group, suggesting exaggerated voluntary physiological reactions to threat among individuals with FM (Rhudy et al., 2013). Taken together, these results suggest that compared to other pain groups and healthy controls, individuals with FM may not exhibit greater startle responses to negative stimuli, but they do display more negative facial expressions. The null startle reflex findings may be due to the small

FM sample size (n=18) or an inability of the photos to successfully activate exaggerated fear responses among FM participants in the form of automatic eyeblink startle (Rhudy et al., 2013).

Overall, individuals with either chronic pain or PTSD appear to have trouble disengaging from threatening stimuli, although no research to date has explored whether this is particularly true for those with comorbid chronic pain and PTSD. Further, individuals with FM, and potentially comorbid PTSD, may portray a unique pattern of reacting to stressful stimuli. Specifically, the scant laboratory research on FM suggests that individuals with FM may not display exaggerated startle responses to negative stimuli, compared to other pain groups, and may instead display negative reactions through voluntary facial expressions and emotional reports. However, further research needs to be conducted to determine potential laboratory reactivity among individuals with FM.

Exaggerated physiological responses in the context of negative emotional stimuli is only one part of the dysregulation that potentially exists in individuals with both PTSD and chronic pain; lack of responsiveness to positive stimuli may also be a problem. For example, individuals with PTSD have a diminished ability to experience positive emotions (Litz, 1992). In fact, individuals with PTSD who were primed with trauma cues showed less expressive facial activity, assessed via facial EMG, in response to positive images compared to controls, suggesting diminshed emotional responses to positive cues (Litz et al., 2000).

Likewise, chronic pain is associated with deficits in positive emotional experiences, especially during stress (Davis, Zautra, & Reich, 2001; Zautra, Affleck, et al., 2005). For example, in a study of FM, rheumatoid arthritis, and healthy controls, patients with FM rated pleasant erotic photos as less arousing (e.g., feelings of excitement) when experimental pain was not present compared to the rheumatoid arthritis group (Rhudy et al., 2013). Patients with FM also rated pleasant erotic photos as less pleasant during a pain induction task compared to all other groups (Rhudy et al., 2013). These findings suggest that pain flares may play an important role in FM, even compared to other pain populations, in dampening responses to positive stimuli, particularly during pain flares (Rhudy et al., 2013). Interestingly, patients with FM in this study startled significantly less to erotic photos than to neutral photos, which was not observed in the other groups despite all groups startling the least to erotic photos. Specifically, patients with FM displayed a blunted startle reflex response to positive photos, suggesting that the unconscious startle response to positive stimuli may not be negatively affected in FM (Rhudy et al., 2013). Another study of patients with FM and healthy controls did not find any group differences in startle reflex magnitude in response to pleasant erotic photos (Bartley et al., 2009). Although further research is needed, these findings suggest that individuals with FM may not exhibit differences in startle magnitude to positive stimuli, but do report positive stimuli to be less pleasurable. The null startle findings from these two studies may again be due to the small FM sample sizes (17 to 18 participants) or an inability of the erotic photos used as pleasant stimuli to successfully impact startle reflex responses between groups. Alternatively, it is possible that physiological differences

between chronic pain groups (particularly FM) and healthy groups are stronger for EMG and emotional ratings than for eyeblink startle responses.

Overall, the data on physiological and emotional reactivity to positive stimuli in chronic pain is mixed, but suggest that individuals with chronic pain may have blunted responses to positive stimuli. This is concerning, as positive emotions can help to boost recovery from stressful situations among individuals with chronic pain (Davis, Thummala, & Zautra, 2014; Zautra, Johnson, & Davis, 2005). Likewise, deficits in positive emotional responses in PTSD may hinder individuals' ability to capitalize on positive emotional experiences (Litz et al., 2000). Thus, deficits in positive emotional reactivity may reduce adaptive coping in individuals with both PTSD and chronic pain. Taken together, comorbid PTSD and chronic pain may be marked by exaggerated physiological reactivity to both negative and positive emotional stimuli as well as dampened emotional ratings in response to positive emotional experiences.

Approaches to Understanding Reactivity to Negative and Positive Social-Emotional Stimuli in Daily Life in Comorbid Chronic Pain and PTSD

In addition to laboratory-based reactivity among individuals with comorbid PTSD and chronic pain, individuals may also display exaggerated emotional distress to negative social interactions and dampened enjoyment from positive social interactions in daily life. As is the case with laboratory data, much of the existing data on interpersonal interactions of individuals with PTSD or chronic pain examine associations with negative social interactions, but overlook the possibility that individuals who are comorbid may also be unable to capitalize on beneficial, positive social experiences. Both PTSD and

chronic pain are associated with interpersonal and emotional difficulties, but how individuals with these comorbid conditions react emotionally to social stress and enjoyment associated with social interactions in daily life is largely unknown.

The scant research available indicates that interpersonal problems and poor emotion regulation jointly play an important role in decreasing functional health in PTSD (Cloitre et al., 2005) and chronic pain (Nes et al., 2009). For example, negative social reactions to disclosure of trauma are associated with PTSD symptoms among sexual assault survivors (Borja, Callahan, & Long, 2006). In addition, individuals with PTSD display greater cardiovascular reactivity to daily stressors compared to those without PTSD, suggesting difficulty coping adaptively with daily stress (Buckley et al., 2004). Further, individuals with PTSD report more relationship and family problems than individuals without PTSD (Monson et al., 2009).

Relatedly, interpersonal stress in chronic pain patients is associated with poor functional health, such as greater inflammatory responses and subsequent fatigue (Davis et al., 2008; Parrish, Zautra, & Davis, 2008). Of particular importance, daily social stressors are associated with poor functional health in chronic pain populations (Parrish et al., 2008), especially for those who are vulnerable to interpersonal stress (Smith & Zautra, 2002). Among individuals with both chronic pain and PTSD, those with more severe PTSD symptomatology, as compared to individuals with low levels of symptoms, report higher levels of punishing responses to their pain from their significant others (Alschuler & Otis, 2012). Further, punishing responses are related to greater pain disability and negative mood, indicating that unsupportive interpersonal interactions can

have a major impact on psychosocial and physical outcomes among individuals with both chronic pain and PTSD symptoms (Alschuler & Otis, 2012). Thus, emotional stressors, particularly social stressors, elicit more maladaptive responses from individuals with comorbid PTSD and chronic pain.

As opposed to poor outcomes associated with interpersonal stress, the benefits of positive social experiences for PTSD and chronic pain are extensive (Charuvastra & Cloitre, 2008; Holtzman, Newth, & Delongis, 2004; Tarrier & Humphreys, 2003). In PTSD, one avenue of coping with symptoms is through social interaction, as social support following trauma is typically thought to be associated with reduced PTSD severity (Charuvastra & Cloitre, 2008). For example, positive social interactions are associated with posttraumatic growth rather than PTSD symptoms (Borja et al., 2006). Likewise, capitalizing on positive social connections appears to be central to recovering from stress and pain episodes and preserving functional health among those in chronic pain (Taylor, Davis, & Zautra, 2013). For instance, positive interpersonal events are associated with positive affect among individuals with chronic pain (Zautra, Affleck, et al., 2005).

Despite the benefits of positive social interactions, inadequate self-regulation in both PTSD and chronic pain may hinder the ability to attend to valuable, positive emotional and social experiences (Cloitre, Koenen, Cohen, & Hyemee, 2002; Cloitre et al., 2005; Nes et al., 2009). Specifically, hypervigilance for threats in PTSD, which permeates both stressful and "safe" situations, leads to the tendency to perceive positive stimuli as potentially threatening and thus less beneficial (Litz, et al., 2000). This may

mean that in trying to reduce the risk of potential harm, individuals with PTSD are less likely to interpret social cues positively. In fact, individuals with PTSD are particularly sensitive to social messages from others, such that any indication of blame or negative responses from others regarding their trauma may actually *increase* their risk for worsened PTSD symptoms (Charuvastra & Cloitre, 2008). Similar deficits in perceptions of positive social stimuli may also exist in chronic pain. Although research on positive social interactions in chronic pain populations is limited, existing EMG data from healthy participants indicates that when individuals are in pain, they show delayed physiological responses to photos of happy faces versus angry faces relative to when they are not in pain (Gerdes, Wieser, Alpers, Strack, & Pauli, 2012). This suggests that positive socio-emotional stimuli are perceived as less positive during pain episodes, which may be particularly important in chronic pain patients. Therefore, individuals comorbid for PTSD and chronic pain may be especially disadvantaged; they may not reap the benefits of social connection compared to individuals with chronic pain alone.

Current Study

Evaluating reactivity among individuals with both PTSD and FM versus FM only is particularly important because individuals with FM often display greater physiological and emotional reactivity in laboratory settings and in daily life compared to other pain populations (Bartley et al., 2009; Parrish et al., 2008; Rhudy et al., 2013). Further, FM is often associated with trauma and PTSD, especially PTSD stemming from sexual trauma (Ciccone, Elliot, Chandler, Nayak, & Raphael, 2005; Häuser et al., 2013; Haviland, Morton, Oda, & Fraser, 2010). Additionally, patients with FM and PTSD experience poorer outcomes than those with FM alone, suggesting that this population may be

especially likely to experience physiological and psychosocial consequences of comorbidity (Sherman, Turk, & Okifuji, 2000).

The current study aimed to evaluate whether among individuals with FM, those with higher levels of past PTSD symptoms: 1) display greater physiological and emotional reactivity to both negative and positive affective stimuli in the laboratory, and 2) display greater negative emotional reactions (i.e., interpersonal stress appraisals) to negative social interactions and reduced positive emotional reactions (i.e., interpersonal enjoyment appraisals) to positive social interactions. Two complementary methods were used to test these hypotheses: 1) physiological assessment of physiological startle and self-report responses during standardized laboratory affective stimuli, and 2) self-report field assessments collected via electronic daily diary reports across 21 days. The laboratory assessment provided the opportunity to compare responses of all participants to the same stimulus materials in a controlled environment, whereas the diary assessments provided an evaluation of responses to a wide variety of positive and negative social interactions that patients encounter in everyday life. Because a positive social environment is related to improved adaptation in PTSD and chronic pain, the events captured in the diary assessment broaden this evaluation to emotion regulation in the most important realm of experience, the social world.

The current study used history of PTSD symptom severity among individuals with FM as opposed to the presence of a DSM-V PTSD diagnosis. It is important to recognize that many people who experience traumatic events and subsequent PTSD symptoms may not qualify for a PTSD diagnosis due to strict diagnostic criteria, despite

experiencing substantial psychological sequelae. Diagnostic criteria focus primarily on categorization of a number of symptoms rather than focusing on the severity of the symptoms themselves, which may be more relevant to quality of life. Thus, the severity of PTSD symptomatology may be a more valid predictor of associated adaptation than whether a person qualifies for a DSM-V diagnosis. It is important to note that PTSD symptom severity in the current study refers to the level of severity when PTSD symptoms were at their worst, which for many individuals, was more than a year ago. Further, the PTSD symptoms correspond to an event that participants denoted as their most traumatic event that happened at any point across the lifespan.

In addition to PTSD symptom severity, the type of trauma experienced may be a key factor in understanding how trauma impacts social-emotional functioning among individuals with chronic pain. In fact, a study of PTSD resulting from a range of different types of traumas found that not only do different kinds of trauma produce diverse overall PTSD severity, but also the severity of specific symptoms varies by event type as well (Kelley et al., 2009). For example, sexual and physical assault victims report greater psychopathology and PTSD symptoms compared to those who experience bereavement-related or non-interpersonal events such as a MVAs (Frans, Rimmö, Åberg, & Fredrikson, 2005; Kelley, Weathers, McDevitt-Murphy, Eakin, & Flood, 2009; Shakespeare-Finch & Armstrong, 2010). Therefore, exploratory analyses examined whether the type of traumatic event experienced plays a role in social-emotional outcomes with a specific focus on sexual trauma versus other types of primarily interpersonal (i.e., physical) and non-interpersonal (i.e., threat, witnessing trauma) events.

Hypotheses

The following hypotheses were tested:

Hypothesis 1a. Higher levels of past PTSD symptoms will be associated with greater startle responses during exposure to negative and positive affective slides compared to neutral slides (See Figure 1).

Hypothesis 1b. Higher levels of past PTSD symptoms will be associated with more negative valence ratings during exposure to negative and positive affective slides compared to neutral slides (See Figure 1).

Hypothesis 1c. Higher levels of past PTSD symptoms will be associated with greater arousal ratings during exposure to negative and positive affective slides compared to neutral slides (See Figure 1).

Hypothesis 2. Social stress diary reports will be higher among those with higher levels of past PTSD symptoms (i.e., between-person differences), and the link between daily increases in negative interpersonal events and social stress (i.e., within-person differences) will be more positive among those with higher versus lower levels of past PTSD symptoms (See Figure 2).

Hypothesis 3. Social enjoyment diary reports will be lower among those with higher levels of past PTSD symptoms (i.e., between-person differences), and the link between daily increases in positive interpersonal events and social enjoyment (i.e.,

within-person differences) will be less positive among those with higher versus lower levels of past PTSD symptoms (See Figure 3).

Exploratory analyses. In addition to examining the main and moderating effect of PTSD symptom severity on reactivity to affective stimuli in the laboratory and interpersonal events in the diaries, other factors associated with PTSD that have been consistently linked to poor adaptation. Specifically, to determine whether outcomes depend on the type of traumatic event experienced, trauma type was explored as a moderator of the link between affective stimuli and emotional and physiological reactions. That is, the test of the primary hypotheses were repeated with trauma type as a moderator instead of PTSD symptom severity. To determine whether sexual traumas produced poorer outcomes than other specific interpersonal and non-interpersonal traumas, the current study trauma type groups included no trauma, physical trauma (interpersonal), sexual trauma, personal threat-related trauma, and witnessing something traumatic.

Methods

Participants

A sample of individuals with chronic pain was recruited from the Phoenix metropolitan area using newspaper advertisements, online postings, and local doctors' offices as part of a larger study on psychological treatments for fibromyalgia. Individuals were included in the study if they: (1) were between the ages of 18 and 72; (2) had pain for three months or more in at least three of four quadrants of the body, or in two quadrants of the body and they had substantial sleep disturbance and fatigue; (3) reported

pain in at least 11 of 18 tender points during a home visit (described below), consistent with diagnostic criteria for FM established by the American College of Rheumatology, (Wolfe et al., 1990); (4) did not have any autoimmune pain disorders; (5) were not currently in other research trials or receiving psychotherapy; and (6) were not pursuing litigation related to their pain condition.

Procedure

Screening. Interested participants were screened by phone to determine initial eligibility. Those who screened eligible underwent a tender point exam administered by a research nurse. The exam included administration of 4 kg of pressure delivered with a dolorimeter to each of 18 tender points and 3 control points. To qualify for study enrollment, participants had to report experiencing some pain in response to pressure on at least 11 of 18 tenderpoints (Wolfe et al., 1990). Upon enrollment, individuals read and signed a consent form and completed an initial questionnaire packet including measures of physical health, emotional health, and pain. Participants also completed a clinical visit from a nurse, which assessed pain and comorbid health issues. Additionally, participants completed a phone interview assessing depression, PTSD, and life events. Next, they completed pre-intervention assessments that included: (1) a laboratory session to assess emotion-modulated startle responses and pain tolerance; (2) 21 days of diary reports regarding interpersonal events, pain, fatigue, sleep quality, mood, and coping; and (3) questionnaires regarding current symptoms and physical and emotional functioning. Participants were then randomly assigned to one of three 7-week treatment conditions. Following completion of treatment, they underwent post-intervention assessments

identical to those in pre-assessment, and completed six- and twelve-month follow-up questionnaires.

Seven hundred and sixteen individuals were initially screened by phone. Of those screened, 444 did not meet inclusionary criteria, primarily due to lack of interest and/or time to complete the study requirements. The remaining 272 were enrolled in the study. Two hundred and twenty of those enrolled proceeded to complete the initial diary assessments. The majority of the 52 individuals who dropped after enrollment and provided an explanation for their withdrawal cited time constraints as the primary reason. The current study draws on data from 220 individuals who completed the phone interview and the pre-intervention diaries. The laboratory data draw from 170 of these individuals who completed the pre-intervention laboratory startle procedure.

Laboratory assessment. Physiological and self-reported emotional reactions to standardized emotion slides with and without an acoustic startle stimulus were obtained using electrodes that assessed eyeblink and facial muscle EMG activity and ratings of affective valence and arousal (Lang, Bradley, & Cuthbert, 1998). Following preparation of participants' skin for electrode placement, lab staff placed Ag/Ag Cl conducting electrodes with gel on the forehead (i.e., ground), left corrugator muscle (i.e., frowning muscle), left zygomatic muscle (i.e. smiling muscle), and left orbicularis muscle (i.e., startle eyeblink). Electrode impedances for all electrodes fell below 10 kΩ. A BioPac MP 100 system (Biopac Systems, Inc.) was employed to process and record EMG activity. The raw EMG signals were sampled digitally at 2000 Hz and were amplified using BioPac EMG bio-amplifiers.

After electrode placement, participants sat quietly for approximately ten minutes to become acclimated to the environment. Then, participants received digitized voice instructions transmitted via headphones, which allowed for standardized delivery of instructions across all participants. Instructions also appeared in writing on a video monitor in front of the participant. The instructions prompted participants to view slides that varied in emotional content and then rate the valence and arousal of each slide after it was presented. Participants were also instructed that they would periodically hear a brief noise over the headphones, and a sample of that acoustic burst was delivered. They were then exposed to three sample slides, two of which included an acoustic startle burst, to familiarize them with study procedures and allow them to ask any questions prior to proceeding to the data collection phase of the protocol.

Individuals were exposed to a total of 36 slides depicting emotional content (12 negative, 12 neutral, 12 positive) while their eyeblink startle, facial EMG, and heart rate responses were assessed. Prior to the display of each slide, an orienting symbol (i.e., "+") was displayed for three seconds to alert the participant of an upcoming picture. Each slide was then presented for six seconds followed by participant ratings of valence and arousal for that slide.

For two-thirds of the slides within each emotional valence category, an acoustic stimulus was presented during slide viewing. The acoustic startle probe consisted of a 95 dB, 50-ms burst of white noise presented through earphones. Headphones were calibrated before each participant to ensure proper voltage and decibels of the probe. The startle probe was randomly delivered 3, 4, or 5 ms after picture onset to prevent

habituation to the startle. EMG data were relayed to a computer and monitored by lab staff members in a separate room while participants viewed slides on a computer in their own room.

Photos used during the startle portion of the laboratory visit were drawn from the International Affective Picture System (IAPS; Lang, Bradley, Cuthbert, 1999). A total of 36 slides depicting affective content (negative, neutral, positive) were included with 12 slides in each category. Slides were selected based on normative ratings of valence and arousal to be highly positive (i.e., positive slides), neither positive nor negative (i.e., neutral slides), or highly negative (i.e., negative slides). Examples of photos from the negative category included a snake, a burn victim, and a toilet. Examples of photos from the neutral category included an umbrella, shoes, and a lamp. Examples of photos from the positive category included images of romantic couples, sailing, and nature scenes. The order of slide presentation was randomized within blocks of six slides. Each block had two slides of each valence (negative, neutral, positive). The six blocks of six slides (n = 36 slides) were also randomized.

A computerized version of the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) was used to assess participants' reactions to each slide. The SAM has two sets of 5 pictographs (see Appendix A), one measuring valence and the other arousal. The valence slide ratings range from 1 (pleasant) to 9 (unpleasant) in which the pleasant end of the scale is depicted by a smiling figure and the unpleasant end of the scale is depicted by a frowning figure. The arousal slide ratings range from 1 (excited/highly aroused) to 9 (calm) in which the excited end of the scale is depicted by a wide-eyed figure and the

calm end depicts a relaxed, sleepy figure. Participants clicked on the drawing that best represented how they were feeling at the time. The SAM has been widely used in research applying the startle probe protocol and has good reliability and validity (Backs, da Silva, & Han, 2005).

Diary assessment. To initiate the pre-intervention diary assessment, a member of the research team met with participants to provide them with a cell phone to use and detailed instructions and training on how to complete the phone diaries. Participants were prompted to complete diary reports four times per day for 21 days via an automated system that called the cell phone, delivered audio recorded questions, and collected responses via phone keypad input from participants. The morning call time was chosen by the participant to occur approximately 30 minutes following normal wakening time in the morning. The other three calls came at 11:00 am, 3:30 pm, and 7:00 pm. If participants missed a call, they could call into the system within three hours of the automated call to complete the questions. Call completions were monitored by study staff members, who routinely checked in with each participant on his/her progress. If participants missed calls for several days in a row, they were contacted immediately by study staff members to remedy any potential barriers to consistent completion. Participants were paid $2 for each day they completed diaries, with a bonus of $1/day for rates of completion that were 50%. Regarding reports used in the current study, participants completed 17.25 end-of-day reports, on average (*SD*=4.75, range = 1-23). Further, participants completed 3,796 of 4,620 observations possible across the sample (82%).

Measures

Copies of all measures can be found in Appendix A.

PTSD symptom history during worst period. The Mini-International Neuropsychiatric Interview (MINI) is a short, structured diagnostic interview for DSM-IV Axis-1 disorders (Sheehan et al., 1998). The MINI Plus, used in this study, is a version of the MINI interview particularly designed for research. The sections assessing symptoms of depression and posttraumatic stress disorder and additional questions about symptoms stemming from trauma were administered as part of the study protocol. The MINI questions involve asking participants about the occurrence of traumatic events across the lifespan, and if they endorse any, asking them to choose the most upsetting event for further evaluation. Then, a series of questions that assess DSM-IV criteria related to the most upsetting event are administered. PTSD symptom severity pertains to the time when PTSD symptoms were at their worst in response to the most upsetting event. The MINI has demonstrated excellent reliability and validity (Sheehan et al., 1998). Internal reliability of symptom severity in the current sample was high (Cronbach's alpha = .81).

Daily occurrence of interpersonal events. Interpersonal events were measured in the daily diary using items from the Inventory of Small Life Events (ISLE) for older adults (Zautra, Schultz, & Reich, 2000). Items on the ISLE were supplemented with additional items created by study investigators to assess interpersonal rejection. Specifically, items regarding instances when a spouse or partner ignored a participant, turned down a participant's requests for time together, was too busy to talk, and being ill-

behaved were supplemented. Participants were asked if 6 desirable and 8 undesirable events occurred with their spouse or partner across the day by responding yes or no to each event. An example of positive events include: "You celebrated with your spouse or partner." An example of negative events include: "Your spouse or partner was critical or angry with you." Participants were also asked about 10 desirable and 5 undesirable events with family across the day by listening to the event choices and keeping count of how many occurred in each category. An example of positive events include: "You received a letter or email from a family member." An example of negative events include: "You were criticized or blamed for something by a family member." Lastly, participants were asked about 6 desirable and 5 undesirable events involving friends or acquaintances that occurred across the day by listening to the event choices and keeping count of how many occurred in each category. An example of positive events include: "You went to a party or other social gathering with friends." An example of negative events include: "You had a conflict with a friend or acquaintance."

To create variables representing positive and negative interpersonal events, the total number of events that participants endorsed from each category across all days were summed and centered within-person. (This process is described in detail in the data analysis section). Sixty-six percent of the variance in negative interpersonal events was within-person and 34% was between-person. Fifty-three percent of the variance in positive interpersonal events was within-person and 47% of the variance was between-person.

Social stress and joy. After each set of questions about undesirable events with a spouse, family, or friends and acquaintances, participants were asked how stressful their relations were with each group. For example, after answering questions about undesirable events with a spouse, participants were asked, "Overall, how stressful were your relations with your spouse or partner today on a scale of 1 to 5?" The response scale included the following options: (1) is not at all; (2) a little; (3) some; (4) quite a bit; or (5) completely. Similarly, after each set of questions about desirable events with a spouse, family, or friends and acquaintances, participants were asked how enjoyable their relations were with each group. For example, after answering questions about desirable events with a spouse, participants were asked, "Overall, how enjoyable were your relations with your spouse or partner today, on a scale of 1 to 5?" The same response scale was provided. Sixty-seven percent of the variance in stress ratings was within-person and 33% was between-person. Fifty-three percent of the variance in enjoyment ratings was within-person and 47% of the variance was between-person.

Background attributes. In addition to social appraisals, general assessments of PTSD and emotional and physical health were collected. Negative and positive affect was measured using 12 items drawn from the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Participants rated the extent to which they experienced each affect during the day for 5 items reflecting negative affect and 7 items reflecting positive affect using a 5-point scale from 1 (not at all) to 5 (completely). Examples of positive affect items included, "How cheerful did you feel?" Examples of negative affect items included, "How angry did you feel? The within-person reliability was .63 for negative affect and .74 for positive affect. Thirty-six

percent of the variance in negative affect ratings was within-person and 64% was between-person. Fifty-five percent of the variance in positive affect ratings was within-person and 45% of the variance was between-person.

Depressive symptoms levels were measured each day using five modified items assessing common symptoms of depression drawn from the Patient Health Questionnaire (Kroenke & Spitzer, 2002). Items were rated on a 3-point scale from 1 (no) to 3 (yes, very much). Items included: "Did you feel… a lack of interest in your activities; down on yourself; restless or slowed down; an increase or decrease in appetite; difficulty concentrating or making decisions?" A mean of these items was computed to create a depressive symptom score for each day. The within-person reliability for depressive symptom items was .64. Fifty-four percent of the variance in depressive symptom ratings was within-person and 46% was between-person.

Daily pain was measured on a 101-point numerical rating scale (Jensen, Karoly, & Braver, 1986). Average pain was assessed in the late morning, early afternoon, and at the end of the day. Participants were asked, "What was your overall level of pain today? 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.'" Forty-eight percent of the variance in pain ratings was within-person and 52% of the variance was between-person.

Role limitations due to physical problems were assessed in the diary using the 4-item Role Physical (RP) subscale from the SF-36 health survey (Ware & Sherbourne, 1992). Participants were asked to rate the following statements: "(1) Did you have difficulty performing work or other activities?, (2) Did you cut down on the amount of

time spent on work or other activities?, (3) Were you limited in the kind of work or other activities you did?, and (4) Today did you accomplish less than you would have liked?" Statements were rated on a scale of 1 to 3 with 1 meaning "no" and 3 meaning "yes, very much." Daily functional impairment scores were computed by averaging the four items. The within-person reliability for functional impairment items was .74. Sixty-four percent of the variance in functional impairment ratings was within-person and 36% was between-person.

Data Reduction and Analytic Strategy

PTSD symptom assessment. To create the PTSD symptom severity variable, individuals with a history of trauma were placed into groups of ascending symptom severity relative to the sample mean. Descriptives were also calculated for the continuous version of the PTSD symptom severity variable prior to dividing it into categories as to provide information on the original mean and standard deviation. The following groups were created: no trauma, low severity (i.e., symptom severity below the mean), moderate severity (i.e., symptom severity at the mean or up to one standard deviation above the mean), and high severity (i.e., symptom severity one standard deviation above the mean or greater). These groups were created to provide a more meaningful way to assess differences between PTSD symptom severity as well as to address the non-normal distributional properties of the symptom index (i.e., absence of symptom severity of people with no trauma exposure) on the variable's distribution.

Additionally, the PTSD evaluation included coding the type of trauma experienced, which was determined by coding the traumas into categories. Type of

trauma was divided into 5 categories: no trauma, sexual trauma, physical trauma, threat to one's safety, and witnessing traumatic harm to someone else. These categories were created to examine differences between sexual trauma and other interpersonal and non-interpersonal traumas based on existing literature.

EMG data reduction. EMG waveforms were first inspected to detect potential artifact due to movement and to properly identify startle responses in the data. Responses that were more than three standard deviations from the mean response for each subject were deleted. The raw data were band-pass filtered over a range of 90-1000 Hz, rectified, and smoothed with a 200-ms moving window. Eyeblink responses were identified by determining the peak value between 20 and 200 ms following the startle probe. To derive startle magnitude, the mean voltage of the orbicularis muscle during the 60-ms before the startle probe stimulus (i.e., baseline) was subtracted from the peak voltage that occurred between 20-200 ms after the startle probe onset. To determine the startle magnitude response to each type of valence, the average startle magnitude across all probed slides for each participant was subtracted from the average startle magnitude for each valence type, thereby creating z-scores for each type of slide (negative, neutral, positive) for each participant. In addition, emotional valence and arousal ratings of the slides were averaged within each slide valence category. For example, arousal ratings to negative slides were computed by averaging the arousal ratings across all negative slides.

Analyses of lab data to test hypotheses 1a-1c. Two-factor mixed ANOVA analyses were used to analyze the laboratory data component of the study. Specifically, for Hypotheses 1a-1c, a two-factor mixed ANOVA model for each dependent variable

(startle magnitude, valence ratings, and arousal ratings) was tested, where PTSD symptom severity group (none, low, moderate, high) was a between-groups fixed effect and picture valence (negative, neutral, positive) was a within-subject repeated measures fixed effect. A PTSD symptom severity group X picture valence interaction was included in each model.

A chi-square test was used to examine whether there were differences in medication use (i.e., yes/no regarding use of any medications, including tricyclic antidepressants, anticholinergics, and opiates) between the PTSD symptom severity groups to determine if it needed to be included as a covariate in laboratory analyses. However, there was no significant association between PTSD symptom severity group and medication use, $\chi^2(3, n = 167) = 4.50$, p=.21. Therefore, medication use was not included in final laboratory analyses.

To identify additional whether age and gender should be included as covariates, an ANOVA was conducted with PTSD symptom severity group predicting age. There was a significant difference between ages of severity groups, $F(3,162) = 3.36$, $p = .02$, and therefore age was included in final laboratory analyses. A chi-square test was used to examine whether there were differences in gender between the PTSD severity groups. There was no significant association between PTSD symptom severity group and gender, $\chi^2(3, n = 165) = 1.20$, p=.75, and therefore gender was not included in final laboratory analyses.

Analyses of diary data to test hypotheses 2 and 3. Multilevel modeling was the most appropriate approach to data analysis for the diary component of the proposed project because the data are structured such that each participant provides end-of-day

reports across a 21-day period (Hox, 2002; Singer, 1998). This design allows for both within- and between-person comparisons. Because observations per participant occur over 21 days, there is a high likelihood of missing data. Multilevel modeling is useful in this respect because it includes observations from all participants, regardless of whether they completed every assessment.

The current study has two levels consisting of end-of-day reports (Level 1 or within-person) nested within individuals (Level 2 or between-person). In this study, the Level 2 variable is PTSD symptom severity assessed during the phone interview. The Level 1 (within-person) is comprised of an individual's end-of-day reports that ask participants about interpersonal events that occurred that day. To disaggregate the between- from the within-person variation included in the end-of-day reports, these event reports were centered within-person. Specifically, each participant's daily score was subtracted from his/her mean score over all days of assessment; thus, each centered score signifies each day's deviations from an individual's mean across all their days of assessment. Level 1 person-centered scores are uncorrelated with Level 2 score on the same variable, facilitating interpretation of effects (Enders & Tofighi, 2007).

To create variables representing positive and negative interpersonal events, the total number of events endorsed across all social domains were summed and centered within-person for positive and negative events, separately. Specifically, each individual's daily sum of negative interpersonal events was subtracted from his/her mean number of negative events over all days of assessment. The same computation was performed with positive interpersonal events. This process of centering around each individual's own average ensures that analyses are testing "when" events occur, rather than testing the

number of total events, thereby making it irrelevant whether participants without spouses may have fewer events to report than those with spouses.

To analyze the models for Hypotheses 2 and 3, main effects and moderation within an MLM framework were tested. For Hypothesis 2, PTSD symptom severity was tested as a predictor of daily social stress (main effect) and as a moderator of the relations between centered negative interpersonal events and daily social stress. For Hypothesis 3, PTSD symptom severity was tested as a predictor of daily social enjoyment (main effect) and as a moderator of the relations between centered positive interpersonal events and daily social enjoyment.

To determine potential covariates, the interactions between level-2 demographic covariates (i.e., age, gender, marital/partnered status, employment status, income, ethnicity) and centered negative events with stress as an outcome and between level-2 demographic covariates and centered positive events with enjoyment as an outcome were tested, following primary analyses. The interactions between changes in negative events and marital/partnered status, and changes in negative events and income, were significant in predicting stress and were therefore included in final stress-related analyses. The interactions between changes in positive events and marital/partnered status and changes in positive events and income were significant in predicting enjoyment and were therefore included in final enjoyment-related analyses.

Lastly, one-way ANOVAs were used to determine differences between PTSD symptom severity groups in background physical and emotional health characteristics, including pain, functional impairment, depression, and affect. Significant effects were followed up with post hoc Bonferroni pairwise comparisons.

Analyses of lab data to test exploratory hypotheses. Two-factor mixed ANOVA analyses were used to analyze the exploratory laboratory data component of the study. Specifically, a two-factor mixed ANOVA model for each dependent variable (startle magnitude, valence ratings, and arousal ratings) where trauma type (none, physical, sexual, threat, witness) was a between-groups fixed effect and picture valence (negative, neutral, positive) was a within-subject repeated measures fixed effect. A trauma type X picture valence interaction was included in each model.

A chi-square test was used to examine whether there were differences in medication use (i.e., yes/no regarding use of any medications, including tricyclic antidepressants, anticholinergics, and opiates) between the trauma type groups to determine if it needed to be included as a covariate in laboratory analyses. However, there was no significant association between trauma type group and medication use, $\chi^2(4, n = 163) = 7.42$, p=.12. Therefore, medication use was not included in final exploratory laboratory analyses.

To identify additional potential covariates, an ANOVA was conducted with trauma type group predicting age. There was a significant difference between ages of trauma types, $F(4,157) = 2.85$, $p = .03$, and therefore age was included in final exploratory laboratory analyses. A chi-square test was used to examine whether there were differences in gender between the trauma type groups. There was no significant association between trauma type and gender, $\chi^2(4, n = 161) = 2.77$, p=.60, and therefore gender was not included in final exploratory laboratory analyses.

Analyses of diary data to test exploratory hypotheses. Main effects and moderation within an MLM framework were used to conduct exploratory analyses.

Trauma type was tested as a predictor of daily social stress (main effect) and as a moderator of the relations between centered negative interpersonal events and daily social stress. Similarly, trauma type was tested as a predictor of daily social enjoyment (main effect) and as a moderator of the relations between centered positive interpersonal events and daily social enjoyment. When a main effect or interaction effect involving trauma type emerged, all trauma types were compared to one another.

In addition, one-way ANOVAs were used to determine differences between trauma type groups in background physical and emotional health characteristics, including pain, functional impairment, depression, and affect.

Results

For clarity and ease of presentation, results are first presented regarding sample demographics and health characteristics. Second, trauma characteristics of the sample are described. Third, all descriptive, hypothesized, and exploratory analyses of lab data are presented. Fourth, all descriptive, hypothesized, and exploratory analyses of diary data are presented.

Sample Demographic, Health, and Trauma Characteristics

Participant demographic and health characteristics can be found in Table 1. The mean age of participants was 51 years old. Most participants were female, had 1-3 years of college, were married, Caucasian, and were working at least part-time. Most participants had an annual family household income between $30,000 and $49,999. Comorbid health issues were prevalent within the sample. More than half the sample reported stomach issues, headaches, and migraines. Nearly one-third reported chronic

fatigue. Approximately 70% of the sample also reported having additional health issues such as arthritis, hypertension, insomnia, or other chronic pain issues. More than half of the sample had received treatment for psychological concerns. Additionally, more than half of the sample was on medications including tricyclic antidepressants, anticholinergics, and opiates.

Table 2 depicts the trauma characteristics within the sample. More than half of the sample reported a traumatic event. Of those who reported experiencing a traumatic event, the mean PTSD symptom severity fell in the middle range of the possible severity scores. Regarding categorical symptom severity groups created for the purpose of analyses, less than half of the sample reported no trauma, approximately a quarter of the sample reported symptom severity below the group mean, and approximately a quarter of the sample reported symptom severity at or within one standard deviation above the group mean, and 12% of the sample reported symptom severity greater than one standard deviation above the group mean. In considering DSM diagnosis criteria, approximately half of the sample did not meet criteria due to no trauma exposure, approximately a quarter of the sample reported trauma but did not meet criteria for PTSD, and approximately a quarter reported trauma and met criteria for PTSD. The average time since the most disturbing traumatic event occurred was approximately 21 years. The average age at the time of the most disturbing traumatic event was 28 years old. Most individuals who reported trauma had not experienced PTSD symptoms in the last year. For participants who reported trauma, most reported being personally threatened, such as being threatened with a weapon or held captive, being involved in a life-threatening accident, or being involved in a natural disaster or witnessing another person being

assaulted, threatened, or killed. The remainder of the sample experienced physical or sexual trauma.

Lab Data Results

Table 3 depicts descriptive statistics for the lab data measures. Average startle magnitude to negative stimuli was greater than startle magnitudes to neutral and positive stimuli. Average startle magnitude to positive stimuli was less than startle magnitudes to negative and neutral stimuli. Positive affective stimuli were rated as more pleasant than neutral affective stimuli, and both were rated as more pleasant than negative affective stimuli. Negative affective stimuli were rated as more arousing than positive and neutral affective stimuli. Positive stimuli were rated as more arousing than neutral affective stimuli. In sum, affective stimuli evoked responses as anticipated in regards to the physiological and emotional responses expected for each valence.

Table 4 depicts intercorrelations among lab data measures. Startle magnitudes to negative affective stimuli were negatively correlated with startle magnitudes to neutral and positive affective stimuli. Startle magnitudes to positive affective stimuli were negatively correlated with startle magnitudes to neutral affective stimuli. Arousal ratings to negative affective stimuli were positively correlated with arousal ratings to neutral and positive affective stimuli. Arousal ratings to neutral affective stimuli were positively correlated with arousal ratings to positive affective stimuli. Valence ratings to negative affective stimuli were negatively correlated with valence ratings to positive affective stimuli. Valence ratings to neutral affective stimuli were positively correlated with valence ratings to positive affective stimuli.

Hypothesis 1a. Hypothesis 1a evaluated whether PTSD symptom severity groups (i.e., no trauma, symptom severity below the mean, symptom severity at the mean or up to one standard deviation above the mean, and symptom severity one standard deviation above the mean or greater) differed with respect to startle magnitude across the three picture valence conditions (i.e., negative, neutral, positive) with age as a covariate. Results for Hypothesis 1a can be found in Table 5. The two-factor mixed ANOVA indicated that that main effect of PTSD symptom severity group on startle magnitude was not significant, $F(3,143) = .00$, $p = 1.00$. The main effect of valence was significant, $F(2,172) = 9.48$, $p < .001$. A follow-up repeated measures ANOVA with a Bonferroni correction indicated that participants exhibited greater startle magnitudes to negative affective stimuli compared to positive stimuli ($p = .001$). There were no differences between negative and positive stimuli compared to neutral stimuli (p=.20 and p=.18, respectively). Lastly, the two-factor mixed ANOVA indicated that the interaction between PTSD symptom severity group and picture valence was not significant, $F(6,94) = .47$, $p = .83$.

Hypothesis 1b. Hypothesis 1b evaluated whether PTSD symptom severity groups differed with respect to valence ratings across the three picture valence conditions (i.e., negative, neutral, positive) with age as a covariate. Results for Hypothesis 1b can be found in Table 5. The two-factor mixed ANOVA indicated that the main effect of PTSD symptom severity group on valence ratings was not significant, $F(3,126) = .35$, $p = .79$. The main effect of valence was significant, $F(2,165) = 579.32$, $p < .001$. A repeated measures ANOVA indicated that participants reported negative affective stimuli to be less pleasant than positive and neutral stimuli ($p < .001$) and reported positive affective

stimuli to be more pleasant than neutral stimuli ($p < .001$). Lastly, the two-factor mixed ANOVA indicated that the interaction between PTSD symptom severity group and picture valence was not significant, $F(6,102) = .67$, $p = .67$.

Hypothesis 1c. Hypothesis 1c evaluated whether PTSD symptom severity groups differed with respect to arousal ratings across the three picture valence conditions (i.e., negative, neutral, positive) with age as a covariate. Results for Hypothesis 1c can be found in Table 5. The two-factor mixed ANOVA indicated that the main effect of PTSD symptom severity group on arousal ratings was significant, $F(3,169) = 4.54$, $p = .004$. A post hoc analysis using a Bonferroni correction indicated that the high PTSD symptom severity group (M=4.75, SD=.18) reported affective stimuli, in general, to be more arousing compared to the moderate PTSD symptom severity group (M=5.57, SD=.16; p = .004). Further, the low PTSD symptom severity group (M=4.95, SD=.16) reported affective stimuli to be more arousing compared to the moderate severity group (p=.037). The main effect of valence was significant, $F(2,214) = 150.54$, $p <.001$. A repeated measures ANOVA with a Bonferroni adjustment indicated that participants reported negative affective stimuli to be more arousing than positive and neutral stimuli ($p < .001$) and reported positive stimuli to be more arousing than neutral stimuli ($p < .001$). Lastly, the interaction between PTSD symptom severity group and picture valence was not significant, $F(6,121) = .26$, $p = .96$.

In summary, results indicated that the severity of past PTSD symptoms did not predict differential responses in startle magnitude, valence ratings, or arousal ratings to affective stimuli in the lab, contrary to prediction. However, the high and low PTSD

symptom severity group reported affective stimuli, in general, to be more arousing compared to the moderate PTSD symptom severity group.

Exploratory lab analyses. The type of trauma experienced (e.g., none, physical, sexual, threat, witness) was explored as a potential predictor of reactivity to affective stimuli in the lab with age as a covariate. Descriptive information regarding startle magnitude, valence, and arousal ratings amongst the different trauma groups can be found in Table 6. A visual depiction of the startle z scores among trauma types can be found in Figure 4. Results for exploratory mixed ANOVA analyses can be found in Table 7. The two-factor mixed ANOVA indicated that the main effect of trauma type was not significant, $F(4,76) = .000$, $p = 1.00$. The main effect of valence was significant, $F(2,59) = 9.28$, $p < .001$. A repeated measures ANOVA with a Bonferroni correction indicated that participants exhibited greater startle magnitudes to negative affective stimuli compared to positive stimuli, as noted above ($p = .001$). The two-factor mixed ANOVA indicated that the interaction between trauma type and picture valence significantly predicted startle magnitude, $F(8,51) = 7.66$, $p < .001$. Following the significant interaction effect, mean differences in startle magnitude were examined between the trauma types separately for each of the three picture valence conditions. The simple effect tests indicated that the trauma type groups did not differ in their average startle magnitude scores when exposed to negative ($p = .11$) or neutral affective stimuli ($p = .14$). However, the trauma type groups did significantly differ in their average startle magnitude scores when exposed to positive affective stimuli ($p < .001$). Pairwise comparisons with a LSD adjustment (i.e., no adjustment) indicated that individuals with a history of sexual trauma exhibited lower startle magnitudes to positive affective stimuli

compared to those with no trauma (p <.001), a history of physical trauma (p=.035), threat-related trauma (p <.001), and witnessing something traumatic (p <.001). Pairwise comparisons with a Bonferroni adjustment, a more conservative adjustment approach, indicated that individuals with a history of sexual trauma exhibited lower startle magnitudes to positive affective stimuli compared to those with no trauma (p <.001), threat-related trauma (p <.001), and witnessing something traumatic (p =.003). The Levene's test of equality of error variances was significant regarding unequal error variances between trauma types in regards to positive startle (p =.003). To determine the effect of this heterogeneity, an ANOVA was run with trauma type predicting startle magnitude to positive affective stimuli and pairwise comparisons using a Dunnett's T3 adjustment for unequal variances. These pairwise comparisons indicated that individuals with a history of sexual trauma exhibited lower startle magnitudes to positive affective stimuli compared to those with a history of no trauma (p = .000), threat-related trauma (p = .000), and those with a history of witnessing something traumatic (p = .003).

In regards to valence ratings, a two-factor mixed ANOVA indicated that the main effect of trauma type on valence ratings was not significant, $F(4,80) = .73$, $p = .57$. The main effect of valence was significant, $F(2,54) = 342.79$, p <.001, as noted above. A repeated measures ANOVA indicated that participants reported negative affective stimuli to be less pleasant than positive and neutral stimuli (p < .001) and reported positive affective stimuli to be more pleasant than neutral stimuli (p < .001), as noted above. The two-factor mixed ANOVA indicated that the interaction between trauma type and picture valence did not significantly predict valence ratings, $F(8,71) = .76$, p =.64.

In regards to arousal ratings, a two-factor mixed ANOVA indicated that the trauma type main effect was significant, $F(4,100) = 4.66$, $p = .002$. A post hoc analysis using a Bonferroni adjustment indicated that individuals with a history of sexual trauma reported affective stimuli, in general, to be more arousing than individuals with a history of physical trauma ($p = .002$) and trended to be more arousing than individuals with a history of no trauma ($p = .062$) and threat-related trauma ($p = .051$). However, the Levene's test of equality of error variances was significant regarding unequal error variances between trauma types in regards to arousal to neutral ($p = .034$) and positive stimuli ($p = .012$). To determine the effect of this heterogeneity, a repeated measures ANOVA was run with trauma type predicting arousal to affective stimuli and pairwise comparisons using a Dunnett's T3 adjustment for unequal variances. Pairwise comparisons indicated that there were no differences in arousal between trauma types suggesting the test was significantly affected by the unequal variances across trauma types. In the two-factor mixed ANOVA, the main effect of valence was significant, $F(2,87) = 104.43$, $p < .001$. A repeated measures ANOVA indicated that participants reported negative affective stimuli to be more arousing than positive and neutral stimuli ($p < .001$) and reported positive stimuli to be more arousing than neutral stimuli ($p < .001$), as noted earlier. The two-factor mixed ANOVA indicated that the interaction between trauma type and picture valence did not significantly predict arousal ratings, $F(8,77) = .80$, $p = .60$.

In summary, individuals with a history of sexual trauma exhibited lower startle magnitudes to positive affective stimuli compared to all other trauma types. However, there were no significant differences in startle magnitude to negative and neutral stimuli

between the trauma types. Further, there were no significant interactions between trauma type and picture valence in predicting valence and arousal ratings. Individuals with a history of sexual trauma reported affective stimuli, in general, to be more arousing than individuals with a history of physical trauma. However, these results should be interpreted with caution as the error variances were not equivalent.

Diary Data Results

Table 8 depicts the means, standard deviations, and ranges of the between-person variables proposed for analyses (i.e., interpersonal events, stress, enjoyment) and descriptive variables (pain, functional impairment, depression, affect). Most individuals experienced approximately four interpersonal events a day, with events more frequently being positive than negative. On average, the sample reported their positive interpersonal events to be "somewhat" enjoyable and their negative interpersonal events to be "a little" stressful. Average pain levels in the study were also in the mid-range of a 0-100 point scale while functional impairment and depressive symptoms were in the mid-range of a 1-3 point scale. Average levels of negative and positive affect were in the mid-range of a 1-5 point scale.

Tables 9 and 10 depict the between- and within-person correlations among study variables. Between-person negative interpersonal events were associated with greater stress, depression, and negative affect and less enjoyment and positive affect; similarly, within-person negative events were associated with greater stress and less enjoyment. Between positive interpersonal events were associated with greater enjoyment and

positive affect and less stress, pain, and negative affect; similarly, within-person positive events were associated with greater enjoyment and less stress.

Table 11 depicts results from ANOVAs that tested whether there were differences between PTSD symptom severity groups in regards to general physical and emotional health characteristics. The high symptom severity group reported higher levels of pain than the no trauma group. Although the main effect of PTSD symptom severity group was significant, there were no pairwise comparison differences in functional impairment between the groups. Both the high and moderate severity groups reported higher levels of depression than the no trauma group. Further, the high severity group reported higher levels of depression than the low severity group. Both the high and moderate severity groups reported higher levels of negative affect than the no trauma group. Lastly, the moderate severity group reported lower levels of positive affect than the no trauma group.

Hypothesis 2. Hypothesis 2 predicted that among individuals with chronic pain, higher levels of past PTSD symptoms would be associated with greater social stress, and on days of elevated negative interpersonal events, social stress would be higher among those with higher levels of past PTSD symptoms compared to those with lower or no levels of past PTSD symptoms. Results for Hypothesis 2 can be found in Table 12, top panel. Analyses included a significant random slope for centered negative events. Both elevations in negative events, $t(3132) = 13.50$, $p < .001$, and PTSD symptom severity group, $t(215) = 2.68$, $p = .008$, significantly predicted greater social stress. The interaction between changes in negative interpersonal events and PTSD symptom severity was not significant, $t(3132) = .47$, $p = .64$, indicating that PTSD symptom

severity does not moderate the relation between changes in negative interpersonal events and stress appraisals. Further, when the interactions and main effects of key demographic variables (i.e., marital/partnered status and changes in negative interpersonal events, and income and changes in negative events) were added to the model, the interaction between PTSD symptom severity and changes in negative events remained non-significant.

Hypothesis 3. Hypothesis 3 predicted among individuals with chronic pain, higher levels of past PTSD symptoms would be associated with less social enjoyment overall, and on days of elevated positive interpersonal events, social enjoyment would be lower among those with higher levels of PTSD symptoms compared to those with lower or no levels of past PTSD symptoms. Results for Hypothesis 3 can be found in Table 12, bottom panel. Analyses included a significant random slope for centered positive events. Elevations in positive events, $t(3134) = 11.85$, $p < .001$, significantly predicted greater social enjoyment, but PTSD symptom severity did not, $t(215) = -.37$, $p = .71$. The interaction between changes in positive interpersonal events and past PTSD symptoms severity was not significant, $t(3134) = -.04$, $p = .97$, indicating that past PTSD symptom severity does not moderate the relation between changes in positive interpersonal events and enjoyment appraisals. Further, when the interactions and main effects of key demographic variables (i.e., marital/partnered status and changes in positive interpersonal events, and income and changes in positive events) were added to the model, the interaction between PTSD symptom severity and changes in positive events remained non-significant.

In summary, although PTSD symptom severity predicted greater social stress, it did not moderate the association between changes in negative interpersonal events and social stress. Further, PTSD symptom severity did not predict social enjoyment, nor did it moderate the association between changes in positive interpersonal events and social enjoyment.

Exploratory diary analyses. Table 13 depicts results from ANOVAs that tested whether there were differences between trauma types groups in regards to general physical and emotional health characteristics. Individuals with a history of threat-related trauma reported greater functional impairment than those with no trauma. Although the main effect of trauma type on negative affect was significant, there were no significant differences in the pairwise comparisons among the groups. There were also no other differences between trauma types in pain, depression, or positive affect.

The type of trauma experienced (e.g, none, physical, sexual, threat, witness) was explored as a potential moderator of the relations between negative interpersonal events and social stress appraisals. Analyses were run using each trauma type as the comparison group versus all other trauma groups to assess for differences between all group comparisons. Moderator analyses included a significant random slope for centered negative events. There were no significant differences in social stress between trauma types, nor were there any interactions between type of trauma and negative interpersonal events in predicting social stress (p = .57).

Exploratory analyses also tested trauma type as a moderator of the relation between elevations in positive events and enjoyment. Analyses were run using each

trauma type as the comparison group versus all other trauma groups to assess for differences between all group comparisons. There were no significant differences in social enjoyment between trauma types. Moderator analyses included a significant random slope for centered positive events. There were no significant interactions between type of trauma and positive interpersonal events in predicting social enjoyment (p = .47).

In sum, results from the exploratory daily diary analyses indicated that there were no differences in social stress or enjoyment between trauma types, nor did trauma type moderate the influence of changes in interpersonal events on social appraisals.

Discussion

It has been widely suggested that experiencing both chronic pain and posttraumatic stress is associated with poorer physical and emotional outcomes compared to having chronic pain alone (Otis et al., 2006). In the current study, the goal was to assess reactivity to negative and positive social-emotional stimuli in both a controlled laboratory setting and in daily life among individuals with comorbid chronic pain and past PTSD symptoms versus chronic pain alone. It was hypothesized that in the laboratory, individuals with higher, versus lower, levels of past PTSD symptoms would show greater startle reflex magnitudes and more negative emotional reactions during exposure to both negative and positive affective stimuli compared to neutral stimuli (i.e., Hypotheses 1a-1c), a pattern reflective of hypervigilant response tendencies to both negative and positive emotional contexts. In a similar vein, it was hypothesized that individuals with higher, versus lower, levels of past PTSD symptoms would experience

greater social stress overall, and greater social stress on days when they experience more negative interpersonal events than usual (i.e., Hypothesis 2). Lastly, it was hypothesized that individuals with higher, versus lower, levels of past PTSD symptoms would experience less social enjoyment overall, and would report smaller boosts in social enjoyment on days when they experience more positive interpersonal events than usual (i.e., Hypothesis 3).

Does physiological and emotional reactivity to affective stimuli in a controlled environment provide clues to why individuals with comorbid pain and trauma experience poor outcomes, as hypotheses 1a-1c suggest? Contrary to expectation, the current findings indicate that individuals with higher levels of past PTSD symptoms do not exhibit greater reactivity to positive or negative stimuli in the laboratory compared to those with chronic pain alone. Specifically, levels of past PTSD symptoms did not predict startle magnitude, arousal ratings, or valence ratings in response to affective stimuli. Therefore, Hypotheses 1a-1c were not supported. Of note, individuals with high levels of past PTSD symptoms reported affective stimuli, in general, to be more arousing compared to those with moderate past PTSD symptoms. These results suggest that individuals with comorbid chronic pain and higher levels of past PTSD symptoms may subjectively experience affective stimuli more activating, but they are not more physiologically or emotionally reactive to affective stimuli in a laboratory setting.

The findings of equivalent startle reflex responses across PTSD symptom severity groups are not consistent with past laboratory research among individuals with past and/or current symptoms of PTSD, which demonstrate increased startle magnitude and

negative emotion to negative stimuli, and less positive emotion when exposed to positive stimuli among those with PTSD versus no PTSD (Asmundson & Katz, 2009; Grillon et al., 2009; Litz et al., 2000; Pole et al., 2007). Differences between current study findings and previous research may be related to a focus on past PTSD symptoms in the current study, rather than current PTSD symptoms or diagnoses in prior literature. Thus, the effects of PTSD symptoms on startle and emotional responses may be limited to those with significant current symptoms, such that the experience of chronic pain may override any residual effects of past PTSD symptoms on reactivity in a laboratory setting. In addition, null findings in the current study may be due to the composition of the slides used in the laboratory paradigm. Participants were exposed to a range of content in both negative- and positive-valenced slides, not content that was specifically targeted to arouse negative emotion directly relevant to trauma or positive emotion directly relevant to social relations. Thus, the images depicted in the slides may not have stimulated sufficient reactivity among participants. Exposure to slides depicting negative stimuli specific to traumatic events experienced by participants, and to positive social stimuli, may have produced greater physiological and emotional reactivity than did the non-trauma specific negative slides and the general positive slides used in the current study. Future research may benefit from gaining an understanding of the impact of PTSD by comparing physiological responses in emotional contexts using stimuli specific to traumatic events and/or social relations experienced among individuals with chronic pain who have current versus past PTSD symptoms.

The current study also aimed to examine emotional reactivity to social stimuli in daily life as a mechanism to explain why individuals with comorbid chronic pain and past

PTSD symptoms experience poor outcomes. In line with expectations, diary data findings indicated that higher levels of past PTSD symptoms were associated with greater social stress. Contrary to expectations, however, higher levels of past PTSD symptoms were not associated with less social enjoyment. Current findings of increased social stress among individuals with higher levels of past PTSD symptoms are similar to those reported in past research indicating increased relationship challenges among individuals with versus without current PTSD (Alschuler & Otis, 2012; Monson et al., 2009). Thus, a history of both current as well as past PTSD symptoms may produce stable, enduring effects on relationships, particularly within negative domains. Conversely, effects of past PTSD symptoms do not seem to have lasting, detrimental effects on positive aspects of relationships (i.e., social enjoyment), although research on deficits in positive domains of relationships is rarely explored in PTSD research.

Although a history of PTSD symptoms appears to have lasting effects on social stress among individuals with chronic pain in the current study, it did not translate into greater reactivity to interpersonal events. Contrary to prediction, individuals with higher levels of past PTSD symptoms did not report greater social stress on days when they experienced more negative interpersonal events than usual. Relatedly, individuals with higher levels of past PTSD symptoms did not report less social enjoyment on days when they experienced more positive interpersonal events than usual. Therefore, Hypotheses 2 and 3 were not supported. Overall, results suggest that individuals with higher level of past PTSD symptoms experience greater stress from social relationships, but not less enjoyment, than those with chronic pain alone. Further, they do not respond less adaptively to changes in interpersonal events compared to those with chronic pain alone.

Taken together, the current findings suggest that a history of PTSD symptoms does not necessarily predict greater current reactivity to social and emotional stimuli in either laboratory settings or daily life among individuals with chronic pain. Findings do suggest, however, that a history of PTSD symptoms does carry an overall burden on individuals with comorbid chronic pain. For example, PTSD symptom severity in the current study was associated with greater social stress, bodily pain, depression, and negative affect as well as less positive affect compared to those with fewer past PTSD symptoms or no trauma exposure. These findings align with those from previous research indicating poor physical and social-emotional outcomes among individuals with comorbid current PTSD and chronic pain (Geisser et al., 1996; Moeller-Bertram et al., 2012; Otis et al., 2006; Ruiz-Párraga et al., 2013; Sherman et al., 2000). Together, existing research and current findings indicate that experiencing chronic pain and having either past or current PTSD symptoms may contribute to physical, emotional, and social long-standing challenges that exceed the symptom burden of having chronic pain alone. Although these associations between past PTSD symptoms and current health status do not appear to be due to current reactivity to social-emotional stimuli, it is possible that reactivity may have been displayed shortly after a traumatic event occurred, but decreased over time. For example, individuals may have been more reactive to negative stimuli and less able to capitalize on positive stimuli when their PTSD symptoms were actively occurring immediately after a traumatic event occurred, and served as a transient mechanism that produced a more stable, pervasive pattern of maladaptive coping over time. Longitudinal studies examining the course of social-emotional and physiological reactivity to traumatic events over time would aid in gaining a greater understanding of

the mechanisms by which individuals who have been exposed to trauma develop poor health outcomes.

These negative long-term effects of trauma suggest that individuals with chronic pain and a history of PTSD symptoms may experience a psychological scar that impacts their future physical and emotional health, similar to that of individuals with a history of depressive episodes, by creating negative ongoing vulnerability to future emotional and cognitive issues (Zeiss & Lewinsohn, 1988). In fact, most individuals in the current study had not experienced their most traumatic event and subsequent PTSD symptoms in over two decades, yet exhibited current poorer overall physical and psychological health compared to those with no trauma or a history of fewer PTSD symptoms. Future research may benefit from exploring additional factors, such as personality (e.g., neuroticism), coping strategies, and social support at the time of a traumatic event, which may contribute to the effects of trauma on health in the long-term.

Beyond the level of past PTSD symptoms individuals have experienced, the type of trauma reported may also be as an important factor in understanding outcomes among comorbid individuals. For example, individuals with a history of sexual trauma often report poorer emotional health, for example, compared to individuals who have experienced non-sexual traumatic events (Kelley et al., 2009). The current study explored whether there were differences in social-emotional outcomes between individuals who reported no trauma, physical trauma, sexual trauma, threat-related trauma, or events related to witnessing something traumatic. Laboratory findings indicated that individuals with a history of PTSD symptoms in response to a sexual

trauma exhibited lower startle magnitudes to positive affective stimuli, relative to neutral affective stimuli, compared to individuals with no trauma history or a history of PTSD symptoms in response to threat-related trauma or events related to witnessing something traumatic. These exploratory results suggest that individuals with a history of PTSD symptoms from sexual trauma view positive stimuli as less threatening than do individuals with no trauma exposure or a history of PTSD symptoms from other types of trauma. Whether this perception of positive stimuli being non-threatening is a beneficial adaptation or not remains to be determined. For example, individuals with a history of PTSD symptoms from sexual trauma viewing positive stimuli as non-threatening may allow them to be better able to capitalize on positive social and emotional experiences. Conversely, viewing all stimuli perceived to be positive as non-threatening could be maladaptive if individuals are not exercising any level of caution. That is, viewing all seemingly pleasant environmental or social stimuli as non-threatening may in fact be dangerous if this generalization keeps individuals from recognizing hidden threats in an enjoyable environment or quickly trusting people who appear kind but have negative intentions. Future work elaborating the physiological response patterns to provocative stimuli in different emotional contexts among those with PTSD symptoms (past or current) from different types of trauma can help establish the replicability and broader meaning of findings from the current study.

Laboratory findings from the current study indicated that there were no differences between PTSD symptom histories associated with different types of trauma in regards to startle magnitude to negative affective stimuli. These findings contrast with past research suggesting individuals with a history of sexual trauma, for example, report

physiological symptoms of greater intensity, such as hyperarousal, compared to individuals with a history of other types of traumas (Kelly et al., 2009). Thus, self-reported physiological arousal may not align with objectively assessed arousal among individuals exposed to trauma.

The current study also explored whether different types of traumatic events produce differences in reactivity to social stimuli in daily life. There were no differences between trauma types in regards to social stress, in general, or social stress on days of higher than usual negative interpersonal events in the diaries. Similarly, there were no differences between trauma types in social enjoyment, in general, or social enjoyment on days of higher than usual positive interpersonal events. These findings contrast with past research suggesting individuals with a history of sexual trauma, for example, exhibit greater social distress compared to individuals with other traumas (Kelly et al., 2009). Additional research on types of trauma comparing reactivity to positive stimuli in laboratory environments and in daily life would be beneficial in further understanding whether laboratory responses to positive stimuli translate into being able to capitalize on positive social stimuli in an individuals' social environment.

As a whole, findings from the current study indicated that experiencing a traumatic event was common among individuals with FM. More than half of participants (58%) in the current sample reported experiencing trauma during their lifetime, which is comparable to rates of trauma ranging from 63.4% to 74.4% in other FM samples (Häuser et al., 2013; Häuser et al., 2015). Previous research in the general population have found rates of trauma exposure to span an even wider range from 25% (Häuser et

al., 2013) to 89.7% in (Kilpatrick et al., 2013). During their worst PTSD symptom period, approximately a quarter of the current sample experienced symptoms that met criteria for PTSD. Past research in FM samples has found rates of current PTSD ranging from 23% to 57% (Arnold et al., 2006; Cohen et al., 2002; Häuser et al., 2013). These rates of meeting criteria for PTSD are much higher than those in the general population, which range from 3% to 9% (Kessler et al., 2005; Kilpatrick et al., 2013; Häuser et al., 2013; Read et al., 2011). These higher rates of current PTSD, but not necessarily trauma exposure, in FM samples compared to the general population suggest that FM patients are a unique population that is less able to recover from trauma.

The current study has several limitations that need to be noted. First, although more than half of the study sample had experienced a traumatic event in their lifetime, it had been over twenty years, on average, since that event occurred. Most individuals were not currently experiencing PTSD symptoms; thus, we may not have had sufficient numbers of people with recent PTSD to detect the enhanced hyper-reactivity to threat that often characterizes those with active PTSD symptoms. However, study findings point to poorer physical and social-emotional outcomes, in general, among individuals with a history of high levels of PTSD symptoms in response to trauma compared to those without trauma or with a history of lower levels of PTSD symptoms in response to trauma, suggesting that despite a lack of effect on current reactivity, there may be lasting effects of PTSD symptoms in response to trauma on health through more stable, rather than fluctuating, patterns of maladaptive coping. Second, PTSD symptoms were assessed using self-report measures during a phone interview, and given that most traumas occurred many years ago, there may be issues with regard to the validity and reliability of

retrospective self-report in the study. Third, the current study included individuals with FM only; therefore, results may not be generalizable to those with other chronic pain conditions. Relatedly, FM is characterized by poorer emotional outcomes compared to other pain conditions or controls (Arnold et al., 2006; Zautra et al., 2005), and such elevated distress may mask potential additive effects of trauma, as individuals with FM are already facing a heavy social-emotional symptom burden. Fourth, current study data are correlational, and thus causal relations among variables cannot be inferred. PTSD symptoms may predict poorer functioning, poorer functioning may predict greater risk of developing PTSD, or PTSD and poorer functioning may have a reciprocal relation that unfolds over time.

Comorbid PTSD and chronic pain create a heavy symptom burden on individuals that includes emotional distress, psychosocial and interpersonal challenges, greater bodily pain, and significant disability compared to those with only one of the conditions (Jenewein et al., 2009; Moeller-Bertram et al., 2012; Otis et al., 2006; Palyo & Beck, 2005; Sherman, Turk, & Okifuji, 2000; Sullivan et al., 2009). Gaining a greater understanding of the mechanisms responsible for poorer outcomes among individuals with these comorbid conditions may aid in the development of targeted psychosocial treatments that can meet the challenges of living with both chronic pain and PTSD.

The current findings have implications for future work with individuals with comorbid chronic pain and traumatic experiences. For example, although individuals with chronic pain and a history of trauma may not display increased reactivity to acute social-emotional stressors, they do experience continued poor emotional and physical

health overall. Assessing not only bodily pain, but also emotional and social distress that is uniquely associated with chronic pain and a history of PTSD symptoms is important in determining the increased challenges individuals with these comorbid conditions are facing so that proper treatment can be tailored to address these specific challenges. For example, integrated treatments that target both chronic pain and issues stemming from PTSD symptoms may be more beneficial than treatments that address only one of the conditions (Otis, Keane, Kerns, Monson, & Scioli, 2009; Otis et al., 2006).

To better understand this long-lasting burden of comorbid PTSD symptoms and chronic pain, it may be useful to consider whether pain creates vulnerability to PTSD or PTSD creates greater vulnerability to pain. Existing literature suggests a strong effect of PTSD on pain symptoms in the long-term. For example, longitudinal studies of individuals with pain resulting from acute injuries or surgeries have found that PTSD and pain are reciprocally related early on after an accident or surgery; however, over time, PTSD symptoms continue to predict chronic pain and pain disability, but not vice versa (Jenewein, Wittman, Moergeli, Creutzig, & Schnyder, 2009; Katz, Asmundson, McRae, & Halket, 2009). These results suggest that PTSD symptoms may exacerbate pain in the long-term, especially among those whose pain is a reminder of the traumatic event that caused the pain (Katz et al., 2009). Therefore, future work may benefit from considering how comorbid PTSD symptoms and chronic pain interact to affect health differently among individuals whose conditions resulted from the same event, versus those whose chronic pain came much earlier or later after a traumatic event.

The field would benefit from further efforts aimed at identifying examining potential physiological and social-emotional mechanisms linking comorbid chronic pain and PTSD symptoms to poor outcomes. For example, exploring physiological (e.g., startle) and emotional reactivity (e.g., emotional ratings, social stress and enjoyment) among a variety of chronic pain samples with current versus past PTSD symptoms would aid in understanding these mechanisms across pain samples and levels of PTSD symptom burden. Further, additional exploration of differential mechanisms of reactivity and poor outcomes among different types of trauma would provide a more detailed understanding of the avenues by which trauma may impact functioning in chronic pain. Overall, trauma appears to play an important role in physical, emotional, and social functioning in chronic pain although the specific mechanisms by which this occurs remain to be fully understood.

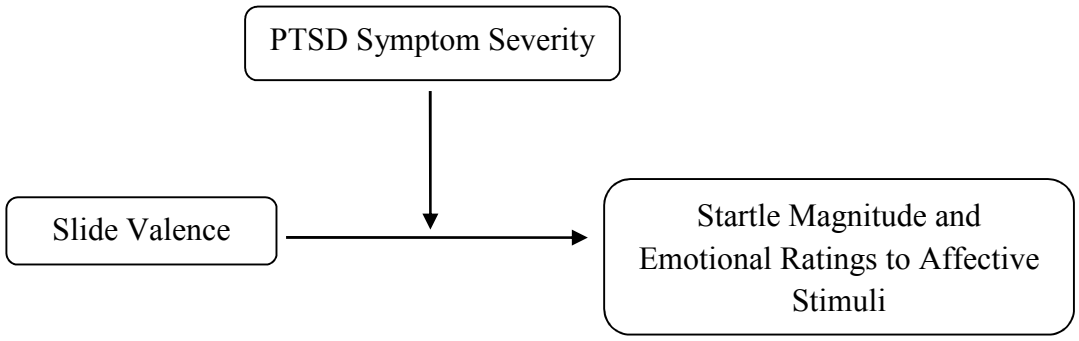


Figure 1. Model for Hypotheses 1a-1c.

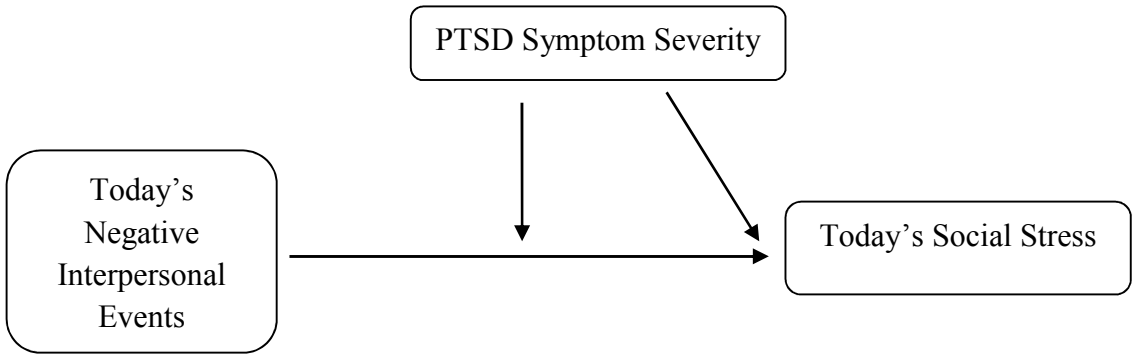


Figure 2. Model for Hypothesis 2.

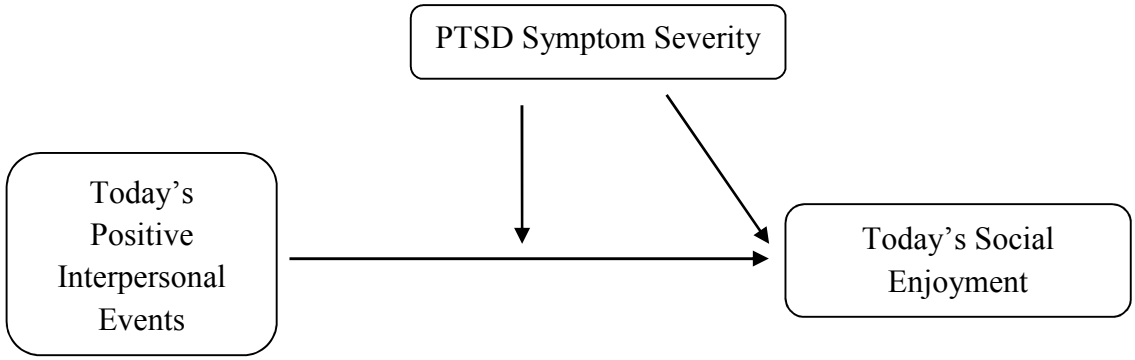
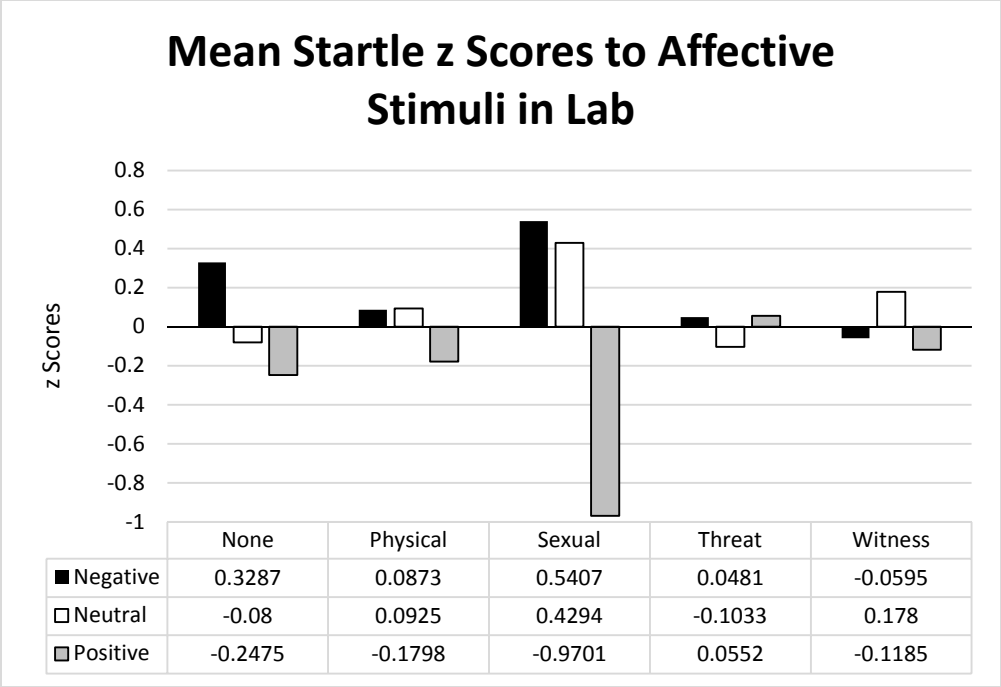


Figure 3. Model for Hypothesis 3.



	None	Physical	Sexual	Threat	Witness
Negative	0.3287	0.0873	0.5407	0.0481	-0.0595
Neutral	-0.08	0.0925	0.4294	-0.1033	0.178
Positive	-0.2475	-0.1798	-0.9701	0.0552	-0.1185

Figure 4. Mean startle z scores to affective stimuli among trauma types.

Table 1

Sample Demographic and Health Characteristics (N=220)

Measures	*N (%)*	Observed Range	*Mean*	*SD*
Age		19-72	51.25	11.02
Male	25 (11.4)			
Female	195 (88.6)			
Education				
5-8 Years	1 (0.5)			
Not completed high school	4 (1.8)			
Completed high school	29 (13.2)			
Post high school/business/trade	30 (13.6)			
1-3 years of college	74 (33.6)			
4 years of college	39 (17.7)			
Post graduate	38 (17.3)			
Unknown	5 (2.3)			
Marital Status				
Partnered/Married	123 (55.9)			
Not Partnered/Married	95 (43.2)			
Unknown	2 (.90)			
Employment				
Working/Volunteering	113 (51.4)			
Not working or volunteering	105 (47.7)			
Unknown	2 (.90)			
Race/Ethnicity				
Caucasian	170 (77.3)			
Black/African American	6 (2.7)			
Asian	3 (1.3)			
Hispanic	30 (13.6)			
Native American	9 (4.2)			
Native Hawaiian/Pacific Islander	2 (0.9)			
Income				
Under $3,000-$10,999	19 (8.7)			
$11,000-$20,999	34 (15.6)			
$21,000-$39,999	49 (22.3)			
$40,000-$59,999	40 (18.2)			
$60,000-$69,999	16 (7.2)			
$70,000-$99,999	28 (12.7)			
$100,000-$149,999	16 (7.2)			
$150,000 and over	2 (.9)			
Unknown	16 (.7.2)			

Health Conditions				
Average Number of Conditions		0-10	4.10	2.13
Vascular Problems	22 (10.0)			
Renal Problems	14 (6.4)			
Diabetes	14 (6.4)			
Lung/Breathing Issue	49 (22.3)			
Stomach Issue	140 (63.6)			
Interstitial Cystitis	7 (3.2)			
Headaches	148 (67.3)			
Migraines	97 (44.1)			
Chronic Fatigue	68 (30.9)			
Hearing Impairment	24 (10.9)			
Vision Disorder	8 (3.6)			
Psychological Treatment	123 (55.9)			
Endocrine Issue	65 (29.5)			
Other Health Issue	123 (55.9)			
On antidepressants, anticholinergics, or opiates	142 (64.5)			

Note: "Unknown" refers to missing data among participants.

Table 2

Characteristics of Trauma Experiences within Sample (N=220)

Measure	*N (%)*	*M*	*SD*	*Observed Range*	*Skewness*	*Kurtosis*
Reported Exposure to Traumatic Event	127 (58)					
Number of traumas (0-4)		1.63	.96	0-4	.37	-.24
One trauma	50 (39.4)					
Two traumas	42 (33.1)					
Three traumas	19 (15.0)					
Four traumas	4 (3.1)					
Unknown	12 (9.4)					
Symptom Severity (0-21)		12.12	6.12	1-21	-.57	-1.10
No trauma exposure	93 (42)					
Severity below mean	51 (23)					
Severity at mean to 1SD above mean	49 (23)					
Severity > 1SD above mean	27 (12)					
DSM Diagnosis (dx)						
No Trauma	116 (52.6)					
Trauma, no PTSD dx	53 (24.0)					
PTSD	50 (22.5)					
Unknown	2 (.90)					
Event Category						
No (DSM) Trauma	118 (53.5)					
Physical Trauma	14 (6.4)					
Sexual Trauma	14 (6.4)					

Threat	34 (15.5)					
Witness	34 (15.5)					
Unknown	6 (2.7)					
Years Since Worst Event		21.58	15.67	0-62	.54	-.60
Age at Worst Event		28.38	14.83	1-64	-.51	.23
Time Since Last PTSD Symptoms						
Within 2 weeks	11 (8.7)					
2-4 weeks	4 (3.1)					
1-6 months	1 (.80)					
6 months-1 year	5 (3.9)					
Greater than 1 year	65 (51.2)					
Unknown	41 (32.3)					

Note: "Unknown" refers to missing data among participants.

Table 3

Descriptives of Startle Magnitudes, Valence and Arousal Ratings (N=170)

Measure	*M*	*SD*	*Observed Range*	*Skewness*	*Kurtosis*
Negative Startle Mag.	.22	.82	-1.15-1.15	-.28	-1.49
Neutral Startle Mag.	.01	.20	-1.15-1.15	.15	-1.50
Positive Startle Mag.	-.23	.77	-1.15-1.15	.62	-.99
Negative Valence Rating	7.77	1.14	3.1-9	-1.40	2.53
Neutral Valence Rating	4.92	.62	1-6.8	-1.54	8.90
Positive Valence Rating	2.92	1.15	1-6.7	.53	.04
Negative Arousal Rating	3.54	1.84	1-9	.98	.49
Neutral Arousal Rating	6.78	1.44	2.1-9	-.23	-.67
Positive Arousal Rating	5.08	1.67	1.6-9	.37	-.47

Note. Startle magnitude values are within-person z-scores across all startle responses. Valence ratings ranged from 1 (very pleasant) to 9 (very unpleasant). Arousal ratings ranged from 1 (highly aroused) to 9 (calm).

Table 4

Intercorrelations of Startle Magnitudes, Valence and Arousal Ratings (N=170)

Measure (Magnitude/Rating)	1	2	3	4	5	6	7	8	9
1. Negative Startle	-								
2. Neutral Startle	-.55***	-							
3. Positive Startle	-.50***	-.46***	-						
4. Negative Valence	-.01	.12	-.12	-					
5. Neutral Valence	-.06	.02	.05	.17*	-				
6. Positive Valence	-.12	.07	.05	.18*	-.42***	-			
7. Negative Arousal	.07	-.18*	.11	-.44***	.06	-.21**	-		
8. Neutral Arousal	.11	-.16	.05	.06	-.09	-.13	-.02	-	
9. Positive Arousal	.01	.003	-.01	.26**	-.17*	.11	-.40***	.30***	-

Note: * $p < .05$; ** $p < .01$; *** $p < .001$

Table 5

Results of Mixed ANOVA Models Testing Hypotheses 1a-1c with PTSD Symptom Severity Predicting Startle Magnitude, Valence Ratings, and Arousal Ratings (N=170)

	df	*F*	*p-value*
Outcome: Startle Magnitude			
PTSD Sx Severity	3,143	.00	1.00
Valence	2,172	9.48	<.001
PTSD Sx SeverityXPicture Valence	6,94	.47	.83
Outcome: Valence Ratings			
PTSD Sx Severity	3,126	.35	.79
Valence	2,165	579.32	<.001
PTSD Sx SeverityXPicture Valence	6,102	.67	.67
Outcome: Arousal Ratings			
PTSD Sx Severity	3,169	4.54	.004
Valence	2,214	150.54	<.001
PTSD Sx SeverityXPicture Valence	6,121	.26	.96

Note: Valence for affective stimuli was coded as follows: 1=negative, 2=neutral, 3=positive. Age is covaried.

Table 6

Level-2 (Between-Person) Startle Magnitudes, Valence and Arousal Ratings Among Trauma Type Groups (N=170)

	No Trauma		*Physical Trauma*		*Sexual Trauma*		*Threat Trauma*		*Witness Trauma*	
Measure (Magnitude/Rating)	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Negative Startle	.33	.86	.09	.82	.54	.54	.05	.81	-.06	.78
Neutral Startle	-.08	.78	.09	.81	.43	.55	-.10	.87	.18	.86
Positive Startle	-.25	.71	-.18	.93	-.97	.23	.06	.82	-.12	.84
Negative Valence	7.82	1.14	7.31	1.54	8.02	.88	7.97	1.12	7.49	1.04
Neutral Valence	4.85	.66	4.98	.49	4.76	.90	5.12	.62	4.93	.42
Positive Valence	2.80	1.12	3.53	.96	2.86	1.30	3.07	1.22	2.96	1.31
Negative Arousal	3.60	1.96	4.22	1.67	3.01	1.23	3.23	2.08	3.63	1.44
Neutral Arousal	6.77	1.51	7.03	1.55	6.10	1.17	7.23	1.08	6.58	1.39
Positive Arousal	5.11	1.78	5.96	1.08	4.55	1.19	5.24	1.74	4.44	1.25

Note. Startle magnitude values are within-person z-scores across all startle responses.

Table 7

Results of Mixed ANOVA Models Testing Exploratory Analyses with Trauma Type Group Predicting Startle Magnitude, Valence Ratings, and Arousal Ratings (N=170)

	df	*F*	*p-value*
Outcome: Startle Magnitude			
Trauma Type	4,76	.000	1.00
Valence	2,59	9.28	<.001
Trauma TypeXPicture Valence	8,51	7.66	<.001
Outcome: Valence Ratings			
Trauma Type	4,80	.73	.57
Valence	2,54	342.79	<.001
Trauma TypeXPicture Valence	8,71	.76	.64
Outcome: Arousal Ratings			
Trauma Type	4,100	4.66	.002
Valence	2,87	104.43	<.001
Trauma TypeXPicture Valence	8,77	.80	.60

Note: Valence for affective stimuli was coded as follows: 1=negative, 2=neutral, 3=positive. Age is covaried.

Table 8

Level-2 (Between-person) Diary Characteristics of Sample (N=220)

Measure	*M*	*SD*	*Observed Range*	*Skewness*	*Kurtosis*
Events (0-40)	4.55	2.20	0-11	.59	.01
Negative Events (0-18)	1.32	1.20	0-6	1.70	3.61
Positive Events (0-22)	3.23	1.75	0-9	.73	.52
Stress (1-5)	1.87	.61	1-4	.59	-.23
Enjoyment (1-5)	3.57	.79	1-5	-.29	-.45
Pain (0-100)	54.06	18.23	6-92	-.29	-.39
Funct. Impairment (1-3)	2.00	.41	1-3	.03	-.30
Depression (1-3)	1.82	.39	1-3	.08	-.58
Negative Affect (1-5)	1.69	.68	1-4	1.51	2.53
Positive Affect (1-5)	2.31	.65	1-4	.58	.71

Note: Pain ratings ranged from 0 (no pain) to 100 (pain as bad as it can be). Stress, enjoyment ratings, and positive and negative affect ratings ranged from 1 (not at all) to 5 (completely). Ratings of depressive symptoms and functional impairment ranged from 1 (no/not at all) to 3 (yes, very much).

Table 9

Intercorrelations of Between-person Daily Diary Study Variables (N=220)

Measures	1	2	3	4	5	6	7	8	9	10
1. Total Events	-									
2. Negative Events	.61***	-								
3. Positive Events	.84***	.08	-							
4. Stress	.13	.65***	-.28***	-						
5. Enjoyment	.12	-.41***	.44***	-.62***	-					
6. Pain	-.05	.12	-.15*	.29***	-.27***	-				
7. Functional Impairment	-.06	.02	-.08	.19**	-.23**	.35***	-			
8. Depression	.12	.35***	-.09	.48***	-.42***	.44***	.60***	-		
9. Negative Affect	.09	.39***	-.16*	.57***	-.40***	.31***	.32***	.67***	-	
10. Positive Affect	.06	-.21**	.22**	-.34***	.53***	-.40***	-.53***	-.61***	-.41***	-

Note: * p< .05; ** p < .01; *** p < .001; "Events" indicate interpersonal events

Table 10

Intercorrelations of Within-person Daily Diary Study Variables

Measures	1	2	3	4
1. ΔNegative Events	-			
2. ΔPositive Events	.04*	-		
3. ΔStress	.50***	-.08***	-	
4. ΔEnjoyment	-.28***	.34***	-.33***	-

Note: * p <.05; ** p < .01; *** p < .001.
Number of observations ranges from 3361 3767.

Table 11

Means of Physical and Emotional Health Outcomes for Each PTSD Symptom Severity Group and Results of ANOVA Models Testing Differences between General Physical and Emotional Health Outcomes among PTSD Symptom Severity Groups (N=220)

	No Trauma		Low Severity		Moderate Severity		High Severity		ANOVA Results *df* = 3,214	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p-value*
Mean Pain	49.98	17.85	54.43	21.59	56.82	15.66	62.78	13.59	4.12	.007[a]
Mean Functional Impairment	1.95	.37	1.92	.44	2.11	.41	2.16	.40	3.86	.01[b]
Mean Depression	1.72	.38	1.76	.39	1.95	.36	2.01	.33	6.74	<.001[c]
Mean Negative Affect	1.49	.47	1.64	.66	1.88	.81	2.07	.81	7.33	<.001[d]
Mean Positive Affect	2.41	.64	2.43	.62	2.11	.70	2.16	.51	3.35	.02[e]

Note: Post hoc analyses include Tukey HSD comparisons.
[a]High severity > no trauma, p=.008.
[b]No significant differences between groups in pairwise comparisons.
[c]Moderate severity > no trauma, p = .004; high severity > no trauma, p = .003; high severity > low severity, p = .026.
[d]Moderate severity > no trauma, p = .02; high severity > no trauma, p = .008. This analyses used Dunnett T3 comparisons for unequal variances.
[e]Moderate severity < no trauma, p = .046.

Table 12

Results of Multilevel Models Testing Hypotheses 2 and 3 with PTSD Symptom Severity, Centered Interpersonal Events, and Their Interactions as Predictors (n=220)

	B	*SE B*	*df*	*t-value*	*p-value*
Hypothesis 2. Interpersonal Stress is DV					
Predictor:					
PTSD Symptom Severity	.10	.04	215	2.68	.008
ΔDaily Negative Events	.28	.02	3132	13.50	<.001
PTSDXΔNegative Events	.001	.01	3132	.47	.64
Hypothesis 3. Interpersonal Joy is DV					
Predictor:					
PTSD Symptom Severity	-.02	.05	215	-.37	.71
ΔDaily Positive Events	.14	.01	3134	11.85	<.001
PTSDXΔPositive Events	-.0003	.01	3134	-.04	.97

Note. Δ indicates person-centered measure. Models include Δnegative events as a random effect for Hypothesis 2 and Δpositive events as a random effect for Hypothesis 3.

Table 13

Means of Physical and Emotional Health Outcomes for Each Trauma Type Group and Results of ANOVA Models Testing Differences between General Physical and Emotional Health Outcomes among Trauma Type Groups (N=220)

	No Trauma		Physical Trauma		Sexual Trauma		Threat Trauma		Witness Trauma		ANOVA Results *df* = 4,207	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p-value*
Mean Pain	52.41	17.74	49.52	21.05	55.80	15.75	59.88	16.71	53.94	21.32	1.37	.25
Mean Functional Impairment	1.95	.37	1.95	.44	2.03	.48	2.20	.43	2.00	.42	2.65	.03[a]
Mean Depression	1.76	.38	1.78	.42	1.92	.39	1.91	.39	1.87	.39	1.67	.16
Mean Negative Affect	1.57	.53	1.62	.61	2.10	1.00	1.74	.90	1.81	.62	2.70	.03[b]
Mean Positive Affect	2.37	.66	2.31	.86	2.20	.70	2.15	.59	2.31	.55	.86	.49

Note: Post hoc analyses include Tukey HSD comparisons.

[a]Threat > no trauma, p=.013.

[b]No significant differences between groups in pairwise comparisons. This analysis used Dunnett T3 comparisons for unequal variances.

References

Alschuler, K.N. & Otis, J.D. (2013). Significant others' responses to pain in veterans with chronic pain and clinical levels of post-traumatic stress disorder symptomatology. *European Journal of Pain, 16*, 312-319.

Alschuler, K.N. & Otis, J.D. (2012). Coping strategies and beliefs about pain in veterans with comorbid chronic pain and significant levels of posttraumatic stress disorder symptoms. *European Journal of Pain, 16*, 312-319.

American Psychiatric Association. (2013) *Diagnostic and statistical manual of mental disorders*, (5th ed.). Washington, DC: Author.

American Society of Anesthesiologists Task Force on Chronic Pain Management. (2010). Practice Guidelines for Chronic Pain Management: An Updated Report by the American Society of Anesthesiologists Task Force on Chronic Pain Management and the American Society of Regional Anesthesia and Pain Medicine. *Anesthesiology, 112*, 810-833.

Arnold, L.M., Hudson, J.I., Keck, Jr., P.E., Auchenbach, M.B., Javaras, K.N., Phil, D., & Hess, E.V. (2006). Comorbidity of fibromyalgia and psychiatric disorders. *Journal of Clinical Psychiatry, 67*, 1219-1225.

Åsbring, P. & Närvänen, A. (2002). Women's Experiences of Stigma in Relation to Chronic Fatigue Syndrome and Fibromyalgia. *Qualitative Health Research, 12*, 148-160.

Asmundson, G.J.C. & Katz, J. (2009). Understanding the co-occurance of anxiety disorders and chronic pain: State-of-the-art. *Depression and Anxiety, 26*, 888-901.

Aupperle, R.L. & Paulus, M.P. (2010). Neural systems underlying approach and avoidance in anxiety disorders. *Dialogues in Clinical Neuroscience, 12*, 517-531.

Backs, R.W., da Silva, S.P., & Hans, K. (2005). A comparison of younger and older adults' self-assessment manikin ratings of affective pictures. *Experimental Aging Research, 31*, 421-440.

Bair, M.J., Wu, J., Damush, T.M., Sutherland, J.M. & Kroenke, K. (2008). Association of Depression and Anxiety Alone and in Combination with Chronic Musculoskeletal Pain in Primary Care Patients. *Psychosomatic Medicine, 70*, 890-897.

Bartley, E.J., Rhudy, J.l., & Williams, A.E. (2009). Experimental assessment of affective processing in fibromyalgia. *The Journal of Pain, 11*, 1151-1160.

Beckham, J.C., Crawford, A.L., Feldman, M.E., Kirby, A.C., Hertzberg, M.A., Davidson, J.R.T., & Moore, S.D. (1997). Chronic posttraumatic stress disorder and chronic pain in Vietnam combat veterans. *Journal of Psychosomatic Research, 43*, 379-389.

Borja, S.E., Callahan, J.L., & Long, P.J. (2006). Positive and negative adjustment and social support of sexual assault survivors. *Journal of Traumatic Stress, 19*, 905-914.

Bradley, M.M., & Lang, P.J. (1994). Measuring emotion: The Self-Assessment Manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*, 49-59.

Buckley, T.C., Holohan, D., Greif, J.L., Bedard, M., & Suvak, M. (2004). Twenty-four-hour ambulatory assessment of heart rate and blood pressure in chronic PTSD and non-PTSD veterans. *Journal of Traumatic Stress, 17*, 163-171.

Carleton, R.N., Asmundson, G.J.G., Collimore, K.C., & Ellwanger, J. (2006). Strategic and automatic threat processing n chronic musculoskeletal pain: A startle probe investigation. *Cognitive Behaviour Therapy, 35*, 236-247.

Charuvastra, A., & Cloitre, M. (2008). Social bonds and posttraumatic stress disorder. *Annual Review of Psychology, 59*, 301-328.

Ciccone, D.S., Elliot, D.K., Chandler, H.K., Nayak, S., Raphael, K.G. (2005). Sexual and physical abuse in women with fibromyalgia syndrome: A test of the trauma hypothesis. *The Clinical Journal of Pain, 21.5*, 378-386.

Cloitre, M., Koenen, K.C., Cohen, L.R., & Hyemee, H. (2002). Skills training in affective and interpersonal regulation followed by exposure: A phase-based treatment for PTSD related to childhood abuse. *Journal of Consulting and Clinical Psychology, 70*, 1067-1074.

Cloitre, M., Miranda, R., Stovall-McClough, C., & Han, H. (2005). Beyond PTSD: Emotion regulation and interpersonal problems as predictors of functional impairment in survivors of childhood abuse. *Behavior Therapy, 36*, 119-124.

Cohen, H., Neumann, Haiman, Y., Matar, M.A., Press, J. & Buskila, D. (2002). Prevalence of post-traumatic stress disorder in fibromyalgia patients: overlapping syndromes or post-traumatic fibromyalgia syndrome? *Seminars in Arthritis and Rheumatism, 32*, 38-50.

Davis, M.C., Thummala, K., & Zautra, A.J. (2014). Stress-related clinical pain and mood in women with chronic pain: Moderating effects of depression and positive mood induction. *Annals of Behavioral Medicine, 48,* 61-70.

Davis, M.C., Zautra, A.J., & Reich, J.W. (2001). Vulnerability to stress among women in chronic pain from fibromyalgia and osteoarthritis. *Annals of Behavioral Medicine, 23*, 215-226.

Davis, M.C., Zautra, A.J., Younger, J., Motivala, S.J., Attrep, J., & Irwin, M.R. (2008). Chronic stress and regulation of cellular markers of inflammation in rheumatoid arthritis: Implications for fatigue. *Brain, Behavior, and Immunity, 22*, 24-32.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science, 11*, 86-89.

Ehring, T. & Quack, D. (2010). Emotion regulation difficulties in trauma survivors: The role of trauma type and PTSD symptom severity. *Behavior Therapy, 41*, 587-598.

Elliot, T.E., Renier, C.M., & Palcher, J.A. (2003). Chronic Pain, Depression, and Quality of Life: Correlations and Predictive Value of the SF-36. *Pain Medicine, 4*, 331-339.

Enders, C.K. & Tofighi, D. (2007). Centering Predictor Variables in Cross-Sectional Multilevel Models: A New Look at an Old Issue. *Psychological Methods, 12*, 121-138.

Fani, N., Tone, E.B., Phifer, J., Norrholm, S.D., Bradley, B., Ressler, K.J.,…Jovanovic, T. (2011). Attention bias toward threat in associated with exaggerated fear expression and impaired extinction in PTSD. *Psychological Medicine, 42*, 533-543.

Frans, Ö, Rimmö, P-A., Åberg, L, & Fredrikson, M. (2004). Trauma exposure and post-traumatic stress disorder in the general population. *Acta Psychiatrica Scandinavica, 111*, 291-299.

Geisser, M.E., Roth, R.S., Bachman, J.E., & Eckert, T.A. (1996). The relationship between symptoms of post-traumatic stress disorder and pain, affective disturbance and disability among patients with accident and non-accident related pain. *Pain, 66*, 207-214.

Gerdes, A.B.M., Wieser, M.J., Alpers, G.W., Strack, F., & Pauli, P. (2012). Why do you smile at me while I'm in pain?—Pain selectively modulates voluntary facial muscle responses to happy faces. *International Journal of Psychophysiology, 85*, 161-167.

Ginzburg, K., Ein-Dor, T., & Solomon, Z. (2009). Comorbidity of posttraumatic stress disorder, anxiety and depression: A 20-year longitudinal study of war veterans. *Journal of Affective Disorders, 123*, 249-257.

Gracely, R.H., Geisser, M.E., Giesecke, T., Grant, M. A.B., Petzke, F., Williams, D.A., & Clauw, D.J. (2004). Pain catastrophizing and neural responses to pain among persons with fibromyalgia. *Brain, 127*, 835-843.

Grillon, C., & Baas, J. (2003). A review of the modulation of the startle reflex by affective states and its application in psychiatry. *Clinical Neurophysiology, 114*, 1557-1579.

Grillon, C., Pine, D.S., Lissek, S., Rabin, S., Bonne, O., & Vythilingam, M. (2009). Increased anxiety during anticipation of unpredictable aversive stimuli in posttraumatic stress disorder but not in generalized anxiety disorder. *Biological Psychiatry, 66*, 47-53.

Hamilton, N.A., Affleck, G., Tennen, H., Karlson, C., Luxton, D., Preacher, K.J., & Templin, J.L. (2008). Fibromyalgia: The role of sleep in affect and in negative event reactivity and recovery. *Health Psychology, 27*, 490-497.

Hamilton, N.A., Zautra, A.J., & Reich, J.W. (2005). Affect and pain in rheumatoid arthritis: Do individual differences in affection regulation and affective intensity predict emotional recovery from pain? *Annals of Behavioral Medicine, 29*, 216-224.

Häuser, W., Galek, A., Erbslöh-Möller, B., Köllner, V., & Kühn-Becker, H., Langhorst, J., Petermann, F.,…Glaesmer, H. (2013). Posttraumatic stress disorder in fibromyalgia syndrome: Prevalance, temporal relationship between posttraumatic stress and fibromyalgia symptoms, and impact on clinical outcome. *Pain, 154*, 1216-1223.

Häuser, W., Hoffmann, E.M., Wolfe, F., Worthing, A.B., Stahl, N., Rothenberg, R., & Walitt, B. (2015). Self-reported childhood maltreatment, lifelong traumatic events and mental disorders in fibromyalgia syndrome: a comparison of US and German outpatients. *Clinical and Experimental Rheumatology, 33*, S86-S92.

Hatton, S.N., Lagopoulos, J., Hermens, D.F., Naismith, S.L., Bennett, M.R., & Hickie, I.B. (2012). Correlating anterior insula gray matter volume changes in young people with clinical and neurocognitive outcomes: An MRI study. *BMC Psychiatry, 12*:*45.*

Haviland, M.G., Morton, K.R., Oda, K., & Fraser, G.E. (2010). Traumatic experiences, major life stressors, and self-reporting a physical-given fibromyalgia diagnosis. *Psychiatry Research* 335-341.

Holtzman, S., Newth, S., & Delongis, A. (2004). The role of social support in coping with daily pain among patients with rheumatoid arthritis. *Journal of Health Psychology, 9*, 677-695.

Hull, A.M. (2002). Neuroimaging findings in post-traumatic stress disorder. *British Journal of Psychiatry, 181*, 102-110.

Jenewein, J., Moergeli, H., Wittmann, L., Büchi, S., Kraemer, B., & Schnyder, U. (2009). Development of chronic pain following severe accidental injury. Results of a 3-year follow-up study. *Journal of Psychosomatic Research, 66*, 119-126.

Jenewein, J., Wittmann, L., Moergeli, H., Creutzig, J., & Schnyder, U. (2009). Mutual Influence of Posttraumatic Stress Disorder and Chronic Pain Among Injured Accident Survivors: A Longitudinal Study. *Journal of Traumatic Stress, 22*, 540-548.

Jensen, K.B., Kosek, E., Petzke, F., Carville, S., Fransson, P., Marcus, H., Williams, S.C.,…Ingvar, M. (2009). Evidence of dysfunctional pain inhibition in fibromyalgia reflected in rACC during provoked pain. *Pain, 144*, 95-100.

Johannes, C.B., Kim Le, T., Zhou, X., Johnston, J.A., & Dworkin, R.H. (2010). The Prevalence of Chronic Pain in United States Adults: Results of an Internet-Based Survey. *The Journal of Pain, 11*, 1230-1239.

Katz, J., Asmundson, G.J.G., McRae, K., & Halket, E. (2009). Emotional numbing and pain intensity predict the development of pain disability up to one year after lateral thoracotomy. *European Journal of Pain, 13*, 870-878.

Kelley, L.P., Weathers, F.W., McDevitt-Murphy, M.E., Eakin, D.E., & Flood, A.M. (2009). A comparison of PTSD symptom patterns in three types of civilian trauma. *Journal of Traumatic Stress, 22*, 227-235.

Kessler, R.C., Berglund, P., Demler, O., Jin, R., Merikangas, K.R., & Walters, E.E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry, 62*, 593-602.

Kilpatrick, D.G., Resnick, H.S., Milanak, M.E., Miller, M.W., Keyes, K.M., & Friedman, M.J. (2013). National estimates of exposure to traumatic events and PTSD prevalence using *DSM-IV* and *DSM-5* criteria. *Journal of Traumatic Stress, 26*, 537-547.

Kool, M.B. & Geenen, R. (2012). Loneliness in patients with rheumatic diseases: the significance of invalidation and lack of social support. *The Journal of Psychology, 146*, 229-241.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1998). Emotion, motivation, and anxiety: Brain mechanisms and psychophysiology. *Society of Biological Psychiatry, 44*, 1248-1263.

Lang, P.J., Bradley, M.M., Cuthbert, B.N. International Affective Picture System (IAPS): instruction manual and affective ratings. Technical Report A-4. Gaineseville, FL: The Center for Research in Psychophysiology, University of Florida, 1999.

Lee, Y.C., Nassikas, N.J., & Clauw, D.J. (2011). The role of the central nervous system in the generation and maintenance of chronic pain in rheumatoid arthritis, osteoarthritis and fibromyalgia. *Arthritis Research and Therapy, 13*, 211.

Liebschutz, J., Saitz, R., Brower, V., Keane, T.M., Lloyd-Travaglini, C., Averbuch, T., & Samet, J.H. (2007). PTSD in Urban Primary Care: High Prevalence and Low Physician Recognition. *Society of General Internal Medicine, 22*, 719-726.

Litz, B.T. (1992). Emotional numbing in combat-related post-traumatic stress disorder: A critical review and reformulation. *Clinical Psychology Review, 12*, 417-432.

Litz, B.T., Orsillo, S.M., Kaloupek, D., & Weathers, F. (2000). Emotional processing in posttraumatic stress disorder. *Journal of Abnormal Psychology, 109*, 26-39.

McFarlane, A.C., Bookless, C., & Air, T. (2001). Posttraumatic stress disorder in the general psychiatric inpatient population. *Journal of Traumatic Stress, 14*, 633-645.

McLean, S.A., Clauw, D.J., Abelson, J.L., & Liberzon, I. (2005). The development of persistent pain and psychological morbidity after motor vehicle collision: Integrating the potential role of stress response systems into a biopsychosocial model. *Psychosomatic Medicine, 67*, 783-790.

Moeller-Bertram, T., Keltner, J., & Strigo, I.A. (2012). Pain and post traumatic stress disorder: Review of clinical and experimental evidence. *Neuropharmacology, 62*, 586-597.

Monson, C.M., Taft, C.T., & Fredman, S.J. (2009). Military-related PTSD and intimate relationships: From description to theory-driven research and intervention development. *Clinical Psychology Review, 29*, 707-714.

Nes, L.S., Roach, A.R., & Segerstrom, S.C. (2009). Executive functions, self-regulation, and chronic pain: A review. *Annals of Behavioral Medicine, 37*, 173-183.

Neugebauer, V., Weidong, L., Bird, G.C., & Han, J.S. (2004). The amygdala and persistent pain. *Neuroscientist, 10*, 221-234.

Otis, J.D., Gregor, K., Hardway, C., Morrison, J., Scioli, E., & Sanderson, K. (2010). An Examination of the co-morbidity between chronic pain and posttraumatic stress disorder on U.S. veterans. *Psychological Sciences, 7*, 126-135.

Otis, J.D., Keane, T.M., Kerns, R.D., Monson, C., & Scioli, E. (2009). The development of an integrated treatment for veterans with comorbid chronic pain and posttraumatic stress disorder. *Pain Medicine, 10*, 1300-1311.

Otis, J.D., Pincus, D.B., & Keane, T.M. (2006). Comorbid Chronic Pain and Posttraumatic Stress Disorder Across the Lifespan: A Review of Theoretical Models. In Young, G., Nicholson, K., & Kane, A.W. (Eds.), *Psychological Knowledge in Court: PTSD, Pain, and TBI.* (242-268). New York, NY: Springer.

Parrish, B.P., Zautra, A.J., & Davis, M.C. (2008). The role of positive and negative interpersonal events on daily fatigue in women with fibromyalgia, rheumatoid arthritis, and osteoarthritis. *Health Psychology, 27*, 694-702.

Palyo, S.A. & Beck, J.G. (2005). Post-traumatic stress disorder symptoms, pain, and perceived life control: Associations with psychosocial and physical functioning. *Pain, 117*, 121-127.

Pole, N., Neylan, T.C., Best, S.R., Orr, S.P., & Marmar, C.R. (2003). Fear-potentiated startle and posttraumatic stress symptoms in urban police officers. *Journal of Traumatic Stress, 16*, 471-479.

Pole, N., Neylan, T.C., Otte, C., Metzler, T.J., Best, S.R., Henn-Haase, C., & Marmar, C.R. (2007). Associations between childhood trauma and emotion-modulate psychophysiological responses to startling sounds: A study of police cadets. *Journal of Abnormal Psychology, 116*, 352-361.

Protopopescu, X., Pan, H., Tuescher, O., Cloitre, M., Goldstein, M., Engelien, W., Epstein, J.,…Stern, E. (2005). Differential time courses and specificity of amygdala activity in posttraumatic stress disorder subjects and normal control subjects. *Biological Psychiatry, 57*, 464-473.

Read, J., Ouimette, P., White, J., Colder, C., & Farrow, S. (2011). Rates of *DSM-IV-TR* trauma exposure and posttraumatic stress disorder among newly matriculated college students. *Psychological Trauma: Theory, Research, Practice, and Policy, 32*, 148-156.

Rhudy, J.L., DelVentura, J.L., Terry, E.L., Bartley, E.J., Olech, E., Palit, S., & Kerr, K.L. (2013). Emotional modulation of pain and spinal nocioception in fibromyalgia. *Pain, 154*, 1045-1056.

Ruiz-Párraga, G.T., & López-Martínez, A.E. (in press). The contribution of posttraumatic stress symptoms to chronic pain adjustment. *Health Psychology,* doi:10.1037/hea0000040

Sareen, J., Cox, B.J., Stein, M.B., Afifi, T.O., Fleet, C., & Asumundson, G.J.G. (2007). Physical and Mental Comorbidity, Disability, and Suicidal Behavior Associated with Posttraumatic Stress Disorder in a Large Community Sample. *Psychsomatic Medicine, 69*, 242-248.

Shakespeare-Finch, J. & Armstrong, D. (2010). Trauma type and posttrauma outcomes: Differences between survivors of motor vehicle accidents, sexual assault, and bereavement. *Journal of Loss and Trauma, 15*, 69-82.

Sharp, T.J. & Harvey, A.G. (2001). Chronic Pain and Posttraumatic Stress Disorder: Mutual Maintenance? *Clinical Psychology Review, 21*, 857-877.

Sheehan, D.V., Lecrubier, Y., Sheehan, K.H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T.,…Dunbar, G.C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry, 59*, 20-33.

Sherman, J.J., Turk, D.C., & Okifuji, A. (2000). Prevalence and impact of posttraumatic stress disorder-like symptoms on patients with fibromyalgia syndrome. *The Clinical Journal of Pain, 16*, 127-134.

Shin, L.M., Rauch, S.L., & Pitman, R.K. (2006). Amygdala, medial prefrontal cortex, and hippocampal function in PTSD. *Annals of New York Academy of Science, 1071*, 67-79.

Shin, L.M., Wright, C.I., Cannistraro, P.A., Wedig, M.M., McMullin, K., Martis, B.,…Rauch, S.L. (2005). A functional magnetic resonance imaging study of amygdala and medial prefrontal cortex responses to overtly presented fearful faces in posttraumatic stress disorder. *Archives of General Psychiatry, 62*, 273-281.

Shipherd, J.C., Keyes, M., Jonvanovic, T., Ready, D.J., Baltzell, D., Worley, V., Gordon-Brown, V., Hayslett, C., & Duncan, E. (2007). Veterans seeking treatment for posttraumatic stress disorder: What about comorbid chronic pain? *Journal of Rehabilitation Research and Development, 44*, 153-166.

Smith, B. W., & Zautra, A. J. (2002). The role of personality in exposure and reactivity to interpersonal stress in relation to disease activity and negative affect in women. *Health Psychology,* **21**, 81-88.

Sturgeon, J.A. & Zautra, A.J. (2013). State and trait pain catastrophizing and emotional health in rheumatoid arthritis. *Annals of Behavioral Medicine, 45*, 69-77.

Sullivan, M.J.L., Thibault, P., Simmonds, M.J., Milioto, M., Cantin, AP.., & Velly, A.M. (2009). Pain, perceived injustice and the persistence of post-traumatic stress symptoms during the course of rehabilitation for whiplash injuries. *Pain, 145*, 325-331.

Tarrier, N., & Humphries, A. (2003). PTSD and the social support of the interpersonal environment: The development of social cognitive behavior therapy. *Journal of Cognitive Psychotherapy, 17*, 187-198.

Taylor, S.S., Davis, M.C., & Zautra, A.J. (2013). Relationship status and quality moderate daily pain-related changes in physical disability, affect, and cognitions in women with chronic pain. *Pain, 154*, 147-153.

Thieme, K., Turk, D.C., & Flor, H. (2004). Comorbid depression and anxiety in fibromyalgia syndrome: relationship to somatic and psychosocial variables. *Psychosomatic Medicine, 66*, 837-844.

Tracey, I., & Mantyh, P.W. (2007). The cerebral signature for pain perception and its modulation. *Neuron, 55*, 377-391.

Tull, M.T., Barrett, H.M., McMillan, E.S., & Roemer, L. (2007). A preliminary investigation of the relationship between emotion regulation difficulties and posttraumatic stress symptoms. *Behavior Therapy, 38*, 303-313.

Turner, J.A., Jensen, M.P., Warms, C.A., & Cardenas, D.D. (2002). Catastrophizing is associated with pain intensity, psychological distress, and pain-related disability among individuals with chronic pain after spinal cord injury. *Pain, 98*, 127-134.

Von Korff, M., Crane, P., Lane, M., Miglioretti, D.L., Simon, G., Saunders, K., Stang, P., Brandenburg, N., & Kessler, R. (2005). Chronic spinal pain and physical-mental comorbidity in the United States: results from the national comorbidity survey replication. *Pain, 113*, 331-339.

Wolfe, F., Smythe, H. A., Yunus, M. B., Bennett, R. M., Bombardier, C., Goldenberg, D. L., . . . Sheon, R. P. (1990). The American College of Rheumatology 1990 Criteria for the Classification of Fibromyalgia. Report of the Multicenter Criteria Committee. *Arthritis and Rheumatism, 33*(2), 160-172.

Wood, P.B. (2004). Fibromyalgia syndrome: A central role for the hippocampus—A theoretical construct. *Journal of Musculoskeletal Pain, 12*, 19-26.

Zautra, A.J., Affleck, G.G., Tennen, H., Reich, J.W., & Davis, M.C. (2005). Dynamic approaches to emotions and stress in everyday life: Bolger and Zuckerman reloaded with positive as well as negative affects. *Journal of Personality, 73*, 1511-1538.

Zautra, A.J., Fasman, R., Reich, J.W., Harakas, P., Johnson, L.M., Olmsted, M.E., & Davis, M.C. (2005). Fibromyalgia: Evidence for deficits in positive affect regulation. *Psychosomatic Medicine, 67*, 147-155.

Zautra, A.J., Johnson, L.M., & Davis, M.C. (2005). Positive Affect as a Source of Resilience for Women in Chronic Pain. *Journal of Consulting and Clinical Psychology, 73*, 212-220.

Zautra, A. J., Schultz, A. S., & Reich, J. W. (2000). The role of everyday events in depressive symptoms for older adults. Dordrecht, Netherlands: Kluwer Academic Publishers.

Zautra, A., Smith, B., Affleck, G., & Tennen, H. (2001). Examinations of Chronic Pain and Affect Relationships: Applications of a Dynamic Model of Affect. *Journal of Consulting and Clinical Psychology, 69*, 786-795.

Zeiss, A.M. & Lewinsohn, P.M. (1988). Enduring deficits after remissions of depression: A test of the scar hypothesis. *Behaviour Research and Therapy, 26*, 151-158.

Zhou, M. (2008). Cortical excitation and chronic pain. *Trends in Neuroscience, 31*, 199-207.

Ziv, M., Tomer, R., Defrin, R., & Hendler, T. (2010). Individual sensitivity to pain expectancy is related to differential activation to the hippocampus and amygdala. *Human Brain Mapping, 31*, 326-338.

APPENDIX.

MEASURES

Occurrence of Interpersonal Events

Spouse/Partner Desirable Events

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

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

You expressed love to your spouse or partner - Press 1 for yes or 2 for no

You celebrated with your spouse or partner - Press 1 for yes or 2 for no

You had a long conversation with your spouse or partner - Press 1 for yes or 2 for no

You kissed and/or had pleasing physical contact with your spouse or partner - Press 1 for yes or 2 for no

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

Spouse/Partner Undesirable Events

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

You argued with your spouse or partner about money - Press 1 for yes or 2 for no

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

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

Your spouse or partner ignored you - Press 1 for yes or 2 for no

Your spouse or partner turned down your request for time together - Press 1 for yes or 2 for no

Your spouse or partner was ill-behaved - Press 1 for yes or 2 for no

Your spouse or partner stopped being affectionate - Press 1 for yes or 2 for no

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

Family Desirable Events

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

You were praised by a family member

You received a letter or email from family member

A family member or members not living at home visited

You talked with family member you had not seen for a long time

You helped a family member

You received a gift from a family member

You worked out a problem with ex-spouse

Your child or children did something nice for you

You taught your child or grandchild something new

You went out to lunch/dinner, movie, etc. with a family member

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

Family Undesirable Events

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

You were criticized or blamed for something by a family member

You had an argument with a family member

You argued with ex-spouse

Your son or daughter was rude or irritable

You had to deal with a stressful family problem

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

Friend/Acquaintance Desirable Events

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

You went to a sport, game, or played cards with friends

You went to a party or other social gathering

You went to a club or organized group meeting

You met a new friend or acquaintance

You went out with friends to lunch, etc

You received a compliment from a friend or acquaintance

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

Friend/Acquaintance Undesirable Events

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

A friend or acquaintance canceled or did not show up for a meeting

A friend or acquaintance did not return your call

You had a conflict with friend or acquaintance

You had to deal with an unfriendly or rude person

You received angry email or phone message from someone you knew

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

Appraisal of Interpersonal Events

Spouse/Partner

Overall, how enjoyable were your relations with your spouse or partner today, on a scale of 1 to 5?

1. is not at all

2. a little

3.some

4.quite a bit, or

5.completely

Overall, how stressful were your relations with your spouse or partner today on a scale of 1 to 5?

1. is not at all

2. a little

3.some

4.quite a bit, or

5.completely

Family

Overall, how enjoyable were your relations with your family today on a scale of 1 to 5?

1. is not at all

2. a little

3.some

4.quite a bit, or

5.completely

Overall, how stressful were your relations with your family today on a scale of 1 to 5?

1. is not at all

2.a little

3.some

4.quite a bit, or

5.completely

Friends/Acquaintances

Overall, how enjoyable were your relations with your friends or acquaintances today on a scale of 1 to 5?

1. is not at all

2.a little

3.some

4.quite a bit, or

5.completely

Overall, how stressful were your relations with your friends or acquaintances today on a scale of 1 to 5?

1. is not at all

2. a little

3. some

4. quite a bit, or

5. completely

Pain

What was your overall level of pain today? 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".

Functional Impairment

On a scale of 1 to 3 from List B on your cheat sheet, where 1 means No, 2 means slightly, and 3 means very much, today:

Did you cut down on the amount of time spent on work or other activities?

Today did you accomplish less than you would have liked?

Were you limited in the kind of work or other activities you did?

On a scale of 1 to 3, did you have difficulty performing work or other activities?

Affect

Please answer the following questions on a scale of 1 to 5, where 1=not at all and 5 = completely

Today did you feel like you had a lot of energy?

Attentive?

Serene?

Loved?

Calm?

Cheerful?

Enthusiastic?

Afraid?

Sad?

Angry?

Ashamed?

Lonely?

Depression

Rate each of the following statements using a scale of 1 to 3, where:

1=no

2=yes slightly

3=yes very much

Today, did you feel a lack of interest in your activities?

Did you feel an increase or decrease in appetite?

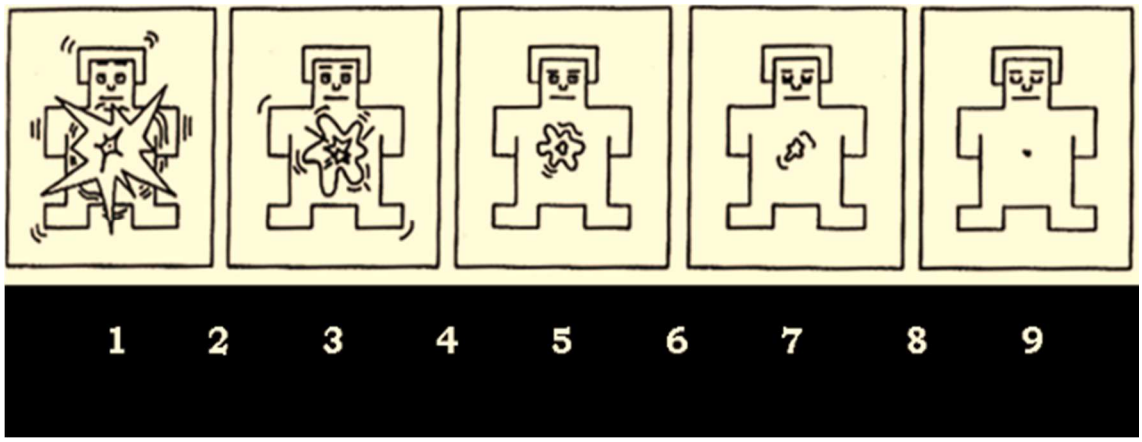
On a scale of 1-3, did you feel restless or slowed down?

Did you feel down on yourself?

Did you have difficulty concentrating or making decisions?

Laboratory Emotional Ratings

Arousal Self-Assessment Manikin (SAM)



Valence Self-Assessment Manikin (SAM)