THE EFFECT OF EMOTION REGULATION STRATEGIES ON THE PAIN EXPERIENCE

A Thesis
Submitted to the Faculty of Graduate Studies and Research
In Partial Fulfillment of the Requirements
For the Degree of

Master of Arts
in
Clinical Psychology

University of Regina

By
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Regina, Saskatchewan
July, 2014

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UNIVERSITY OF REGINA

FACULTY OF GRADUATE STUDIES AND RESEARCH

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Amy Jean Diane Hampton, candidate for the degree of Master of Arts in Clinical Psychology, has presented a thesis titled, *The Effect of Emotion Regulation Strategies on the Pain Experience*, in an oral examination held on July 28, 2014. The following committee members have found the thesis acceptable in form and content, and that the candidate demonstrated satisfactory knowledge of the subject material.

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Abstract

Pain, an unpleasant subjective and multidimensional experience associated with actual or potential tissue damage, is fundamentally a psychological phenomenon with emotional components. As such, the multi-component coordination of processes by which emotions are moderated, emotional regulation (ER), is of particular interest. Two primary ER strategies are reappraisal and suppression. Few studies have explored the effects of suppression and reappraisal on pain outcomes. The purpose of this study was to examine: 1) differences among suppression, reappraisal, and monitoring-control experimental conditions (i.e., conditions involving verbal instruction to engage in specific ER strategies) on indicators of pain and affect; 2) the relationship between participants’ self-reported suppression and reappraisal tendencies with pain threshold/tolerance; 3) if participants’ tendencies to use either suppression or re-appraisal interacted with experimental condition instructions.

Of the 151 participants recruited, 142 completed the study. Participants first completed the Emotion Regulation Questionnaire (Gross & John, 2003) to quantify their typical self-reported suppression and reappraisal use and then completed pain threshold and tolerance tasks involving use of an advanced thermal stimulator. Subsequently, a baseline resting period occurred before participants were randomly assigned to either a suppression (n = 53), reappraisal (n = 48), or monitoring (n = 41) condition. They then completed a 10-trial pain task and a recovery period. Self-report measures of pain intensity, pain unpleasantness, anxiety, and tension were collected before randomization, following the pain task, and following recovery. Facial expressions, heart rate, and galvanic skin response were recorded during the baseline,
10-trial pain task, and recovery periods. The Facial Action Coding System (Ekman, Friesen, & Hager, 2002) was used to quantify general and pain-related facial activity. An automated program was used to quantify expressions related to emotional states.

Consistent with biopsychosocial formulations of the pain experience (Hadjistavropoulos et al., 2011), this study demonstrated that psychological processes significantly moderate both verbal (e.g., self-report) and nonverbal (e.g., facial expressions) pain expressions. Namely, using reappraisal strategies to regulate a painful experience was related to significantly lower pain intensity, pain unpleasantness, anxiety, and tension ratings as well as reduced general and pain-related facial activity compared to not using an ER strategy. Similarly, using suppression strategies was also related with lower self-reported pain intensity ratings as well as general and pain-related facial activity. Yet, unlike reappraisal, using suppression was not related to reductions in pain unpleasantness, anxiety, and tension ratings. Unexpectedly, no relationship between a person’s self-reported tendency to use suppression or reappraisal, and pain threshold or tolerance emerged. Moreover, typical self-reported tendencies were not found to interact with experimental condition assignment. Finally, the frequency of six emotional facial displays were not clearly related to exposure to thermal stimuli or to specific ER strategies.

The results suggest that using reappraisal and to some extent suppression, may have some clinical implications in the regulation of acute phasic pain. Nonetheless, more research should be conducted to clarify the relationship between ER and pain, particularly the relationship between suppression and pain. Research is also needed to further examine the clinical implications of these findings.
Acknowledgement

This project would have not been possible without the tremendous support of several individuals. I would like to express much gratitude to my supervisor, Dr. Thomas Hadjistavropoulos. Thank you for providing me with unrelenting encouragement, incremental expertise, and continuous guidance. Your support has truly been the foundation of this project. I would also thank my committee members, Dr. Bridget Klest and Dr. David Clark. I have appreciated all of your thoughtful feedback and considerable support.

I would also like extend the deepest gratitude to Dr. Jaime Williams. Your patience, expertise, and assistance were invaluable. Thank you for believing in this project. I would also like to thank Michelle Gagnon for your mentorship throughout the entirety of this project and Eleni Gardikiotis for the substantial assistance in many features of this work. Thank you to my other lab mates Omeed Ghandehari and Ashley Viklund for your help in the completion of this project.

I would also like to acknowledge Thomas Hadjistavropoulos, the Government of Saskatchewan (for their contribution through a Saskatchewan Innovation Scholarship), and the University of Regina Faculty of Graduate Studies and Research for their financial support during the completion of my Master’s degree. I also acknowledge the Canada Foundation for Innovation and the Government of Saskatchewan for their financial support for the equipment used in this study.

Finally I would like to thank Dale Dirske, Sophie Duranceau, Kirstie Walker, and Daniel LeBouthillier, for the infinite help and encouragement throughout this process.
Dedication

I would like to dedicate this thesis to my parents and “the cohort”.

Dad and Mum, thank you for pushing me to be my best, loving me at my worst, and being my companions in the journey.

The cohort, thank you for your unwavering encouragement and helping me reach for the stars.
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List of Abbreviations

Action Unit (AU)

Descriptor Differential Scales (DDS)

Emotion Regulation (ER)

Emotion Regulation Questionnaire (ERQ)

Facial Action Coding System (FACS)

Galvanic Skin Response (GSR)

Heart Rate (HR)

International Association for the Study of Pain (IASP)

Visual Analogue Scale (VAS)
The Effect of Emotion Regulation on the Pain Experience

Overview

It was not until Melzack and Wall (1969) proposed the gate control theory of pain that the influence of psychological parameters in the complex experience of pain was widely acknowledged. Since the proposition of this revolutionary conceptualization of pain, psychological determinants of pain, including the relationship between pain and emotion, have been heavily explored. Pain has strong emotional components (Cai & Oderda, 2012; Lumley et al., 2011; Robinson & Riley, 1999; Walker, Hopman, Harrison, Tripp, & VanDenKerkhof, 2012). However, few studies have explored the effects of emotion regulation (ER; Gross, 2007) strategies on the pain experience.

Reappraisal and suppression are two primary and distinct ER strategies (Gross, 2007). Reappraisal involves adjusting tendencies and affect before emotions have been fully activated, whereas suppression involves the inhibition of emotions that have already been evoked (Gross, 2007). In laboratory settings, where participants were instructed to engage in a specific ER strategy (i.e., participants were instructed to reappraisal, suppression, or use their self-reported tendencies following an emotional-eliciting task such as mental math to induce anxiety) distinct responses to participants’ physiological arousal, memory, and dyadic rapport have been documented. Few studies have explored, however, ER in relation to the expression of pain. The studies that have explored the relationship between ER and pain have yielded mixed findings. For instance, although suppression is commonly proposed as having a paradoxical, deleterious impact (Elfant, Burns, & Zeichener, 2008), it has also been inversely related (Braams, Blechert, Boden,
& Gross, 2012), and not related (Burns, 2006; Cioffi & Holloway, 1993; Sullivan, Rouse, Bishope, & Johnston, 1997) to self-reported pain levels. Furthermore, the effects of experimentally elicited reappraisal use (i.e., through instructions) or the interaction between individuals’ self-reported ER strategies use and experimental induction of ER strategies on pain indicators has not been explored.

The purpose of this investigation was threefold. Specifically, the effects of three ER strategy induction conditions (suppression, reappraisal, and monitoring) on self-reported pain, self-reported emotions, nonverbal expressiveness (general, pain-related, and emotional states including neutral, happiness, sadness, fear, surprise, anger, and disgust), and physiological reactivity (heart rate and galvanic skin response) during a pain inducing task and during recovery were examined. Pain threshold and pain tolerance in relation to participants’ self-reported, typical suppression and reappraisal use was also explored. Finally, the interaction between participants’ self-reported, typical, suppression and reappraisal use when placed in either suppression or reappraisal experimental induction condition on self-reported pain ratings, self-reported emotions ratings, nonverbal expressiveness (general, pain-related, and emotional states including neutral, happiness, sadness, fear, surprise, anger, and disgust), and physiological reactivity (heart rate and galvanic skin response) during a pain inducing task and recovery was explored.

**Pain**

Pain is an individual, subjective, and multidimensional experience (Melzack, 1993). The International Association for the Study of Pain (IASP) defines pain as an unpleasant sensory and emotional experience associated with actual or potential tissue
damage, or described in terms of such damage (International Association for the Study of Pain, 2012). However, pain was not always thought of as a complex experience that involves potent psychosocial features. The evolution of the conceptualization of pain underscores its complexity as well as the importance of exploring psychological determinants, including emotion regulation (ER), in the pain experience.

**Early frameworks of pain.** Our understanding of pain has an extensive history (Gatchel, 1999). Theories and models of pain have drastically shifted from simplistic ascending peripheral pathways to the comprehensive integration of factors, where the influence of psychological, behavioural, and social processes in pain are acknowledged. For instance, early theories of pain, beginning with Descartes in the 17th century, conceptualized a direct one-to-one correspondence between pain and tissue damage. These early approaches of understanding pain did not include the role of social, emotional, and cognitive factors (Gatchel, 1999). Although similar biomedical conceptualizations of pain persist (Melzack & Katz, 2004; Moayedi & Davis, 2013), these models do not fully explain the variable relationship between pain and tissue damage or account for the influence of psychosocial factors. For example, social influences (e.g., presences of an observer, observing a confederate tolerate pain) and pain beliefs (e.g., pain catastrophizing) have shown to greatly impact pain variables (e.g., pain threshold or pain expressions; Craig & Weiss, 1971; Hadjistavropoulos et al., 2011; Sullivan, Adams, & Sullivan, 2004; Sullivan et al., 1997). Moreover, biomedical models do not fully explain the experience of pain in the absence of injury or clear organic sign
of tissue damage (e.g., many types of chronic pain; phantom limb pain persisting after tissue healing; Melzack & Katz, 2004).

**The gate control theory of pain.** The gate control theory of pain revolutionized our understanding of pain because, according to the theory, psychosocial features (in addition to physiological features) impact the pain experience (e.g., beliefs, thoughts, emotions, ER; Melzack & Wall, 1965). Specifically, Melzack and Wall (1965) posited that a gating mechanism, located in the spinal dorsal horn, modulates pain by nerve impulses from afferent fibres (Melzack & Wall, 1965). According to the gate control theory of pain, two distinct types of fibres transmit nociceptive information (i.e., sensory information with the potential of being interpreted as painful by the brain) to the brain through the spinal cord. Small A myelinated fibres facilitate the action potential of the gate by transmitting nociceptive information to the brain, while large C unmyelinated fibres inhibit the ability of the gate to transmit non-nociceptive information (i.e., physical sensations; Melzack & Wall, 1965). Melzack and Wall (1965) hypothesized that the gating mechanism regulates the transmission of nociceptive information to the brain, where pain is ultimately perceived. In support of their theory, empirical evidence for the purported physiological mechanism exists (Basbaum & Fields, 1984; Bjordal, Johnson, & Ljunggreen, 2003; Humphries, Johnson, & Long, 1996; Julien & Marchand, 2006; S. Y. Kim, Jeong, Jung, & Kim, 2011). However, Melzack and Wall (1965) also proposed that descending fibres from the brain’s supraspinal regions influence the opening and closing of the gate. As such, it was recognized that psychological features including thoughts, emotion, and beliefs can influence the pain experience. Support for these features of the
theory is also available (e.g., Sullivan et al., 2004; Sullivan, Bishop, & Pivik, 1995; Sullivan, Tripp, & Santor, 2000).

The gate control theory of pain, as it was initially proposed, did not explain pain experiences that did not have a clear transmission of nociceptive messages to the brain (e.g., phantom limb pain experienced by amputees long after the tissue healed; Melzack, 1993). Hence, the neuromatrix model of pain was proposed to supplement the gate control theory. Namely, Melzack (1999) proposed that the neuromatrix (i.e., a widespread network of neurons) continuously processes information and formed characteristic patterns of neuronal loops (i.e., the neurosignature) that ultimately produce physical sensations. Hence, phantom limb experiences were thought to be the result of the neurosignature, which was established prior to amputation (Melzack, 1999). Since the gate control theory of pain and neuromatrix model were proposed, the variable and complex relationship between pain and tissue damage could be explained (Asmundson & Wright, 2004). Evidence for the gate control theory of pain also supported the development and further appreciation of alternative biopsychosocial frameworks of pain, where pain is thought to arise from the dynamic and continuously evolving interactions among biological factors (e.g., predispositions, medical ailments), psychological factors (e.g., emotional state, cognitions), and social factors (e.g., culture, social context; Asmundson & Wright, 2004; Hadjistavropoulos et al., 2011).

Since the purpose of this study was to explore the impact of a complex internal experience (i.e., ER strategies) on both verbal (i.e., self-report) and nonverbal (i.e., facial displays) expressions of pain, the theoretical orientation for this study is rooted within the
biopsychosocial communications model of pain (Craig, Prkachin, & Grunau, 2011; Hadjistavropoulos & Craig, 2002; Hadjistavropoulos et al., 2011; Larochette, Chambers, & Craig, 2006; Prkachin & Craig, 1995). Unlike biopsychosocial formulations such as operant models (Fordyce, Shelton, & Dundore, 1982) and fear avoidance models of pain (Lethem, Slade, Troup, & Bentley, 1983) where the focus is on the reinforcement of pain behaviours and intrapersonal factors (Fordyce et al., 1982; Lethem et al., 1983; Vlaeyen & Linton, 2012), within the communications model, pain is conceptualized within a highly complex psychosocial context.

**The communications model of pain.** The impact of internal factors (e.g., ER) and the multidimensional expression of pain are two primary areas of exploration in this study and are both emphasized in the communications model of pain. Based on early work by Rosenthal (1982), the communications model focuses on pain as an A→B→C process of communication wherein internal states (A) are encoded and expressed through behaviours (B) that can then be decoded by observers (C) who draw conclusions about the nature of the sufferer’s experience and who may choose to intervene (Hadjistavropoulos & Craig, 2002; Hadjistavropoulos et al., 2011; Prkachin & Craig, 1995).

**Step A: The internal experience.** The internal experience of pain is a highly complex phenomenon that is affected by a multitude of psychological factors (Hadjistavropoulos & Craig, 2002; Hadjistavropoulos et al., 2011). For instance, psychosocial processes, including cultural context (Morris, 2010), social modeling (Chambers, Craig, & Bennett, 2002; Craig & Weiss, 1971), and catastrophizing (i.e., an
exaggerated negative orientation; Sullivan, Adams, & Sullivan, 2004; Sullivan, Bishop, & Pivik, 1995; Sullivan, Tripp, & Santor, 2000), are important determinants of pain. Hence, it may be suggested that ER strategies may also moderate the highly dynamic internal experience associated with painful stimuli. Moreover, painful stimuli are processed through complex parallel and serial activation of numerous regions in the brain. This complex processing is consistent with pain as a perception rather than as an exclusively sensory experience (Price, 2000; Tölle et al., 1999). Distinct dimensions of pain have been found; for instance, the affective dimension of pain is different than the sensory intensity dimension of pain (Mason et al., 2008; Wright, Asmundson, & McCreary, 2001). Consequently, this study considers both the sensory intensity and unpleasantness dimensions of pain.

**Step B: Encoding pain.** According to the model, the complex internal experience of pain would typically elicit an equally complex, multidimensional expression (Hadjistavropoulos & Craig, 2002; Hadjistavropoulos et al., 2011). Regardless of the acknowledgement of this multidimensional expression, pain is often narrowly assessed. That is, self-report measures are the most commonly relied upon indices of pain (Reading, 1989). Yet, exclusive reliance on self-report is a potential limitation, given that the association between experiencing pain and reporting pain is highly context dependent and susceptible to a variety of psychosocial influences (Anand & Craig, 1996).

Based on the communications model, the nonverbal expression of pain is the result of considerable automaticity (e.g., the reflexive withdrawal of a limb or a facial grimace) in contrast to self-report, which is largely reliant on cognitive executive
mediation (Hadjistavropoulos & Craig, 2002; Hadjistavropoulos et al., 2011). Moreover, it has been shown that nonverbal expressions can provide additional, incremental information to self-report measures (Craig, 1992; Labus, Keefe, & Jensen, 2003) and may be assessing distinct dimensions of pain (Hadjistavropoulos, LaChapelle, MacLeod, Snider, & Craig, 2000; Manne, Jacobsen, & Redd, 1992). Hence, Hadjistavropoulos et al. (2011) caution exclusive reliance on self-report measures of pain and encourage the use of a variety of pain indices, including nonverbal expressions. Therefore, based on the communications model of pain, this study included assessments of pain variables expressed both verbally and nonverbally in order to capture both the more controlled as well as the more reflexive expressions of pain.

**Step C: Decoding pain.** According to the communications model, the task of decoding a sender’s pain cues is complex given the interpersonal judgement and biases that may influence the observer’s interpretations (Hadjistavropoulos & Craig, 2002). Many factors contribute to the complexity of the sender/observer transaction (Hadjistavropoulos & Craig, 2002). For example, demographic characteristics of the sender and of the observer have both been shown to impact the observer’s interpretations of the sender’s pain experience (Hadjistavropoulos, McMurtry, & Craig, 1996; Hadjistavropoulos, Ross, & von Baeyer, 1990; Kallai, Barke, & Voss, 2004; Levine & De Simone, 1991). Moreover, nonverbal expressions may be more difficult to decode because observers may interpret them as more ambiguous and more subject to their biases (Hadjistavropoulos, Ross, & von Baeyer, 1990; Hadjistavropoulos, McMurtry, & Craig, 1996; Kallai, Barke, & Voss, 2004; Levine & De Simone, 1991). Systems that
employ explicit and objective standards of coding non-verbal responses (e.g., Facial Action Coding System; FACS; Ekman, Friesen, & Hager, 2002) are less prone to bias because they have been standardized and focus on specific pain expressions that are valid and reliable indicators of pain. Hence, the proposed study will employ both self-report and a standardized system for coding pain expression (i.e., FACS; Ekman, Friesen, & Hager, 2002) as indices of pain. Furthermore, this study also included measurement of heart rate and galvanic skin response because pain tends to be accompanied by physiological arousal (Bruehl & Chung, 2004; Hellerud & Storm, 2002; Ledowski et al., 2006; Maxiner, 1991; Olsen et al., 2013).

**Conclusion.** The overview of pain theories and models highlights the drastic shift from simplistic biomedical models to more comprehensive theories that include the complex and dynamic interaction among psychological, behavioural, and social processes in pain. The gate control theory of pain was particularly paramount because it legitimized psychological processes, including emotions and ER, as contributors to the pain experience. Since the development of the gate control theory of pain, psychosocial factors have been heavily explored as they may prevent, reduce, or exacerbate the pain experience. The communications model of pain provides the theoretical orientation for this project because it incorporates key features of the gate control theory of pain (i.e., that internal processes can influence the pain experience) and also conceptualizes pain within a highly complex psychosocial context where pain reactions rely on cognitively mediated versus automatic processing. Hence, according to the communications model of pain, multimodal assessments of pain, including both verbal and nonverbal expressions,
should be conducted to best capture the pain experience. Moreover, standardized systems should be employed in order to quantify pain expressions because of the potent impact of observer biases on the decoding nonverbal cues. One objective of this research was to contribute to the development of the communications model of pain by describing the effect of a specific internal experience (i.e., ER) on pain expressions.

**Emotions and Pain**

The organization of physiological, cognitive, motivational, behavioural, and subjective responses may be facilitated by the activation of emotions (Neese, 1990). Namely, the purpose of experiencing emotions was thought to be in response to an event with the purpose of maintaining, changing, advancing, or forestalling consequences (Fridga, 1986; Neese, 1990; Neese & Ellsworth, 2009). Therefore, emotions are most likely elicited when situations are appraised as relevant to individuals’ objectives or survival because they enhance their capacity to adapt effectively to environmental challenges (Neese, 1990; Fridga, 1986; Gross, 2007).

Like pain, emotions are whole-body experiences that involve multidimensional processes. Moreover, emotions may be expressed both verbally and behaviourally, such as facial expressions (Ekman, 1982; Ekman H., 1979; Gross, 2007; Izard, 2007). According to biopsychosocial models of pain, emotions are also considered to be potent determinants and consequences of the pain experience. Furthermore, the most established definition of pain indicates that the pain experience is an emotional one (IASP, 2012). Hence, it is clear that emotions and pain are inextricably intertwined.
The robust association between pain and emotional/affective states has been repeatedly documented (Cai & Oderda, 2012; Lumley et al., 2011; Robinson & Riley, 1999; Walker et al., 2012). For instance, sufferers of chronic pain are at an increased risk of experiencing elevated levels of anxiety (Asmundson, Jacobson, Allerdings, & Norton, 1996; Banks & Kerns, 1996; Gormsen, Rosenberg, Bach, & Jensen, 2010) compared to a healthy population. Furthermore, inducing negative affect (e.g., sadness, fear, anxiety, anger) compared to inducing a neutral or positive affect (e.g., satisfaction, relief, relaxation) has been associated with elevated self-reported pain ratings and lower pain tolerance (Rainville, Bao, & Chretien, 2005; Tang et al., 2008; van Laarhoven et al., 2012). Moreover, individuals experiencing pain often express more negative affect both verbally (Burns, 2006) and nonverbally (i.e., facial expressions; Hale & Hadjistavropoulos, 1997). Although evidence supports that emotions and pain are highly related experiences, few have explored the relationship between the over-arching mechanisms behind the expression of emotions, (i.e., ER), and pain.

**Emotion Regulation**

Individuals are not just passive participants in the emotional experience, they also have the capacity to manipulate their emotional responses (Fridga, 1986). That is they can make voluntary decisions directed at changing an emotional reaction. However, modifications to emotional experiences may also involve automatic strategies that individuals’ typically employ (Fridga, 1986). Therefore, the term regulation includes any voluntary or automatic processes leading to modification of an emotional experience (Fridga, 1986).
For emotions to be adaptive (i.e., guiding behaviour and fostering awareness; Fridga, 1986; Neese, 1990), an emotional response must be flexible (rather than stereotypical), contextual (rather than rigid), performance directed (rather than over or under arousing), and have the capacity to change quickly (rather than entrenched; Thompson, 1994). It has been speculated that ER is critical for modifying these features of the emotional reaction (Aldao, 2013; Thompson, 1994). Although the study of ER began in the area of emotional development in children, the construct has since been examined in adults (Gross, 1998b).

According to a comprehensive definition, ER is a multi-componential coordination of processes by which emotions are moderated to control emotional latency, duration, rise, magnitude, and intensity (Gross, 2007). This regulatory process facilitates an appropriate response to the dynamic demands of the environment (Aldao, 2013). Three primary tenets encompass the definitions of ER. First, ER may increase, decrease, or maintain emotional arousal. Second, as noted previously, ER may be either conscious or unconscious; therefore, it is a regulation process that includes a variety of voluntary and involuntary responses that may alter the trajectory of an emotional reaction. Finally, ER is inherently neither a positive or negative event. It is natural, partly because of cultural influences, to emphasize the enhancement of positive emotions and inhibition of negative emotions, but it must be underscored that ER encompasses regulatory processes used to dampen, enhance, or maintain positive, neutral, and negative emotions.

ER has been divided into two types of strategies (Gross, 2007): (a) antecedent-focused strategies alter the trajectory of emotion eliciting events; and (b) response-
focused strategies purposefully modify current emotional states. Reappraisal, which consists of changing tendencies and beliefs before an emotion has fully been activated, is antecedent-focused (Gross, 2007). For example, one may cognitively reinterpret a potential emotional reaction in a more desirable way. Suppression, which requires the inhibition of an ongoing emotion-expressive behaviour, is response-focused (Gross, 2007). An emphasis is placed on reducing the arousal of a current emotional state. For example, a suppression strategy is preventing any expression of an emotional reaction. Both strategies have been extensively examined and have been shown to result in discrete responses under emotion inducing contexts (Gross, 2002).

**Reappraisal and suppression.** Several differences between reappraisal and suppression use have been determined in emotion induction studies (e.g., anxiety is induced through a math task). Identifying distinct responses between these two ER strategies during emotion induction facilitated hypotheses regarding anticipated effects of these two strategies on pain variables. Additionally, the impact of ER strategies on verbal abilities and interpersonal interaction further underscores the importance of a multidimensional assessment of pain.

Indices of physiological reactivity reflect an individual's ability to adapt effectively to changing demands. Thus, physiological reactivity is strongly related to both emotional arousal (Appelhans & Luecken, 2006; Levenson, 2003) and pain (Maxiner, 1991). Distinct physiological responses have been associated with specific emotion regulation strategies (Butler et al., 2003; Denson, Grisham, & Moulds, 2011; Gross, 1998a; Harrison et al., 2006). Although the purpose of suppression is to reduce
expressive behaviours, this strategy actually elicits greater cardiovascular and
electrodermal responses (Gross & Levenson, 1993; Gross & Levenson, 1997; Gross,
1998a; Harris, 2001), compared to reappraisal, which results in a more adaptive, less
reactive, physiological response (Denson et al., 2011; Mauss, Cook, Cheng, & Gross,
2007). These results suggest that the engagement of a strategy that is intended to suppress
emotions may, invariably, have a paradoxical effect, eliciting a greater emotional
response (Wegner, 1994).

In addition, suppression has been related to impaired performance on a verbal
memory task, reduced dyadic rapport, and diminished quality of interpersonal interaction
compared to reappraisal (Butler et al., 2003; Richards & Gross, 2000). It may be
speculated that it is the impaired verbal performance that subsequently causes diminished
interpersonal interaction. Importantly, verbalizations and interpersonal interactions are
often necessary for assessing subjective experiences (e.g., pain and affect). Reduced
verbal performance related to suppression induction may, inherently, confound the results
obtained by verbal self-report. Hence, conclusions based solely on self-report measures
may be biased. Consequently, in this investigation, pain and affect were assessed through
a standardized observational coding system in addition to self-report.

Evidence that reappraisal and suppression induction alter physiological reactivity,
verbal performance, and dyadic rapport suggest that emotion regulation strategies may
also moderate the pain experience. Despite the accumulating research examining the
association between emotions and pain, few studies have explored the effects of ER on
pain. Studying the relationship between ER and pain may promote a more comprehensive
understanding of pain and affect. Ultimately, understanding pain in relation to ER may result in more effective clinical interventions for pain sufferers. Initial investigations have provided the foundation for future research to examine the relationship of ER strategies and pain in greater depth.

**Emotion Regulation and Pain**

Studies where pain variables were examined as a function of ER strategies have generally either examined the effects of experimentally inducing strategies or the effects of typical, self-reported ER tendencies (i.e., assessed through self-report measures) on indicators of pain (e.g., self-report pain intensity). The former approach involves participants being randomly assigned to experimental conditions where they then receive ER instructions explaining how to consciously apply a specific ER strategy. Subsequently, differences in pain variables (e.g., self-reported pain ratings) among the experimental conditions are examined (e.g., Burns, 2006; Elfant et al., 2008; Masedo & Esteve, 2007; Quartana, Yoon, & Burns, 2007). For instance, participants randomized to a suppression induction condition may be asked to not think about any discomfort that they may be experiencing and to remove any thoughts about their discomfort from their minds. Conversely, participants randomized to a control/nonsuppression condition may be instructed to allow their minds to wander and to think about whatever they desired. All participants would then complete a pain task (e.g., a cold pressor task). Subsequently, differences between conditions on self-report measures of pain intensity may be compared. Interestingly, pain as a function of reappraisal induction has not been explored. This is a significant limitation that this study addresses.
In the latter approach, where the effects of typical, self-reported ER tendencies on pain expressions are explored, self-report measures are used to quantify typical ER use. Specifically, measures assess the tendency to rely on specific strategies or abilities to control and recognize emotions. Pain outcomes (e.g., self-reported pain intensity ratings) are then studied in relation to participants’ responses to these questionnaires (e.g., Agar-Wilson & Jackson 2012, Hamilton et al., 2007; Ruiz-Aranda et al., 2010).

In the following section, experimental studies are reviewed that examined pain indicators as a function of ER strategies. The literature reviewed is organized by this general, methodological difference discussed earlier, where pain outcomes were examined as a function of ER induction (i.e., through experimental manipulation) or as a function of typical, self-reported tendencies (i.e., assessed through self-report measures). In two investigations, however, the interaction between typical, self-reported tendencies and experimental condition (i.e., experimental manipulation) were analyzed. Therefore, this section ends with a separate discussion of these two investigations.

**Experimentally manipulated emotion regulation.**

**Self-report measures of pain and affect.** In investigations where pain as a function of ER induction was examined, self-report measures are often the most heavily relied upon indicators of pain and, thus far, they have been the only indicators of affect. Versions of the psychometrically sound numeric rating scale (Jensen & Karoly, 2011) or visual analogue scale (Huskisson, 1983) have been typically employed to assess pain and affect. Pain has also been assessed through verbal pain ratings that separately examined
sensory aspects of pain (i.e., the physical intensity of the stimulation) and affective dimensions (i.e., the distress or suffering association with stimulation) of pain.

Immediately following a pain task, suppression induction has been found to not be related (Burns, 2006; Cioffi & Holloway, 1993; Sullivan et al., 1997), to be positively related (Elfant et al., 2008; Masedo & Rosa Esteve, 2007), and to be negatively related (Braams et al., 2012) to self-report measures of pain intensity. During a one to two minute recovery period from a pain task suppression induction has been associated with a slower recovery, indicated by consistently higher pain ratings compared to other experimental conditions (e.g., distraction, monitoring, or acceptance; Cioffi & Holloway, 1993; Masedo & Rosa Esteve, 2007). However, Burns (2006) demonstrated no significant differences in pain intensity ratings during recovery between participants in a suppression condition compared to those in other conditions (i.e., sensory focus, distraction, and control). In terms of affect, suppression induction has not been related to negative affect (Burns, 2006; Quartana, Bounds, Yoon, Goodin, & Burns, 2010) as well as positively related to negative affect (Elfant, et al., 2008, Masedo & Rosa Esteve, 2007). For instance, Masedo and Rosa Esteve (2007) found that participants in a suppression condition reported higher distress than participants in an acceptance condition, but similar levels of distress as participants in a spontaneous-coping condition. Contrary to these findings, suppression has also been related to an actual decrease in negative affect (Braams et al., 2012). Again, Braams et al. (2012) found that suppression is adaptive, indicated by a significant reduction in anxiety ratings.
These discrepancies may have been a function of methodological differences. Specifically, Braams et al. (2012), who revealed a beneficial impact of suppression use, employed a pain induction method that evokes a weaker sense of unpleasantness (i.e., electric shock; Rainville, Feine, Bushnell, & Duncan, 1992) compared to the other studies reviewed (i.e., cold pressor task). Moreover, Elfant et al. (2008), who found suppression was positively related to pain outcomes, analyzed data from a larger sample and, therefore, had increased power compared to the studies where a relationship between suppression induction and pain variables was not detected (Burns, et al., 2006; Cioffi & Holloway, 1993; Sullivan et al., 1997). Furthermore, the inconsistent findings yielded by Burns (2006), where no differences between suppression and other conditions were found, may have been a result of an additional stressful counting task (i.e., serial subtraction by seven during which the experimenter urged participants to perform well and go quickly). As previously reviewed, self-reported pain ratings may be more dependent on higher mental processes (Hadjistavropoulos, et al., 2011); thus, may be more susceptible to distortion by a counting task. Since these methodological concerns were identified, the study reported herein included a safe, valid, and reliable pain task to evoke an appropriate sense of unpleasantness and discomfort (Hoffman et al., 2004; Hoffman et al., 2006; Kumru et al., 2013; Neziri et al., 2011; Neziri, Scaramozzino et al., 2011). Moreover, a power analysis was conducted prior to recruitment to ensure that power was sufficient to detect significant differences in this study. Furthermore, unlike the study of Burns (2006), this investigation did not include an additional stressful task.
**Nonverbal expressions.** Using self-report as the primary indicator of pain is limited because the expression of pain is multimodal and includes both verbal and nonverbal reactions that may differ with respect to which they rely on cognitive executive mediation (i.e., the nonverbal expression of pain is the result of considerable reflexive automaticity whereas self-report is more reliant on cognitive processes; Hadjistavropoulos & Craig, 2002; Hadjistavropoulos et al., 2011). Moreover, pain behaviours and self-reported pain ratings may be reflecting distinct features of the pain experience (Hadjistavropoulos et al., 2000; Manne et al., 1992; Richards, Nepomuceno, Riles, & Suer, 1982). Furthermore, suppression use has been shown to have a detrimental impact on verbal expression; hence, self-report measures may be inherently biased where assessment of suppression is concerned (Butler et al., 2003; Richards & Gross, 2000). Regardless of the importance of assessing nonverbal expressions, the effects of reappraisal induction on nonverbal expressions of emotion have never been examined (e.g., facial emotional expressions). Only the impact of suppression induction on pain behaviours (i.e., bracing, rubbing, guarding, grimacing, and sighing) have been analyzed (i.e., Burns et al., 2008). Following an anger-inducing task, chronic pain patients in the suppression condition displayed more pain behaviours compared to those who were in the control condition (Burns et al., 2008). Although these results suggest that suppression induction may, ironically, increase the target behaviour that the individual is trying to decrease, the generalizability of this conclusion is limited. Burns et al. (2008) exclusively examined chronic pain patients following the completion of an anger-inducing task. As a result, their findings may not generalize to a more diverse population (i.e. acute pain...
patients or a healthy sample) or to a sample with more variable affect (i.e. positive affect).

A primary purpose of this study was to address the paucity of research that includes assessments of nonverbal expressions. The observational method implemented by Burns et al. (2008) has only been validated for the assessment of pain behaviours in sufferers of chronic low back pain (Keefe & Block, 1982). Hence, an alternative, valid protocol for the assessment of pain expression in a healthy population should be considered within this research area. Moreover, since no study has included an assessment of nonverbal emotional expressions, a novel feature of the study detailed herein was the assessment of nonverbal indicators of emotions.

Facial displays include a range of actions that contain broad information including emotions, motives, dispositions, intensions, and thoughts (Craig, 1992). As such, this study included the assessment of facial expressions coded through the Facial Action Coding System (FACS; Ekman, Friesen, & Hager, 2002). Emotional expressions were analyzed with an advanced computerized face reader, based on FACS, and capable of identifying emotional expressions in real time (Noldus Information Technologies, 2010).

The FACS (Ekman, Friesen, & Hager, 2002) was originally developed to objectively categorize human facial movements but the system has since been validated as a method of assessing pain and emotions (e.g., Craig & Patrick, 1985; Craig, Hyde, & Patrick, 1991; Craig et al., 2011; Craig, 1992; Ekman & Friesen, 1971; Ekman, 1982; Ekman, 1992; Hadjistavropoulos, Craig, Hadjistavropoulos, & Poole, 1996; Hadjistavropoulos, LaChapelle, Hadjistavropoulos, Green, & Asmundson, 2002; Hale &
Hadjistavropoulos, 1997; Larochette et al., 2006). Specifically several facial action units (AUs) have been found to be consistently related to the pain experience (e.g., inner brow raise, outer brow raise, brow lower, cheek raise, lids tighten, nose wrinkle, upper lip raise, lip pucker, lip stretch, lip press, lips part, jaw drop, mouth stretch, eyes closed, and blink; Craig, 1992; Prkachin & Craig, 1995) and emotional states (e.g., cheek raise + lip corner pull reflect happiness, and inner brow raise + brow lowerer + lip corner depressor reflect sadness; Noldus Information Technologies, 2010). Hence, facial expressions of participants were quantified through the FACS by a trained coder (in terms of specific action units) and computerised analysis identified emotional expressions in real time.

**Psychophysiological parameters.** In addition to eliciting a variety of perceptual responses, pain may also induce a complex autonomic, physiological response (Maxiner, 1991). A noxious stimulus is often accompanied by elevations in blood pressure, heart rate, and electrodermal reactivity (Bruehl & Chung, 2004; Harrison et al., 2006; Hellerud & Storm, 2002; Ledowski et al., 2006; Maxiner, 1991; Olsen et al., 2013). As such, physiological parameters including heart rate and skin conductance levels may be assessed as correlates of pain.

Suppression induction has been predictive of an increased physiological response (Coiffi & Holloway, 1993; Burns, 2006) and an attenuated physiological response (Braams et al., 2012). The inconsistent findings may be a result of differences in pain induction methods (Braams et al., 2012; Rainville et al., 1993). Based on the paucity of research and mixed findings, further investigation of psychophysiological correlates of
pain induction is necessary. As such, this study included the assessment of heart rate and galvanic skin response.

**Typical self-reported emotion regulation strategies**

It is somewhat unclear from the literature the impact of self-reported typical (i.e., without being prompted) ER strategy use and the pain experience. The self-reported tendency to rely on cognitive reappraisal appears to be beneficial to the individual. It has been associated with lower self-reported pain intensity and higher pain tolerance in most studies (Agar-Wilson & Jackson, 2012; Connelly et al., 2007; Hamilton, Zautra, & Reich, 2007; Paquet, Kergoat, & Dube, 2005; Ruiz-Aranda, Salguero, & Fernandez-Berrocal, 2010; Ruiz-Aranda, Salguero, & Fernandez-Berrocal, 2011). Yet, van Middendorp et al. (2008) found no such relationship between reappraisal and pain intensity. The literature regarding suppression is also somewhat unclear. The self-reported tendency to use suppression has been related to higher levels of self-reported pain intensity in some studies (Gilliam et al., 2010; Quartana et al., 2010), yet no relationship was found in another study (van Middendorp et al., 2008). Similar to this latter result, Uysal and Lu (2011) found no relationship between self-reported suppression use and pain tolerance or threshold. They found that the self-reported tendency to use suppression was related to higher levels of psychological distress and self-concealment (which, in turn related to lower pain tolerance), suggesting that suppression may actually be harmful to the individual (Uysal & Lu, 2011).

The mixed findings may be a function of imprecisely assessing typical, self-reported ER tendencies. For instance, instead of examining specific ER strategies (i.e.,
reappraisal or suppression), ER abilities have been inferred through the interpretation of self-reported affect in daily diaries (e.g., Connelly et al., 2007; Paquet et al., 2005), or by scales that measure the ability to control, perceive, facilitate, understand, and manage emotions (e.g., Agar-Wilson & Jackson, 2012; Ruiz Aranda et al., 2011). As such, these studies did not involve specification of the precise ER strategies that are adaptive in relation to pain. Furthermore, constructs that are not directly related to specific ER strategies (e.g., unwanted intrusive thoughts and self-distraction), have also been included in assessments of typical, self-reported tendencies (e.g., Gilliam et al., 2010).

Consequently, the ER strategy usage has not been assessed in its purest form. Moreover, assessments have lacked psychometric rigor (i.e., single item measure with no psychometric information; e.g., Quartana et al., 2010). Thus, conclusions from these investigations should be interpreted with caution.

This study included an empirically constructed and validated measure of self-reported typical ER strategy tendencies: The Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). The ERQ is a valid and reliable self-report assessment of suppression and reappraisal. Although the utility of this measure is apparent, only two studies reviewed used the ERQ (Uysal & Lu, 2011; van Middendorp et al., 2008) and only one of the studies (van Middendorp et al., 2008) included the questionnaire in its entirety (i.e., both subscales). Hence, the ERQ was employed in this investigation for the assessment of self-reported reappraisal and suppression.

**Interaction between self-reported ER tendencies and ER induction.** Although the majority of the studies reviewed examined the impact of either self-reported ER or...
experimentally induced ER on pain, the interaction between self-reported ER and ER induction may be an important area of exploration (Aldao, 2013). Specifically, typical self-reported tendencies may moderate the relationship between ER induction and pain. Understanding how self-reported ER tendencies and ER induction interact may provide a more in-depth comprehension understanding of pain and emotions. This may, in turn, have implications for treatment protocols. For instance, several researchers have encouraged the development of targeted, individualized interventions (Denison, Asenlof, Sandborgh, & Lindberg, 2007; Nicassio, Meyerowitz, & Kerns, 2004; Turner, Holtzman, & Mancl, 2007). Hence, understanding the moderating impact of patient-level characteristics before the tailoring of the intervention is essential. Specifically, it may be anticipated that differences will emerge when participants’ self-reported ER strategies match or mismatch the experimental ER induction condition.

Despite the importance of considering participants’ ER repertoire in experimental manipulation studies (Aldao, 2013), few have examined the interaction between self-reported ER tendencies and experimental induction conditions on pain indicators (e.g., Burns, Quartana, & Bruehl, 2007; Burns, Quartana, & Bruehl, 2011; Elfant et al., 2008). Only self-reported “repression” (i.e., avoidance of conscious awareness of distressing experiences and emotions; Kreitler & Kreitler, 1990; Myers & Brewin, 1996; Myers & Steed, 1999) and “anger regulation style” (i.e., anger-in style reflects the inhibition of anger expression and anger-out style reflects experiencing anger in an expressive way; Spielberger et al., 1985) have been examined in relation to ER induction and pain outcomes. Researchers classified participants as being in a “matching” interaction when
they reported using suppression-type strategies (i.e., anger-in/repressors) and were placed in the suppression induction conditions and a “mismatching” interaction when those who reported using nonsuppression-type strategies (i.e., anger-out) were placed in the suppression induction condition. Mixed findings were reported.

Participants in a matching interaction were shown to experience an elevated (i.e., repressors in the suppression condition; Elfant et al., 2008) as well as an attenuated (i.e., anger-in style in the suppression condition; Burns et al., 2007) pain response during recovery from a pain task. Conversely, participants in a mismatching interaction (i.e., anger-out style in the suppression condition) have consistently experienced the greatest cardiac reactivity, most observable grimaces and sighs during a pain task, as well as slower recovery following a pain task (Burns et al., 2007; Burns et al., 2011). The discrepant results may have been a function of the different self-reported suppression-type strategies that were assessed (i.e., self-reported anger regulation and self-reported repression).

Although results were inconsistent, findings demonstrate that self-reported tendencies can moderate the relationship between pain indices and ER induction condition. Thus, the inclusion of an assessment of self-reported tendencies may provide a more thorough description of the relationship between ER and pain. No study has examined the interaction between the typical, self-reported tendency to use suppression and reappraisal and suppression and reappraisal induction. Through planned statistical regressions, this study involved an examination of pain as a function of the interaction between ER induction condition and self-reported ER strategy.
Conclusion. It is clear that debate surrounds the impact of ER strategies on pain. For instance, suppression induction has been positively related (Elfant et al., 2008), inversely related (Braams et al., 2012), and not related (Burns, 2006; Cioffi & Holloway, 1993; Sullivan et al., 1997) to self-reported pain levels. Regardless, the studies reviewed have provided a foundation for the development of future research to facilitate a clearer comprehension of the relationship between ER and pain. Understanding the relationship between ER and pain may be beneficial because results may facilitate a more comprehensive understanding of the complex experience of pain. Moreover, in a broader sense, results may also enhance clinical understanding of the impact of ER strategies on pain, and thus prompt revisions of current practices for treating pain.

Purpose and Hypotheses

This project closely followed the protocols from the studies conducted by Coiffie and Halloway (1993) and by Burns, Elfant, and Quartana (2010) and Elfant et al. (2008; two articles were published from the same study). Participants from these studies were first randomized to a distraction, suppression, or monitoring condition (Coiffie & Holloway, 1993) or to a suppression or nonsuppression condition (Burns, Elfant, & Quartana, 2010; Elfant et al., 2008) and then completed a pain task. Subsequently, a brief recovery period was assessed. Self-reported pain intensity was assessed in both studies and physiological indicators (e.g., heart rate and skin conductance level) were assessed in the study conducted by Coiffie and Halloway (1993). Although results and the methodological procedures from these studies provide the framework for this investigation, they are somewhat limited. A reappraisal induction condition was not
included and the assessment of self-reported ER tendencies and nonverbal expressions was not conducted. The design of this study overcomes these limitations.

The purpose of this investigation was threefold. The first goal was to examine the effects of three ER strategy induction conditions: (1) suppression, (2) reappraisal, and (3) monitoring-control on self-reported pain intensity, pain unpleasantness, anxiety, and tension, as well as nonverbal facial expressions (general, pain-related, as well as happiness, sadness, anger, surprise, fear, and disgust, and neutral states), and physiological reactivity (heart rate and galvanic skin response) during a pain inducing task (i.e., through the advanced thermal stimulator) and during recovery. Since no ER and pain study has included a reappraisal condition, following reappraisal induction protocols from emotion induction studies (e.g., Butler, et al., 2003, Richards & Gross, 2000), reappraisal was included as an experimental condition in this study. The second purpose was to examine the impact of self-reported reappraisal and suppression use on pain threshold and tolerance. Based on the paucity of research, the final goal was to conduct an exploratory analysis examining the moderating effects of self-reported reappraisal and suppression tendencies on ER experimental condition assignment and self-reported pain intensity, pain unpleasantness, anxiety, and tension, as well as nonverbal facial expressions (general, pain-related as well as happiness, sadness, anger, surprise, fear, and disgust, and neutral states), and physiological reactivity (heart rate and galvanic skin response) during a pain inducing task (i.e., through the advanced thermal stimulator) and during recovery.

Based on previous research, two primary hypotheses were proposed:
I. It was hypothesized that an interaction between condition and time (i.e., baseline, pain task, recovery) on pain indicators would be identified. Specifically, it was expected that participants in the suppression condition would report greater pain intensity, pain unpleasantness, anxiety, and tension ratings, as well as display more nonverbal general and pain-related expressiveness and heightened physiological reactivity during the pain task and throughout the subsequent recovery than those in the reappraisal or monitoring conditions. Conversely, it was hypothesized that participants in the reappraisal condition would report lower pain intensity, unpleasantness, anxiety, and tension ratings, as well as display lower nonverbal general and pain-related expressiveness and decreased physiological reactivity during the pain task and throughout the subsequent recovery period than those in the suppression or monitoring conditions. Since no study has examined the impact of ER strategies on nonverbal emotional expressions during a pain task, no hypotheses were generated regarding the effects of condition on emotional facial expressions (i.e., neutral, happiness, sadness, fear, surprise, anger, and disgust).

II. It was hypothesized that self-reported ER strategies (quantified by the ERQ) would be related with pain threshold and pain tolerance. Specifically, it was expected that Suppression subscale scores would be inversely related to pain threshold and tolerance and that Reappraisal subscale scores would be positively related with pain threshold and tolerance.
Method

Participants

This study was approved by the University of Regina Research Ethics Board (see Appendix A). Recruitment was conducted by advertising the study on the University of Regina’s Department of Psychology Sona System (Sona Systems, 1997) as well as through advertisements posted at the University of Regina (see Appendix B) and announcements during university classes.

The Sona System (Sona Systems, 1997) allows studies to be advertised and to indicate time slots that are available to those who are interested in participating. Students at the University of Regina are eligible to create accounts within the system and sign up for advertised times slots to participate in studies. The exclusion criteria (see below) were clearly stated on the description of the study and students were explicitly asked not to sign up if they met one of the criteria. Once participants signed-up for the study, a reminder email was sent to confirm the exclusion criteria (see below) and to remind them to not ingest caffeine and alcohol at least three hours before their scheduled time (see Appendix C for the email template). Consistent with the Psychology Department Pool of Research Participants regulations, participants received course credit for their participation.

A power calculation suggested that a sample of 160 participants was required (Erdfelder, Faul, & Buchner, 1996). This power calculation assumed a 1-beta of .80 and an alpha level (α) of .05. Given that several analyses were conducted, power calculations were completed for each analysis. The analysis requiring the greatest number of participants (i.e., the multivariate analysis of variance examining group differences on
facial expression over time) was used to determine the required number of participants. Recruitment was discontinued after reaching a sample size of 151 participants because hypothesized relationships reached statistical significance.

Of the total 151 participants recruited, one participant declined to participate in the study, technical problems occurred with one participant (i.e., a power outage), and seven participants discontinued the 10-trial thermal stimulation task. Hence, the final sample included 142 participants. Of this total final sample, 68% were female. The average age was 20.78 ($SD = 3.20$), with an average of 2.27 ($SD = 1.38$) years of university education.

Consistent with previous studies examining pain outcomes as a function of ER strategy application (e.g., Burns, 2006; Burns, Elfant, & Quartana, 2010; Quartana et al., 2010; Sullivan et al., 1997) exclusion criteria included: (a) any current cardiovascular disorder or use of medications that affect cardiovascular function (e.g., beta blockers) because of their effects on heart rate and blood pressure, therefore, impact on psychophysiological measures (Burger, Kamalesh, Kumar, & Nesto, 1996; Sandrone et al., 1994); (b) current use of any analgesic medication because medications effectively reduce pain during a variety of different pain experiences (Caraceni et al., 2012; Chappell et al., 2009; Comer et al., 2010; Ong, Seymour, Lirk, & Merry, 2010); (c) chronic pain in the last year defined as daily pain for three or more months because sufferers of chronic pain have shown a heightened response to experimentally induced pain (Burns, 2006); and (d) skin sensitivities. Caffeine and alcohol were also restricted; participants were asked to not ingest caffeine or alcohol for at least three hours before the experiment because of the altering physiological impact of caffeine (Koenig et al., 2013) and the
analgesic effects of alcohol (Kim et al., 2013; Maxwell, Gowers, Moore, & Wilson, 2010). Participants completed a self-report questionnaire (see Appendix D) that confirmed they did not meet any of the exclusion criteria.

**Equipment**

**Psychophysiological assessment.** Since noxious stimulation typically results in elevations in blood pressure, heart rate, cardiac output (Bruehl & Chung, 2004; Maxiner, 1991; Olsen et al., 2013), and electrodermal reactivity (Harrison et al., 2006; Hellerud & Storm, 2002; Ledowski et al., 2006), heart rate and galvanic skin response (i.e., indices of physiological arousal), were recorded throughout the experiment. These physiological responses were assessed by the wireless monitoring BioPac, Systems, Inc (2010).

Measures of heart rate were obtained from three electrodes on participants’ chest, two under the collar bones and one on the left upper rib and were recorded in beats per minute (bpm). Measures of galvanic skin response were derived from electrodes placed on the index finder and thenar eminence of the left hand and were recorded in micro siemens (μS). Each physiological indicator was recorded every 20 seconds and three averaged scores were calculated for the (1) baseline resting period, (2) the pain task, and (3) the recovery period.

**Advanced thermal stimulator.** Thermal pain was induced by the Medoc Pathway Pain and Sensory Evaluation System, advanced thermal stimulator model (Medoc Advanced Medical Systems Ltd, Ramat Yishay, Israel). The system allows for programmable control of cold and heat stimuli through the Advanced Thermal Stimulator thermode. Temperatures between 0°C and 55°C at a rate up to 8°C per second can be precisely produced. The thermode has an approximate 30mm X 30mm square surface.
contact with the skin and was placed on the participant’s upper inside forearm. Thermal stimulation is easily administered (Edens & Gil, 1995) and has been shown to be a safe, valid, and reliable method of pain induction (Hoffman et al., 2004; Hoffman et al., 2006; Kumru et al., 2013; Neziri et al., 2011; Neziri, Scaramozzino et al., 2011). Advantages of the thermal pain stimulator include precise control of stimulus intensity and convenience/hygiene.

Participants completed three tasks with the thermal stimulator. In the first two tasks (i.e., the pain threshold and tolerance tasks), participants were given a manual trigger and informed to terminate the painful stimulus by pressing the trigger button. In the third task, participants were instructed that they could verbally abort the task at any time.

**FaceReader.** Facial expressions related to basic emotions were measured by the computer software program FaceReader (Noldus Information Technologies, 2010). The program is an advanced automated system that objectively assesses videos frame-by-frame through algorithms synthesized from a data base of prototypical emotional-related facial movements. Through a three step process, the system quantifies six basic emotional expressions (i.e., happiness, sadness, anger, surprise, fear, and disgust) as well as neutral states. First, the program identifies the participant’s face. Subsequently, using active appearance modelling, the face is reconstructed using key points in the face and by projecting variability between these points from a large database of annotated images. Finally, facial expressions are then classified based on an automated system that was trained to recognize the six basic emotions and neutral states (Ekman, Friesen, & Hager,
2002). The program has the capacity to account for age, ethnicity, gender, amount of hair, presence of facial hair, and glasses.

FaceReader is a commonly used tool for the assessment of facial expressions in a variety of populations (e.g., Chentsova-Dutton & Tsai, 2010; Choliz & Fernandez-Abascal, 2012; Sideridis, Kaplan, Papadopoulos, & Anastasiadis, 2014). It has been found to have excellent reliability and validity (e.g., Cohen, Morrison, & Callaway, 2013; Den Uyl & Van Kuilenburg, 2008; Noldus Information Technology, 2008; Sideridis et al., 2014; Sideridis et al., 2014). For instance, den Uyl and van Kuilenberg (2005) found that the system identified emotions to an average accuracy of 89%. Furthermore, Cohen, Morrison, and Callaway (2013) supported the construct validity of the software by demonstrating the computerized facial analysis outcomes were significantly related to expected clinical self-report measures.

**Measures**

**Demographic questionnaire.** A brief questionnaire was used to collect demographic information and to ensure that all participants met the eligibility requirements (see Appendix D).

**Emotion regulation questionnaire (ERQ).** The Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) was used to assess participants’ self-reported typical tendencies to engage in suppression and reappraisal (see Appendix E). The ERQ is a psychometrically validated tool that is composed of ten items measured on a 7-point Likert scale (1 = *strongly disagree*; 7 = *strongly agree*). Six items comprise the Reappraisal subscale and four items comprise the Suppression subscale. Subscale scores are calculated by averaging the corresponding items. Higher scores suggest a greater
tendency to use the strategy measured by the subscale. Such a two factor solution has demonstrated robust fit (confidence fit index = .96, 90% confidence interval) in a large sample ($n = 1,188$) and was supported in all demographic groups examined (e.g., European, African American, Asian American, Native American, Latino, and Pacific Islanders; Melka, Lancaster, Bryant, & Rodriguez, 2011).

Minimal between-factors correlation found in this sample ($r = -.141$) and in other populations ($r = .02$; Melka et al., 2011) suggests two independent factors. Adequate internal reliability for the Reappraisal ($\alpha = .792$) and Suppression ($\alpha = .782$) subscales was found in this sample, similar to reliability found by others (Suppression subscale $\alpha = .73$ to .77; Reappraisal subscale $\alpha = .79$ to .88; Lam, Dickerson, Zoccola, & Zaldivar, 2009; Melka et al., 2011). The reliability and validity of the instrument has been supported in several studies (Ehring, Tuschen-Caffier, Jewgenija, Fischer, & Gross, 2010; Lam et al., 2009; Melka et al., 2011).

The descriptor differential scales (DDS). The DDS are two scales that assess the sensory intensity and unpleasantness dimensions of pain (Gracely, Dubner, & McGrath, 1979). Each scale consists of 13 descriptors that are presented in two vertical columns (see Appendix F). Participants were asked to pick one word or one word pair from each column three times during the experiment: (1) before randomization, (2) immediately following the pain task reflecting back to the most intense period during the longer thermal stimulator task, and (3) at the completion of the recovery period reflecting back to the most intense period during the longer thermal stimulator task.

The scales are thought to be objective indices of dimensions of pain because of the high agreement between individuals and the values they associate with each
descriptor (Gracely, McGrath, & Dubner, 1978a) Furthermore, the DDS have shown to be valid as they are sensitive to small changes in pain intensity (Doctor, Slater, & Atkinson, 1995) and are highly related with other self-report measures of pain (e.g., visual analog pain scales; Doctor, Slater, & Atkinson, 1995). The ability to distinguish between the sensory intensity and unpleasant dimensions of pain has also been demonstrated (Atkinson et al., 1998; Gracely, McGrath, & Dubner, 1978b). Specifically, notriptyline (i.e., a tricyclic antidepressant), which is used in the treatment of chronic pain, reduced the sensory intensity scale but not the unpleasantness scale in chronic back pain patients during an 8-week trial (Atkins et al., 1998). Conversely, diazepam (i.e., a benzodiazepine), which is used in the treatment of anxiety disorders and does not alter sensory sensitivity (Chapman & Feather, 1973), reduced the unpleasantness scale and not the sensory intensity scale of the DDS in healthy controls during exposure to a noxious stimulus (Gracely, McGrath, & Dubner, 1978b). Finally, the reliability of the DDS is acceptable for both the sensory intensity ($r = .96$) and unpleasantness ($r = .89$) subscales (Gracely, McGrath, & Dubner, 1978a).

**Self-reported emotion visual analogue scales (VASs).** VASs are widely used self-report measures of subjective experiences (see Appendix G; Folstein & Luria, 1973; Wewers & Lowe, 1990). In this study, VASs were used to assess anxiety and tension. Modelled by previous research (e.g., Braams, Blechert, Boden, & Gross, 2012; Burns, 2006; Elfant, Burns, & Zeichener, 2008; Quartana, Yoon, & Burns, 2007), a 6-point Likert-type format was used ($0 = not at all, 5 = extremely$). Participants were instructed to complete the emotion VASs three times during the experiment: (1) before randomization, (2) immediately following the pain task reflecting back to the most intense period during
the longer thermal stimulator task, and (3) at the completion of the recovery period reflecting back to the most intense period during the longer thermal stimulator task.

VASs have been demonstrated to be valid and reliable methods of assessing subjective experiences (Cella & Perry, 1986). Specifically, test-retest reliability of VASs ranges from .61 to .73 (Folstein & Luria, 1973; Wewers & Lowe, 1990) and VASs’ scores have been shown to be highly related to more comprehensive batteries of emotions/affective states (Wewers & Lowe, 1990), such as anxiety (Kindler, Harms, Amsler, Ihde-Scholl, & Scheidegger, 2000).

**Manipulation check questionnaire.** Similar to other studies, a brief manipulation check questionnaire was developed in order to test the validity of the suppression and reappraisal induction conditions (see Appendix H; Braams et al., 2012; Denson, Grisham, & Moulds, 2011; Gilliam et al., 2010). The 12-item questionnaire (see Appendix H) was composed of two subscales. Six items reflected the extent the participant engaged in reappraisal and six items reflect the extent the participant engaged in suppression. Each question was rated on a 5-point Likert scale where 1 = *not at all* and 5 = *a lot*. This questionnaire style manipulation check has been validated by previous experimentally induced ER strategies studies (e.g., Braams et al., 2012; Denson et al., 2011; Gilliam et al., 2010).

**Operationalization of Pain Threshold, Tolerance, and Nonverbal Expressions**

**Pain threshold.** The first trial of pain induction determined participants’ pain threshold. The thermode was placed on the left forearm and was heated to a baseline temperature of 32°C. Participants were provided with verbal instructions (see Appendix I). The thermode was then heated 1°C every second to a maximum temperature of 50°C.
and would only be held at that temperature for a maximum of five seconds. The temperature (in degrees °C) at which participants pressed the manual trigger (capable of terminating the heat stimulus) was recorded as the pain threshold. Studies employing the advanced thermal stimulators have used a similar design and demonstrate a high degree of accuracy and replicability (e.g., Blankenburg et al., 2010; Hohmeister, Demirakca, Zohsel, Flor, & Hermann, 2009; Huang, Wang, & Lin, 2010; Lin, Hsieh, Chao, Chang, & Hsieh, 2005; Meier, Berde, DiCanzio, Zurakowski, & Sethna, 2001).

**Pain tolerance.** The second trial of pain induction determined participants’ pain tolerance. The thermode was on the left forearm and was heated to a baseline temperature of 32°C. Participants were provided with verbal instructions (see Appendix J). The thermode was then heated 1°C every second to a maximum temperature of 50°C where it would be held for a maximum of five seconds. The temperature (i.e., in degrees °C) at which participants pressed the manual trigger was recorded as pain tolerance. Studies employing the advanced thermal stimulators have used a similar design and established a high degree of accuracy and replicability for this procedure (e.g., Fillingim, King, Ribeiro-Dasilva, Rahim-Williams, & Riley, 2009; Thibodeau, Welch, Katz, & Asmundson, 2013).

**Facial Action Coding System** (FACS; Ekman, Friesen, & Hager, 2002). Facial reactions in response to painful stimulation were assessed using the FACS. These facial expressions were recorded using video cameras during the baseline period, the pain induction task, and the recovery period. Using established criteria, a qualified FACS coder (i.e., who passed an examination administered by the developers of the system; Ekman, Friesen, & Hager, 2002) identified the intensity, frequency, and duration of 41
discrete facial actions units (AUs). Several investigations have demonstrated that the FACS is highly reliable (e.g., Hadjistavropoulos et al., 2000; Kunz, Mylius, Schepelmann, & Lautenbacher, 2008).

Empirical evidence has confirmed content, construct, and criterion validity of the facial expression assessment of pain (Craig et al., 2011). For instance, genuine facial displays of pain are distinguishable from facial displays in response to non-noxious events (Hale & Hadjistavropoulos, 1997) and faked pain facial displays (Hill & Craig, 2002). Adequate interrater reliability has also been found ($r = .71-.79-95$; Craig & Patrick, 1985; Craig et al., 1991; Larochette et al., 2006). Several AUs that have been consistently related to the pain experience, include AU1 (inner brow raise), AU2 (outer brow raise), AU4 (brow lower), AU6 (cheek raise), AU7 (lids tighten), AU9 (nose wrinkle), AU10 (upper lip raise), AU12 (lip pucker), AU14 (dimpler), AU17 (chin raiser), AU20 (lip stretch), AU24 (lip press), AU25 (lips part), AU26 (jaw drop), AU27 (mouth stretch), AU43 (eyes closed), and AU45 (blink; Hadjistavropoulos & Craig, 2002; Kunz, Chatelle, Lautenbacher, & Rainville, 2008; Prkachin, 1992; Prkachin, 2005).

Given the extremely time consuming nature of FACS coding and consistent with previous research (e.g., Hadjistavropoulos et al., 1996; Hale & Hadjistavropoulos, 1997), only segments of each video were FACS coded. Specifically, an 8-second video segment was coded for each of three time points: (1) the final 8-seconds of baseline; (2) the most expressive 8-seconds of the first peak of stimulation during the 10-trial pain task; and (3) the first 8-seconds of recovery. A trained FACS coder (who completed the self-study program and passed the examination developed by the developers of the system), blind to the participants’ ER induction condition and time period of video segment, completed
FACS coding for each video segment. All coding took place using slow-action (frame-by-frame) video. A total frequency and average intensity FACS score was calculated for all AUs and separately for pain-related AUs. Following the protocol of previous studies that have employed FACS to examine pain expression (Kunz et al., 2008; Kunz, Mylius et al., 2008; Kunz, Mylius, Schepelmann, & Lautenbacher, 2009), pain-related AUs, specific to this study, were examined separately. Specifically, based on literature precedence (Kunz et al., 2008; Kunz, Mylius et al., 2008; Kunz et al., 2009), pain-related AUs were considered to be those that occurred in at least 7 pain segments (i.e., 5% of 142).

Intrarater reliability in this study was evaluated based on a random sampling of 20% of the video segments. Intrarater reliability involves the trained FACS coder recoding a random sampling of segments (without access to original coding; Gwet, 2008). Based on Ekman, Friesen, and Hager’s (2002) recommendation, percent agreement for frequency (between the first and second time that the segments were coded) was calculated by the following formula: Percent Agreement = (2 x Number of Agreements)/Total Number of Items Scores. The intrarater reliability of intensity was determined by correlating intensity scores for each AU. In this study, the percent agreement was .92 and the average correlation for the AUs was .91.

Procedure

Participants were asked to come to the Health Psychology Laboratory to participate in the study. Upon arrival, informed consent was obtained. This process included a brief description of the study’s procedures, the thermal stimulator, and risks and benefits of participating in the study. Consenting participants were then asked to
complete the demographic questionnaire and the ERQ. Following the completion of these measures, the heart rate electrodes and leads where then attached. This was conducted at this time in order to allow the participants sufficient time and privacy to attach these leads so that the rest of the study could be conducted in a controlled time frame (i.e., participants ranged in the amount of time that they attached the leads from around 3 to 10 minutes). Subsequently, the thermode was attached and participants completed the pain threshold and pain tolerance tasks (see Appendices I and J for the verbal instructions provided to participants). Following these two tasks, the thermode was removed from participants’ arm and the electrodes for the galvanic skin response were placed on participants’ left index finger and thenar eminence and the leads were attached. Video recording camera was also set up at this point. Participants were then provided with a brief explanation of the DDS and the emotion VASs and it was explained that they would be prompted three times during the study to complete these measures. Participants then completed a ten minute resting period (baseline), where psychophysiological measures and facial expression were recorded during the final 425 seconds.

Upon completion of the baseline rest period, participants were prompted to complete the DDS and the emotion VASs. Subsequently, the thermode was placed inside participants’ right forearm. Consistent with previous research (e.g., Burns, 2006; Burns et al., 2008; Burns, Quartana, & Bruehl, 2011; Butler et al., 2003; Cioffi & Holloway, 1993; Elfant et al., 2008), 142 participants were randomly assigned to a either a suppression (n = 53), reappraisal (n = 48), or monitoring (n = 41) condition and then read a script that provided instructions corresponding to their condition placement (refer to Appendix K for the instructions that were provided to each condition). As underscored (Aldao, 2013),
instructions for each condition included: (a) direct language pertaining in subjective, behavioural, and physiological domains; (b) specific examples of how to apply the strategy; and (c) specific instructions against the use of other strategies. Following provision of the instructions, all participants were provided with the opportunity to ask questions regarding the instructions. They were also explicitly asked if they understood the instructions. Subsequently, participants completed the third thermal stimulator task that involved the thermode heating from 32°C to 47°C at a rate of 0.7 °C/second. Once the thermode reached 47°C, the temperature was held constant for five seconds then returned to 32°C at a rate of 7°C/second. The 32°C temperature was held for five seconds before the trial would start again. Participants completed ten trials of this task, lasting approximately 425 seconds in total.

Following the pain task, the thermode was removed and participants were prompted to complete the DDS and the emotion VASs representing how they felt during the most painful or intense period of the longer thermal stimulator task that they had just completed. Following the completion of the measures, they were instructed to turn to the final page of the questionnaire package (i.e., where they could not see their previous responses), continue engaging in the emotion regulation strategy, and look into the camera for the final resting period. At the end of the 425 second recovery period, participants were asked to complete the DDS and the emotion VASs again reflecting how they felt during the most painful or intense period of the longer thermal stimulator task they completed. After completing the questionnaire, participants were told that they had completed the experimental portion of the study and that they could stop engaging in the ER strategy. The physiological monitoring equipment was then disconnected and
participants filled out the manipulation check questionnaire. At the end of the study, all participants were debriefed.

**Statistical Analysis**

All analyses were conducted with Statistical Package for Social Sciences, version 18 (SPSS, 2009). In order to identify the pain-related AUs for this study, AU frequencies were calculated for all pain video segments. Only the AUs that occurred in at least 7 pain segments (i.e., 5% of 142) were considered pain-related. Once the pain-related AUs were identified, four FACS scores were calculated:

1. An average intensity score was the average of the intensity scores of all AUs.
2. A total frequency score was the sum of the frequencies of all AUs.
3. A pain-related frequency score was the sum of the frequencies of pain-related AUs.
4. An average pain-related intensity score was the average intensity score found on all pain-related AUs.

As per previous protocols (e.g., Braams et al., 2012; Denson et al., 2011; Gilliam et al., 2010), the success of the experimental manipulation was determined by conducting one-way ANOVAs (comparing the three experimental conditions) and follow up planned comparisons of the sum of the reappraisal items and sum of the suppression items. If the experimental manipulation was successful, participants in the reappraisal condition would score significantly higher on the sum of the reappraisal items compared to participants in the other two conditions and participants in the suppression condition would score significantly higher on the sum of the suppression items compared to participants in the other two conditions. Finally, participants in the monitoring condition would score
significantly lower than participants in the other two conditions on both the sum scores of the suppression items and the sum scores of the reappraisal items. Demographic differences across conditions (i.e., suppression, reappraisal, and monitoring) with respect to age and level of education were tested using one-way ANOVAs and sex differences across conditions were tested using chi-square.

To test hypothesis I, concerning the effects of condition placement and time on self-reported pain ratings (i.e., DDS subscales), self-report affect ratings (i.e., anxiety and tension VASs), psychophysiological indicators (i.e., heart rate and galvanic skin response), facial expressions (i.e., neutral, happiness, sadness, fear, surprise, anger, and disgust), total facial activity (i.e., frequency and intensity of all AUs), and pain-related facial activity (frequency and intensity of pain-related AUs), a series of 3 (conditions) x 3 (baseline, pain task, recovery period) multivariate analyses of variance (MANOVA) were conducted. Multivariate significance was followed by ANOVAs. In all models, the within-subjects factor was pain task (i.e., baseline, during pain induction, and recovery) and the between-subjects factor was experimental condition (i.e., suppression, reappraisal, and monitoring). Mauchly’s tests were conducted in order to test the assumption of sphericity. In instances where the assumption of sphericity was violated, degrees of freedom were corrected. When estimates of sphericity were greater than 0.75, Huynh-Feldt correction was used, and when estimates were less than 0.75, Greenhouse-Geisser correction was used (Field, 2009). Significant univariate effects were followed-up with pairwise comparisons of mean differences (MD), where the multiple comparisons were adjusted by using Bonferroni’s correction (Tabachnick & Fidell, 2007). Given the
high number of ANOVAs, a conservative alpha level of .01 was adopted to minimize the probability of Type 1 error.

To test hypothesis II, concerning the effects of self-reported ER strategies on pain threshold and tolerance, multiple linear regression analyses were conducted. The independent variables included in the models were the ERQ Reappraisal and Suppression subscale scores, sex, and age. Dependent variables were participants’ pain threshold and pain tolerance (in degree Celsius, °C). If the model accounted for significant variance, each variable’s unique contribution to the model was tested after all other variables were entered into the equation.

To examine if self-reported ER strategies (ERQ scores) interact with condition placement on pain indicators, multiple regression procedures were used. Participants from the monitoring condition were not included in the regressions because the purpose was to explore whether there was an interaction between experimentally eliciting one’s typically used ER strategies vs. non typical strategies. In order to examine the interaction, the categorical variable condition was coded, where -1 was arbitrarily designated to participants who were in the suppression condition and +1 was arbitrarily designated to participants in the reappraisal condition (West, Aiken, & Krull, 1996). Self-reported typical ER tendencies were then derived from participants’ ERQ Reappraisal and Suppression subscale scores. Then, two interaction terms were calculated: (1) ERQ Reappraisal subscale score multiplied by the coded condition variable (i.e., -1 or +1); and (2) ERQ Suppression subscale score multiplied by the coded condition variable (i.e., -1 or +1).
The two interaction terms, ERQ Reappraisal and Suppression subscale scores, sex, and age were entered as predictor variables. Dependent variables included self-reported pain ratings (i.e., DDS subscales), self-report affect ratings (i.e., anxiety and tension VASs), psychophysiological indicators (i.e., heart rate and galvanic skin response), facial expressions (i.e., neutral, happiness, sadness, fear, surprise, anger, and disgust), total facial activity (i.e., frequency and intensity of all AUs), and pain-related facial activity (frequency and intensity of pain-related AUs). Given the high number of regressions, a conservative alpha level of .01 was adopted to minimize the probability of Type 1 error. A conservative approach to the regression was used. That is, if the full model was significant, each variable’s unique contribution to the regression was evaluated after all other variables were entered into the equation.
Results

Table 1
Demographic Information by Experimental Condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Main Effect</th>
<th>Sex</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td># (%)</td>
<td># (%)</td>
<td></td>
</tr>
<tr>
<td>Suppression</td>
<td></td>
<td>32 (60.45)</td>
<td>22 (41.5)</td>
<td></td>
</tr>
<tr>
<td>Reappraisal</td>
<td></td>
<td>12 (34.4)</td>
<td>24 (62.5)</td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td></td>
<td>14 (29.3)</td>
<td>18 (39.6)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># (%)</th>
<th># (%)</th>
<th># (%)</th>
<th>(\chi^2(2))</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 (60.45)</td>
<td>12 (28.9)</td>
<td>14 (29.3)</td>
<td>.390</td>
<td>.680</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(M (SD))</th>
<th>(M (SD))</th>
<th>(M (SD))</th>
<th>(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>20.89</td>
<td>20.98</td>
<td>20.41</td>
</tr>
<tr>
<td></td>
<td>(3.65)</td>
<td>(3.45)</td>
<td>(2.14)</td>
</tr>
<tr>
<td>Education(^1)</td>
<td>2.13 (1.33)</td>
<td>2.46 (1.46)</td>
<td>2.22 (1.35)</td>
</tr>
</tbody>
</table>

\(^1\)Years of university
Demographics

One-way ANOVAs were conducted to evaluate possible demographic differences across conditions with respect to age and years of university education. A chi-square test was conducted to test for differences in the number of male and female participants across conditions. As shown in Table 1, no significant differences were found.

Manipulation check

A 12-item questionnaire, six items relating to reappraisal and six items relating to suppression, was examined in order to test the success of the experimental manipulation. First, item-total correlations were calculated and are shown in Table 2. Since item 6 (i.e., “how often did your mind wander from trying to re-evaluate your thoughts”) and item 12 (i.e., “how often did your mind wander from trying to suppress your thoughts”) had an item-total correlation with their corresponding subscales that was less than .20, as per psychometric guidelines (Allen & Yen, 1979), they were not included in analyses. Therefore, the two 5-item subscales were included in analyses that tested the success of the experimental manipulation (see Table 2 for subscale means and standard deviations). Both scales demonstrated adequate internal consistency (Reappraisal subscale $\alpha = .80$; Suppression subscale $\alpha = .84$).

Results supported the success of the manipulation. Specifically, one-way ANOVAs showed significant differences among conditions on the Reappraisal subscale, $F(2,139) = 6.82$, $p = .001$, and the Suppression subscale, $F(2,139) = 19.44$, $p < .001$. Follow up planned comparisons demonstrated that participants assigned to the reappraisal condition scored significantly higher on the Reappraisal subscale, compared to participants in the other two conditions, $t(139) = 3.28$, $p = .001$. Participants assigned to
the suppression condition scored significantly higher on the Suppression subscale compared to participants in the other two conditions, $t(139) = 4.40, p < .001$. Participants in the monitoring condition scored significantly lower on both the Reappraisal subscale, $t(139) = -3.21, p = .002$, and Suppression subscale, $t(139) = -6.04, p < .001$, compared to participants in the other two conditions. These findings supported the success of the experimental manipulation.
Table 2

Manipulation Check Questionnaire: Item and Subscale Means and Standard Deviations and Item-Total Correlations

<table>
<thead>
<tr>
<th>Items</th>
<th>Suppression M (SD)</th>
<th>Reappraisal M (SD)</th>
<th>Monitoring M (SD)</th>
<th>Item Total r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I tried to re-evaluate any thoughts about discomfort</td>
<td>3.51 (1.27)</td>
<td>4.04 (.87)</td>
<td>3.49 (1.23)</td>
<td>.856</td>
</tr>
<tr>
<td>2. I tried to reappraise my thoughts about discomfort</td>
<td>3.38 (1.23)</td>
<td>4.00 (.92)</td>
<td>3.15 (1.15)</td>
<td>.811</td>
</tr>
<tr>
<td>3. I tried to think in a way that kept me calm</td>
<td>4.36 (.93)</td>
<td>4.52 (.83)</td>
<td>3.93 (1.10)</td>
<td>.604</td>
</tr>
<tr>
<td>4. How hard did you try to re-evaluate your thoughts</td>
<td>3.72 (1.18)</td>
<td>3.92 (1.03)</td>
<td>3.29 (1.12)</td>
<td>.796</td>
</tr>
<tr>
<td>5. How successful were you at re-evaluating your thoughts</td>
<td>3.83 (1.14)</td>
<td>3.81 (.816)</td>
<td>3.34 (1.13)</td>
<td>.509</td>
</tr>
<tr>
<td>6. How often did your mind wander from trying to re-evaluate your thoughts</td>
<td>3.00 (.99)</td>
<td>3.29 (.94)</td>
<td>3.46 (1.13)</td>
<td>.102</td>
</tr>
<tr>
<td>Sum of Reappraisal Items (Items 1-6)</td>
<td>21.74 (4.02)</td>
<td>23.85 (2.98)</td>
<td>20.66 (4.67)</td>
<td></td>
</tr>
<tr>
<td>7. I tried to suppress my thoughts about discomfort</td>
<td>3.94 (1.06)</td>
<td>3.92 (.90)</td>
<td>2.98 (1.44)</td>
<td>.558</td>
</tr>
<tr>
<td>8. I tried to ignore my thoughts about discomfort</td>
<td>4.15 (1.08)</td>
<td>3.73 (.98)</td>
<td>2.80 (1.42)</td>
<td>.342</td>
</tr>
<tr>
<td>9. I tried to not pay attention my thoughts about discomfort</td>
<td>4.23 (1.03)</td>
<td>3.69 (1.04)</td>
<td>2.95 (1.26)</td>
<td>.339</td>
</tr>
<tr>
<td>10. How hard did you try to suppress your thoughts</td>
<td>3.74 (1.16)</td>
<td>3.67 (.95)</td>
<td>2.93 (1.17)</td>
<td>.576</td>
</tr>
<tr>
<td>11. How successful were you at suppressing your thoughts</td>
<td>3.72 (1.01)</td>
<td>3.65 (.86)</td>
<td>2.95 (1.09)</td>
<td>.310</td>
</tr>
<tr>
<td>12. How often did your mind wander from trying to suppress your thoughts</td>
<td>3.19 (1.08)</td>
<td>3.33 (.95)</td>
<td>3.20 (1.23)</td>
<td>.096</td>
</tr>
<tr>
<td>Sum of Suppression Items (Items 7-12)</td>
<td>22.96 (4.11)</td>
<td>21.98 (3.28)</td>
<td>17.81 (5.63)</td>
<td></td>
</tr>
<tr>
<td>Final Subscales</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suppression Subscale (Items 7-11)</td>
<td>19.77 (4.12)</td>
<td>18.64 (3.19)</td>
<td>14.61 (4.97)</td>
<td></td>
</tr>
<tr>
<td>Reappraisal Subscale (Items 1-5)</td>
<td>18.79 (4.17)</td>
<td>20.29 (3.18)</td>
<td>17.20 (4.42)</td>
<td></td>
</tr>
</tbody>
</table>

*Items rated on a 5-point Likert scale

*Item-total correlations with corresponding scale (i.e., items 1-6 were correlated with sum of the reappraisal items and items 7-12 were correlated with the sum of the suppression items)

*Items were removed for analyses because item-total correlation with corresponding subscales were < .20 (Allen & Yen, 1979)
Table 3
Frequency of AUs that Occurred in at least 5% of Pain Segments (i.e., Pain Related AUs).

<table>
<thead>
<tr>
<th>AU (label)</th>
<th>Frequency of AU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
</tr>
<tr>
<td>AU1 (inner brow raise)</td>
<td>10</td>
</tr>
<tr>
<td>AU2 (outer brow raise)</td>
<td>10</td>
</tr>
<tr>
<td>AU4 (brow lower)</td>
<td>19</td>
</tr>
<tr>
<td>AU6 (cheek raise)</td>
<td>12</td>
</tr>
<tr>
<td>AU7 (lids tighten)</td>
<td>26</td>
</tr>
<tr>
<td>AU9 (nose wrinkle)</td>
<td>7</td>
</tr>
<tr>
<td>AU10 (upper lip raise)</td>
<td>12</td>
</tr>
<tr>
<td>AU12 (lip pucker)</td>
<td>21</td>
</tr>
<tr>
<td>AU14 (dimpler)</td>
<td>9</td>
</tr>
<tr>
<td>AU17 (chin raiser)</td>
<td>33</td>
</tr>
<tr>
<td>AU23 (lip tightener)</td>
<td>8</td>
</tr>
<tr>
<td>AU24 (lip press)</td>
<td>11</td>
</tr>
<tr>
<td>AU25 (lips part)</td>
<td>17</td>
</tr>
<tr>
<td>AU26 (jaw drop)</td>
<td>21</td>
</tr>
<tr>
<td>AU43 (eye closure)</td>
<td>17</td>
</tr>
<tr>
<td>AU45 (blink)</td>
<td>125</td>
</tr>
</tbody>
</table>

Note: Frequency was only examined during the pain video segments; AU = Action Unit
Pain-Related AUs

Frequencies were conducted to determine pain-related AUs (see Table 3).

Hypothesis I

According to hypothesis I, participants in the reappraisal condition would express lower levels of pain, tension, and anxiety than participants in the monitoring condition who would, in turn, express lower levels than participants in the suppression condition. To determine if there were condition differences on pain expressions over time, 3 (suppression, reappraisal, monitoring) X 3 (baseline, pain task, recovery) mixed-model MANOVAs were conducted. In each case, multivariate significance was followed by univariate analyses (ANOVAs). These ANOVAs were mixed-model 3 (suppression, reappraisal, monitoring) X 3 (baseline, pain task, recovery). Given the large number of comparisons, the overall alpha level for the ANOVAs was set at a conservative .01. The dependent variables tested were as follows: pain intensity, pain unpleasantness, anxiety ratings, tension ratings, total AU frequency and average overall AU intensity, pain-related AU frequency and average intensity, physiological indicators (i.e., heart rate and galvanic skin response) and the various emotional expressions identified by the FaceReader expressed as a percentage of time during which each emotion (i.e., happiness, sadness, fear, surprise, anger, and disgust) or neutral facial expression occurred.
Table 4

Self-Reported Indices: Means and Standard Deviations

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Condition</th>
<th>Time Point</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>Pain Task</td>
<td>Recovery</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td></td>
</tr>
<tr>
<td>Pain Intensity</td>
<td>Suppression</td>
<td>2.64 (6.17)</td>
<td>16.49 (11.71)</td>
<td>11.69 (11.16)</td>
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</tr>
<tr>
<td></td>
<td>Reappraisal</td>
<td>1.47 (2.63)</td>
<td>15.59 (9.11)</td>
<td>10.69 (9.20)</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>17.06 (13.86)</td>
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</tr>
<tr>
<td></td>
<td>All Participants</td>
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<td>19.00 (12.55)</td>
<td>12.91 (11.66)</td>
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</tr>
<tr>
<td>Pain Unpleasantness</td>
<td>Suppression</td>
<td>.68 (2.03)</td>
<td>7.56 (8.00)</td>
<td>6.24 (7.33)</td>
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</tr>
<tr>
<td></td>
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<td>6.46 (5.68)</td>
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</tr>
<tr>
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<td>8.16 (8.20)</td>
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<td>Anxiety</td>
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<td>1.99 (1.47)</td>
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</table>
Table 5

Significant Condition Differences by Time Point/Task

<table>
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<tr>
<th>Outcome</th>
<th>Baseline</th>
<th>Pain Task</th>
<th>Recovery</th>
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</thead>
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<tr>
<td>Pain Intensity</td>
<td>R=S&lt;M</td>
<td>R&lt;M</td>
<td></td>
</tr>
<tr>
<td>Pain Unpleasantness</td>
<td>R&lt;M</td>
<td>R&lt;M</td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>R&lt;M</td>
<td>R&lt;M</td>
<td></td>
</tr>
<tr>
<td>Tension</td>
<td>R&lt;M</td>
<td>R&lt;M</td>
<td></td>
</tr>
<tr>
<td><strong>All AUs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Frequency</td>
<td>R=S&lt;M</td>
<td></td>
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<tr>
<td>Average Intensity</td>
<td>R=S&lt;M</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total Frequency</td>
<td>R=S&lt;M</td>
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<tr>
<td>Average Intensity</td>
<td>R=S&lt;M</td>
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<tr>
<td><strong>Emotion-Related Facial Expressions</strong></td>
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<tr>
<td>Disgust</td>
<td>R=M&lt;S</td>
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</table>

R=Reappraisal condition; M=Monitoring condition; S=Suppression condition; AU=Action Unit
**Self-reported pain and emotions.** Examination of Table 4 suggested that participants reported higher scores on all self-report measures immediately following the pain task compared to baseline, and lower scores on all self-report outcomes following recovery compared to following the pain task. Moreover, examination of mean scores also indicated that participant scores varied as a function of condition (e.g., reappraisal condition participants reported the lowest pain intensity, pain unpleasantness, anxiety, and tension compared to participants in the other conditions). Statistical analyses were employed to determine if the differences identified by visual inspection of the means were statistically significant.

The MANOVA focused on self-reported pain intensity, pain unpleasantness, anxiety, and tension. Using the Wilks criterion, the 3 X 3 (condition x time) mixed-model MANOVA demonstrated that the multivariate between-subjects effect (condition), \( \lambda = .871, F(8,268) = 2.39, p = .017 \), the within-subjects effect (time), \( \lambda = .303, F(8,130) = 37.38, p < .001 \), and interaction effect (condition x time), \( \lambda = .796, F(16,260) = 1.97, p = .016 \), were all statistically significant. Follow up univariate analyses were conducted to clarify these effects.

**DDS pain intensity.** The first ANOVA demonstrated a between-subjects effect, \( F(2,138) = 9.19, p < .001 \), a within-subjects effect, \( F(2,276) = 151.53, p < .001 \), as well as a significant interaction for DDS pain intensity, \( F(4,274) = 4.30, p = .002 \). Follow up pairwise comparisons demonstrated that participants within each condition reported significantly increased pain intensity scores immediately following the pain task compared to baseline (suppression: \( MD = 13.85, SE = 1.67, p < .001 \); reappraisal: \( MD = 14.12, SE = 1.74, p < .001 \); monitoring: \( MD = 22.93, SE = 1.88, p < .001 \)). Consistent
with hypothesis I, participants in the reappraisal condition reported significantly lower pain intensity compared to participants in the monitoring condition immediately following the pain task, $MD = 10.61$ ($SE = 2.50$) $p < .001$. In contrast to hypothesis I, participants in the suppression condition scored significantly lower than participants in the monitoring immediately following the pain task, $MD = 9.70$ ($SE = 2.45$) $p < .001$.

Participants within each condition also reported significantly lower pain intensity following recovery compared to immediately following the pain task (suppression: $MD = -4.80$, $SE = 1.45$, $p = .004$; reappraisal: $MD = -4.89$, $SE = 1.51$, $p = .005$; monitoring: $MD = -9.13$, $SE = 1.64$, $p < .001$), but significantly higher pain intensity ratings following recovery compared to baseline (suppression: $MD = 9.05$, $SE = 1.71$, $p < .001$; reappraisal: $MD = 9.22$, $SE = 1.78$, $p < .001$; monitoring: $MD = 13.79$, $SE = 1.93$, $p < .001$). Consistent with hypothesis I, participants in the reappraisal condition reported significantly lower pain intensity compared to participants in the monitoring condition following recovery, $MD = 6.37$ ($SE = 2.43$) $p = .029$. Contrary to hypothesis I, participants in the suppression condition did not report significantly greater pain intensity ratings compared to participants in the reappraisal or monitoring conditions following recovery. See Table 5 and Figure 1 for a visual summary of comparison results.
Figure 1. Average self-reported DDS pain intensity ratings by condition.
**DDS pain unpleasantness.** The ANOVA demonstrated a significant main within-subjects effect, $F(2,276) = 74.61, p < .001$, as well as a significant interaction for pain unpleasantness, $F(4,274) = 3.50, p = .008$. No significant between-subjects effect was found. Although follow up pairwise comparisons (given the significant interaction effect) demonstrated that participants in all conditions reported significantly greater pain unpleasantness immediately following the pain task compared to baseline (suppression: $MD = 6.89, SE = 1.12, p < .001$; reappraisal: $MD = 4.99, SE = 1.17, p < .001$; monitoring: $MD = 10.21, SE = 1.26, p < .001$), consistent with hypothesis I, participants in the reappraisal condition reported significantly lower pain unpleasantness, $MD = 4.50 (SE = 1.71) p = .029$, compared to participants in the monitoring condition immediately following the pain task. In contrast to hypothesis I, participants in the suppression condition did not report significantly higher pain unpleasantness immediately following the pain task compared to participants in the reappraisal or monitoring conditions.

Although no significant differences were identified in any condition between pain unpleasantness ratings recorded following the pain task and ratings recorded following the recovery period, participants within each condition reported significantly higher pain unpleasantness ratings following recovery compared to baseline (suppression: $MD = 5.56, SE = .96, p < .001$; reappraisal: $MD = 3.06, SE = .99, p = .008$; monitoring: $MD = 7.88, SE = 1.08, p < .001$). Consistent with hypothesis I, participants in the reappraisal condition reported significantly lower pain unpleasantness, $MD = 4.09 (SE = 1.47) p = .018$, compared to participants in the monitoring condition immediately following recovery. Contrary to hypothesis I, participants in the suppression condition did not
report significantly greater pain unpleasantness at the end of the recovery period compared to participants in the reappraisal or monitoring conditions following recovery. See Table 5 and Figure 2 for a visual summary of comparison results.
Figure 2. Average self-reported DDS pain unpleasantness ratings by condition.
**Anxiety.** The ANOVA demonstrated a significant main within-subjects effect, \( F(1.73, 240.80) = 30.62, p < .001 \), as well as a significant interaction for anxiety, \( F(3.47, 239.06) = 3.85, p = .007 \). A significant between-subjects effect was not found. Although follow up pairwise comparisons (following up the significant interaction effect) showed that participants in all conditions reported significantly greater anxiety immediately following the pain task compared to baseline (suppression: \( MD = .60, SE = .16, p = .001 \); reappraisal: \( MD = .46, SE = .17, p = .026 \); monitoring: \( MD = 1.22, SE = .19, p < .001 \)), consistent with hypothesis I, only participants in the reappraisal condition reported significantly lower anxiety compared to participants in the monitoring condition immediately following the pain task, \( MD = .72 (SE = .27) p = .025 \). Contrary to hypothesis I, participants in the suppression condition did not report significantly higher anxiety than participants in the reappraisal or monitoring conditions immediately following the pain task.

Only participants in the suppression, \( MD = -.33 (SE = .13) p = .029 \), and reappraisal, \( MD = -.35 (SE = .13) p = .021 \), conditions reported significantly less anxiety following recovery compared to immediately following the pain task. Furthermore, only participants in the monitoring condition reported significantly elevated anxiety ratings following the recovery period compared to baseline, \( MD = .93 (SE = .21) p < .001 \). Consistent with hypothesis I, participants in the reappraisal condition reported significantly lower anxiety, \( MD = .78 (SE = .27) p = .013 \), compared to participants in the monitoring condition following recovery; however, in contrast to hypothesis I, participants in the suppression condition did not report significantly lower anxiety than
participants in the reappraisal or monitoring following recovery. See Table 5 and Figure 3 for a summary of comparison results.
Figure 3. Average self-reported anxiety ratings by condition.
**Tension.** The ANOVA demonstrated a significant main within-subjects effect, \(F(1.90, 262.56) = 44.35, p < .001\), as well as a significant interaction for tension, \(F(3.81, 260.66) = 5.73, p < .001\). A significant between-subjects effect was not found. Follow up pairwise comparisons (given the significant interaction effect) showed that only participants in the suppression, \(MD = -.94 (SE = .20) \ p < .001\) and monitoring, \(MD = 1.63 (SE = .22) \ p < .001\), conditions reported significantly higher tension ratings immediately following the pain task compared to baseline. Although a similar trend was identified for participants in the reappraisal condition (i.e., experienced similar reductions in tension), this trend failed to research statistical significance, \(MD = .49 (SE = .21) \ p = .059\). Consistent with hypothesis I, tests demonstrated that participants in the reappraisal condition reported significantly lower tension, \(MD = .89 (SE = .31) \ p = .014\), compared to participants in the monitoring condition immediately following the pain task. In contrast to hypothesis I, participants in the suppression condition did not report significantly greater tension than participants in the reappraisal or monitoring conditions immediately following the pain task.

Although participants within each condition reported significantly lower tension (suppression: \(MD = -.47, SE = .15, p = .007\); reappraisal: \(MD = -.49, SE = .21, p = .027\); monitoring: \(MD = -.45, SE = .17, p = .029\)) following the recovery period compared to immediately following the pain task, only participants in the suppression, \(MD = .47 (SE = .18) \ p = .030\), and monitoring, \(MD = 1.18 (SE = .21) \ p < .001\), conditions reported significantly higher tension ratings at the end of recovery compared to baseline. Consistent with hypothesis I, participants in the reappraisal condition reported significantly lower tension compared to participants in the monitoring condition at this
time (i.e., following recovery), $MD = .86 (SE = .28) \ p = .007$. In contrast to hypothesis I, participants in the suppression condition did not report significantly greater tension following the recovery period compared to participants in the reappraisal or monitoring conditions. See Table 5 and Figure 4 for a summary of comparison results.
Figure 4. Average self-reported tension ratings by condition.
Table 6
Observational Measures: Means and Standard Deviations

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Condition</th>
<th>Baseline</th>
<th>Pain Task</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Galvanic Skin Response (μS)</strong></td>
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<td>5.57</td>
<td>5.75</td>
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<td><strong>Heart Rate (bpm)</strong></td>
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<td>4.91</td>
<td>6.28</td>
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<td>3.04</td>
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<td><strong>Total Frequency: Pain-Related AUs</strong></td>
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<td>4.75</td>
<td>4.70</td>
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<td>4.25</td>
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<td>.13</td>
<td>.15</td>
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bpm = beats per minute; μS = microsiemens; AUs = Action Units
Psychophysiological indices. Examination of the means in Tables 6, concerning participants’ mean galvanic skin response and heart rate over time, indicated that galvanic skin response increased during the pain task compared to baseline and then remained relatively stable in the recovery period. Interpretation of the means also suggested that participants’ heart rate appears to have remained relatively stable during the entirety of the experiment. Statistical analysis was employed to determine if the differences identified by visual inspection of the means were statistically significant. Results of the 3 X 3 (condition x time) mixed-model MANOVA (focusing on heart rate and galvanic skin response) indicated that the multivariate within-subjects effect (time) was statistically significant, $\lambda = .777, F(4,133) = 9.53, p < .001$. The between-subjects effect (condition), $\lambda = .976, F(4,270) = .84, p = .503$, and the interaction effect (time x condition) were not statistically significant, $\lambda = .969, F(8,266) = .52, p = .839$. Given the significance of the MANOVA within subjects effect, follow up ANOVAs were conducted.

Galvanic skin response. The follow up ANOVA demonstrated a significant main within-subjects effect for galvanic skin response, $F(1.92, 137.08) = 16.19, p < .001$. Neither the between subjects effect nor the interaction were statistically significant. Tests of within-subjects contrasts demonstrated that participants experienced significantly elevated galvanic skin responses during the pain task compared to baseline, $F(1,138) = 35.41, p < .001$.

Heart rate. The follow up ANOVA demonstrated no significant main effects nor interaction.
**Facial expressions: All AUs.** Examination of means in Table 6 concerning participants’ total frequency of and average intensity of all AUs suggests that more facial activity occurred during the pain task and recovery than during baseline. Condition differences also appear to exist. Statistical analysis was employed to determine if the differences identified by visual inspection of the means were statistically significant. Results of the 3 X 3 (condition x time) mixed-model MANOVA indicated that the multivariate within-subjects effect (time), $\lambda = .769$, $F(4,136) = 10.19$, $p < .001$, and the between-subjects effect (condition), $\lambda = .908$, $F(4,276) = 3.41$, $p = .101$, were statistically significant. The multivariate interaction effect (condition x time) was also statistically significant, $\lambda = .840$, $F(8,272) = 3.10$, $p = .002$. These significant effects were followed up using univariate analyses.

**Total frequency: All AUs.** The follow up ANOVA demonstrated a significant between-subjects effect, $F(1.73, 137.27) = 9.88$, $p < .001$, as well as a significant interaction for total frequency of all AUs, $F(3.67, 135.13) = 4.45$, $p = .002$. The main within-subjects effect was not significant. Pairwise comparisons demonstrated that only participants in the monitoring condition displayed more frequent facial activity during the pain task than during baseline, $MD = 3.37$ ($SE = .73$) $p < .001$. Consistent with hypothesis I, participants in the reappraisal condition expressed less frequent facial activity during the pain task compared to participants in the monitoring condition, $MD = -3.39$ ($SE = .91$) $p = .001$. Contrary to hypothesis I, participants in the suppression condition also displayed less frequent facial activity during the pain task compared to participants in the monitoring condition, $MD = -3.05$ ($SE = .89$) $p = .002$. 

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Although no change was found between the pain task and recovery, consistent with hypothesis I, only participants in the suppression, $MD = 1.32 \ (SE = .69) \ p = .039$, and monitoring conditions, $MD = 1.83 \ (SE = .60) \ p = .008$, displayed more frequent facial activity during recovery than baseline. Contrary to hypothesis I, no significant differences among conditions were observed during recovery. See Table 5 and Figure 5 for a visual summary of comparison results.
Figure 5. Average total action unit (AU) frequency by condition.
Average intensity: All AUs. The follow up ANOVA demonstrated a significant main within-subjects effect, \( F(1,139) = 5.53, p = .005 \), between-subjects effect, \( F(1.77, 246.18) = 9.88, p < .001 \), effects as well as significant interaction effects for average AU intensity, \( F(3.54,244.41) = 4.79, p = .002 \).

Pairwise comparisons demonstrated that participants in the reappraisal, \( MD = 2.85 \) (SE = 1.09) \( p = .030 \), and monitoring, \( MD = 5.41 \) (SE = 1.18) \( p < .001 \), conditions displayed more intense facial activity during the pain task than during baseline. Consistent with hypothesis I, participants in the reappraisal condition expressed significantly less intense facial activity during the pain task compared to participants in the monitoring condition, \( MD = -3.68 \) (SE = 1.43) \( p = .034 \). Contrary to hypothesis I, participants in the suppression condition also expressed significantly less intense facial activity during the pain task compared to participants in the monitoring condition, \( MD = -5.44 \) (SE = 1.40) \( p < .001 \). Only participants in the monitoring condition expressed significantly less intense facial displays during recovery than during the pain task, \( MD = -4.17 \) (SE = 1.21) \( p = .002 \). Contrary to hypothesis I, no significant differences among conditions were observed during recovery. See Table 5 and Figure 6 for a visual summary of comparison results.
Figure 6. Averaged action unit (AU) intensity by condition.
Facial Expressions: Pain-related AUs. Examination of means in Table 6 concerning participants’ total frequency of pain-related AUs demonstrated increased activity during the pain task than during baseline and that this activity remained relatively stable into recovery. Similarly, examination of Table 6 suggested that participants expressed more intense facial displays during the pain task than during baseline or recovery. Condition differences also appear to exist. Specifically, it appears that participants in the monitoring condition express the most intense and frequent pain-related AUs during the pain task compared to participants in either the reappraisal or monitoring conditions. Statistical analyses were employed to determine if the differences identified by visual inspection of the means were statistically significant. A 3 X 3 (condition x time) mixed-model MANOVA indicated that the multivariate within-subjects effect (time), $\lambda = .757$, $F(4,136) = 10.89$, $p < .001$, the between-subjects effect (condition), $\lambda = .896$, $F(4,276) = 3.90$, $p = .004$, as well as the interaction effect (condition x time), $\lambda = .816$, $F(8,272) = 3.64$, $p < .001$, were all statistically significant.

Total pain-related AU frequency. The follow up ANOVA demonstrated a significant a within-subjects effect, $F(1.90,264.60) = 7.84$, $p = .001$, as well as a significant interaction for total frequency of pain-related AUs, $F(3.81,262.69) = 4.94$, $p = .001$. A significant between-subjects effect was not found. Follow up pairwise comparisons (given the significant interaction effect) demonstrated that only participants in the monitoring condition expressed significantly more frequent pain-related facial displays during the pain task than during baseline, $MD = 3.27$ ($SE = .68$) $p < .001$. Consistent with hypothesis I, participants in the reappraisal condition expressed significantly less frequent pain-related facial displays during the pain task than
participants in the monitoring condition, $MD = -3.42$ ($SE = .86$) $p < .001$. Contrary to hypothesis I, participants in the suppression condition also expressed significantly less frequent pain-related facial displays during the pain task than participants in the monitoring condition, $MD = -2.94$ ($SE = .84$) $p = .002$.

Although no differences in the total frequency of pain-related AUs between pain task and recovery was found, consistent with hypothesis I, participants in the suppression, $MD = 1.28$ ($SE = .50$) $p = .033$, and monitoring, $MD = 1.78$ ($SE = .57$) $p = .006$, conditions expressed significantly more frequent pain-related facial displays during recovery than during baseline. Inconsistent with hypothesis I, no significant differences among conditions were observed during recovery. See Table 5 and Figure 7 for a visual summary of comparison results.
Figure 7. Average total pain-related action unit (AU) frequency by condition.
**Average pain-related AU intensity.** The follow up ANOVA demonstrated significant between-subjects, $F(1,139) = 6.35$, $p = .002$, within-subjects, $F(1.75, 242.60) = 11.77$, $p < .001$, effects as well as interaction effects for average pain-related AU intensity, $F(3.49, 240.86) = 5.45$, $p = .001$. Follow up pairwise comparisons demonstrated that, participants in the reappraisal, $MD = .19$ ($SE = .07$) $p = .014$, and monitoring, $MD = .34$ ($SE = .07$) $p < .001$, conditions displayed significantly more intense pain-related facial displays during the pain task than during baseline. Consistent with hypothesis I, participants in the reappraisal condition expressed significantly less intense pain-related facial displays during the pain task than participants in the monitoring condition, $MD = -.22$ ($SE = .09$) $p = .040$. Contrary to hypothesis I, participants in the suppression condition also expressed significantly less intense pain-related facial displays during the pain task than participants in the monitoring condition, $MD = -.34$ ($SE = .84$) $p < .001$.

Contrary to hypothesis I, only participants in the monitoring condition expressed significantly less intense pain-related facial displays during recovery than during the pain task, $MD = -.26$ ($SE = .07$), $p = .001$, and no significant differences among conditions were observed during recovery. See Table 5 and Figure 8 for a visual summary of comparison results.
Figure 8. Average pain-related action unit (AU) intensity by condition.
Table 7

Frequencies of Emotion-Related Facial Expressions: Means and Standard Deviations

<table>
<thead>
<tr>
<th>Expression</th>
<th>Condition</th>
<th>Time Point</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>Pain Task</td>
<td>Recovery</td>
</tr>
<tr>
<td>Neutral</td>
<td>Suppression</td>
<td>59.54 (19.74)</td>
<td>62.54 (22.66)</td>
<td>60.57 (19.75)</td>
</tr>
<tr>
<td></td>
<td>Reappraisal</td>
<td>58.22 (16.92)</td>
<td>60.56 (18.03)</td>
<td>58.17 (17.64)</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>57.52 (18.95)</td>
<td>62.76 (16.84)</td>
<td>63.08 (16.49)</td>
</tr>
<tr>
<td></td>
<td>All Participants</td>
<td>58.51 (18.49)</td>
<td>61.94 (19.47)</td>
<td>60.49 (18.13)</td>
</tr>
<tr>
<td>Happiness</td>
<td>Suppression</td>
<td>4.97 (9.93)</td>
<td>2.23 (7.88)</td>
<td>3.55 (8.36)</td>
</tr>
<tr>
<td></td>
<td>Reappraisal</td>
<td>3.53 (7.47)</td>
<td>3.55 (8.26)</td>
<td>4.64 (8.38)</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>7.18 (10.64)</td>
<td>5.42 (8.54)</td>
<td>5.03 (9.59)</td>
</tr>
<tr>
<td></td>
<td>All Participants</td>
<td>5.12 (9.45)</td>
<td>3.59 (8.24)</td>
<td>4.35 (8.70)</td>
</tr>
<tr>
<td>Sadness</td>
<td>Suppression</td>
<td>24.09 (18.78)</td>
<td>22.69 (22.74)</td>
<td>22.42 (18.71)</td>
</tr>
<tr>
<td></td>
<td>Reappraisal</td>
<td>29.85 (17.21)</td>
<td>27.76 (16.71)</td>
<td>27.96 (16.49)</td>
</tr>
<tr>
<td></td>
<td>All Participants</td>
<td>25.55 (18.50)</td>
<td>24.63 (19.67)</td>
<td>24.03 (17.50)</td>
</tr>
<tr>
<td>Anger</td>
<td>Suppression</td>
<td>3.77 (7.27)</td>
<td>5.39 (11.26)</td>
<td>4.62 (8.87)</td>
</tr>
<tr>
<td></td>
<td>Reappraisal</td>
<td>3.55 (6.73)</td>
<td>2.57 (6.17)</td>
<td>4.54 (8.48)</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>5.15 (10.05)</td>
<td>2.42 (5.37)</td>
<td>3.69 (8.44)</td>
</tr>
<tr>
<td></td>
<td>All Participants</td>
<td>4.10 (7.98)</td>
<td>3.58 (8.34)</td>
<td>4.32 (8.56)</td>
</tr>
<tr>
<td>Surprise</td>
<td>Suppression</td>
<td>3.66 (7.69)</td>
<td>3.98 (7.87)</td>
<td>5.06 (10.36)</td>
</tr>
<tr>
<td></td>
<td>Reappraisal</td>
<td>1.94 (4.76)</td>
<td>1.55 (4.02)</td>
<td>1.43 (3.63)</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>4.32 (9.04)</td>
<td>2.67 (7.54)</td>
<td>3.19 (6.84)</td>
</tr>
<tr>
<td></td>
<td>All Participants</td>
<td>3.27 (7.31)</td>
<td>2.78 (6.74)</td>
<td>3.29 (7.72)</td>
</tr>
<tr>
<td>Fear¹</td>
<td>Suppression</td>
<td>0 (0)</td>
<td>14 (1.03)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>Reappraisal</td>
<td>0 (0)</td>
<td>.13 (.88)</td>
<td>.18 (1.21)</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>All Participants</td>
<td>0 (0)</td>
<td>.10 (.81)</td>
<td>.06 (.70)</td>
</tr>
<tr>
<td>Disgust¹</td>
<td>Suppression</td>
<td>.66 (2.12)</td>
<td>0 (0)</td>
<td>.11 (.77)</td>
</tr>
<tr>
<td></td>
<td>Reappraisal</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>0 (0)</td>
<td>.20 (1.29)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>All Participants</td>
<td>.25 (1.33)</td>
<td>.06 (.70)</td>
<td>.04 (.47)</td>
</tr>
</tbody>
</table>

¹ A constant of +1 was added to scores for statistical tests
**Emotion-related facial expressions.** Examination of the means presented in Table 7 concerning the average percent of emotional expressions by condition during baseline, the pain task, and recovery demonstrated that participants’ emotional facial displays remained relatively stable throughout the study period. Nonetheless, differences across conditions were tested. Results of a 3 X 3 (condition x time) mixed-model MANOVA indicated that the multivariate within-subjects effect (time), $\lambda = .961$, $F(14,125) = 1.45, p = .142$, and between-subjects effect (condition), $\lambda = .910$, $F(14,264) = .091, p = .551$, did not reach statistical significance. The multivariate interaction effect (condition x time), however, was statistically significant, $\lambda = .695$, $F(28,250,264) = 1.79, p = .01$. Given the significant interaction effect, six discrete 3 x 3 follow up ANOVAs testing neutral, happiness, sadness, anger, surprise, and fear percentages of occurrence (i.e., what percentage of time each expression was displayed during each period under investigation) demonstrated no significant within-subjects effects, between-subjects effects, or interactions. The ANOVA testing mean frequency of disgust demonstrated a significant interaction, $F(2.89, 198.17) = 3.96, p = .10$, but no significant within-subjects or between-subjects effects. Pairwise comparisons (following up on the significant interaction effect) of mean disgust frequency demonstrated that participants in the suppression condition expressed significantly more disgust at baseline than participants in the reappraisal, $MD = .66 (SE = .26), p = .037$, or monitoring, $MD = .66 (SE = .27) p = .048$. Moreover, participants in the suppression condition expressed significantly more disgust during baseline than during the pain task, $MD = .66 (SE = .20) p = .004$, and recovery, $MD = .56 (SE = .15) p = .001$. See Table 5 for a visual summary of comparison results.
Table 8

Regression Model Predicting Pain Tolerance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta</th>
<th>$F$ (4,139)</th>
<th>$p$</th>
<th>$r^2$ Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Sex</td>
<td>-.29</td>
<td>12.65</td>
<td>.001</td>
<td>.08</td>
</tr>
<tr>
<td>Age</td>
<td>.13</td>
<td>2.30</td>
<td>.117</td>
<td>.02</td>
</tr>
<tr>
<td>ERQ Reappraisal subscale</td>
<td>-.09</td>
<td>1.24</td>
<td>.267</td>
<td>.01</td>
</tr>
<tr>
<td>ERQ Suppression subscale</td>
<td>-.04</td>
<td>.19</td>
<td>.663</td>
<td>&lt; .01</td>
</tr>
</tbody>
</table>

ERQ = Emotion Regulation Questionnaire

*Significant predictor
Hypothesis II

To test if self-reported ER strategies relate to pain threshold and pain tolerance, two linear regression equations were calculated. Predictors were ERQ Suppression and Reappraisal subscale scores, sex, and age. In contrast to hypothesis II, participants’ tendencies to engage in suppression or reappraisal (as measured by the ERQ) were not related to either pain threshold or tolerance. Specifically, the model did not account for significant variance in participants’ pain threshold although it approached statistical significance, $F(4,139) = 2.30, p = .062, R^2 = .062$. Nonetheless, the model accounted for statistically significant variance in participants’ pain tolerance, $F(4,139) = 4.29, p = .003, R^2 = .11$. Subsequent analysis of each variable’s unique contribution to the prediction was then examined after all other variables were entered into the equation (see Table 8). The Table 8 findings suggested that males demonstrated significantly higher pain tolerance than females.

Exploratory Analysis

To examine if self-reported ER strategies interacted with condition several multiple linear regression equations were calculated. Interaction terms (see Methods section for description of the calculation of the interaction terms), ERQ Reappraisal and Suppression subscale scores, sex, and age were entered as predictors in each model. Pain Intensity and Pain Unpleasantness subscales from the DDS, Anxiety and Tension VASs, galvanic skin response, heart rate, and facial activity (i.e., frequency and intensity of all AUs), pain-related facial activity (frequency and intensity of pain-related AUs) and average percentage of facial expression (i.e., neutral, happiness, sadness, fear, surprise, anger, and disgust) were dependent variables. This model did not significantly predict
any dependent measures suggesting that self-reported ER strategy usage did not interact with condition placement.
Discussion

This study involved examination of nonverbal and verbal expressions in response to acute, phasic noxious stimuli and in relation to emotional regulatory strategies (i.e., suppression and reappraisal). Specifically, the following were explored: (1) the application of these strategies in response to experimental instructions (i.e., experimental manipulation); (2) participants’ typical, self-reported tendencies to use specific ER strategies; and (3) the interaction between one’s typical, self-reported approach to emotional regulation (e.g., extent of self-reported typical reappraisal and suppression use) and experimental instructions to use either reappraisal or suppression.

Consistent with biopsychosocial formulations of the pain experience (Hadjistavropoulos, et al., 2011), this study demonstrated that psychological processes significantly moderate both verbal (e.g., self-report) and nonverbal (e.g., facial expressions) pain expressions. Specifically, using reappraisal strategies to regulate a painful experience was related to significantly lower pain intensity, pain unpleasantness, anxiety, and tension ratings, as well as reduced general and pain-related facial activity compared to not using an ER strategy. Similarly, using suppression strategies was also related with significantly lower self-reported pain intensity ratings as well as general and pain-related facial activity. Yet, unlike reappraisal, using suppression strategies was not related to reductions in pain unpleasantness, anxiety, and tension ratings. Unexpectedly, no relationship between a person’s tendency to use suppression or reappraisal, and pain threshold or tolerance emerged. Moreover, self-reported typical tendencies were not found to interact with experimental condition assignment. Finally, the frequency of seven
different emotional facial displays was not clearly related to exposure to thermal stimuli or to specific ER strategies.

This investigation has important strengths and makes a contribution to the vast literature on ER and pain. First, the focus of this investigation was the examination of pain in relation to suppression and reappraisal. Although experimental instructions to engage in reappraisal have been found to lead to more adaptive, less reactive responses to negative affect induction (e.g., anxiety; Denson et al., 2011; Mauss et al., 2007), this is the first study that examined pain expressions as a function of experimentally encouraged reappraisal.

Another key feature of this study was the assessment of nonverbal pain expressions. Specifically, this study was the first to investigate a wide range of facial reactions to noxious stimuli as a function of ER. Although nonverbal pain expressions are recognized as important features of the pain experience (Hadjistavropoulos et al., 2011), only one previous investigation (i.e., Burns et al., 2008) involved the examination of the association between nonverbal reactions to pain and ER strategies. However, in the previous investigation, only pain behaviours (e.g., bracing, grimacing) as a function of using suppression or nonsuppression during a structured pain task was examined (Burns et al., 2008). Moreover, only sufferers of chronic pain were included in the Burns et al. (2008) investigation and an anger-induction task was completed prior to the pain task (i.e. participants were harassed while completing a computerized maze task). Therefore, it is not clear whether the Burns et al.'s (2008) results would generalize to non-chronic pain populations. In addition, this was also the first study to employ a novel, automated program in the assessment of emotional facial displays. General and pain-related facial
activity was assessed through FACS and facial expressions of emotions were quantified using sophisticated and well validated software.

An additional methodological strength of this study included use of a psychometrically established assessment of typical reappraisal and suppression tendencies (i.e., the ERQ). Finally, this study involved examination of the interaction between ER tendencies and experimentally induced strategies (i.e., being assigned to the suppression or reappraisal condition while the participant’s self-reported tendency was either to use suppression or reappraisal). Although the interaction between typical “repression” and consciously applied suppression/nonsuppression as well as typical “anger-regulation style” and consciously applied suppression/nonsuppression has been examined in the context of pain (Elfant et al., 2008; Burns et al., 2007; Burns et al., 2011), this was the first study that explored the interaction between typical, self-reported suppression and reappraisal tendencies and condition assignment (i.e., being instructed to consciously apply suppression or reappraisal).

**Effect of Suppression and Reappraisal Induction**

**Reappraisal.** Although no study has examined pain as a function of reappraisal induction, the results were consistent with non-pain studies, where the adaptive impact of using reappraisal to regulate affect during an anxiety or anger inducing task was demonstrated (Feinberg, Willer, Antonenko, & John, 2012; Gross, 1998a; McRae, Ciesielski, & Gross, 2012; Szasz, Szentagotai, & Hofmann, 2011). Specifically, as hypothesized (i.e., hypothesis I), instruction to use reappraisal strategies led to a less reactive, more adaptive, response to noxious stimuli. Namely, during the acute, phasic pain task, participants in the reappraisal condition expressed significantly less frequent
and less intense general and pain-related facial displays compared to participants in the monitoring condition. They also reported lower pain intensity, pain unpleasantness, anxiety, and tension ratings compared to participants in the monitoring condition following the pain task and recovery. However, contrary to hypothesis I, participants in the reappraisal condition did not display a significantly reduced physiological response (i.e., heart rate and galvanic skin response). It is noted that the pattern of differences in facial activity was identical when all AUs were examined vs. when all pain-related AUs were examined suggesting that examination of pain-related AUs may be sufficient for future studies of this kind.

It may be speculated that a condition by time interaction for heart rate and galvanic skin response did not emerge because of different protocols used in this study and in other related investigations. For instance, participants in this study completed the pain threshold and tolerance tasks before the baseline, 10-trial pain task, and recovery period. Therefore, participants in this study may have experienced an increased physiological response following the two brief exposures that subsequently remained high throughout the duration of the study. In support, a comparison between participants’ baseline heart rates between this study and the study conducted by Burns et al. (2006; where a significant condition and time interaction was found) demonstrated that participants from this study experienced an elevated heart rate during baseline (i.e., an average of 78.85 beat per minute) compared to participants of Burns et al. (2006; i.e., an average 63.31 to 68.08 beats per minute across conditions). Moreover, other investigations that showed a condition by time interaction for physiological indicators (i.e., Coiffi & Halloway, 1993) exclusively focused on change scores. Since change
scores are associated with an inherent lack of reliability, potential for regression to the mean, and tendency to draw false conclusions (Bergh & Fairbank, 2002). Coiffi and Halloway’s (1993) results may be an unreliable illustration of the relationship between physiological output and ER strategies.

**Suppression.** An unexpected relationship between suppression and pain emerged. It was hypothesized that participants in the suppression condition would display the most intense and frequent facial expressions as well as report the highest level of pain and negative affect (i.e., hypothesis I). Like participants in the reappraisal condition however, it was found that participants in the suppression condition also expressed significantly less frequent and intense general and pain-related facial displays during the acute, phasic pain task compared to participants in the monitoring condition. Moreover, participants in the suppression condition reported significantly lower pain intensity ratings immediately following the pain task compared to participants in the monitoring condition. However, suppression use was not related to anxiety and tension ratings, nor to physiological reactivity.

Although these results were not consistent with the paradoxical, deleterious impact of suppression that has been demonstrated elsewhere (e.g., Elfant et al., 2008; Cioffi & Holloway, 1993; Masedo & Rosa Esteve, 2007; Sullivan et al., 1997), results concerning the effect of suppression use on self-reported pain and affect levels following a painful task have been inconsistent (e.g., Braams et al., 2012; Burns, 2006; Sullivan et al., 1997). For instance, Cioffi and Holloway (1993) only found that suppression resulted in significantly increased pain ratings following a two minute recovery period, and not immediately following the pain task. Moreover, Burns (2006) found no significant group
differences on pain intensity or negative affect ratings following the conscious application of suppression vs. other consciously applied strategies (i.e. sensory focus, distraction, control). Finally, Braams et al. (2012) proposed “that suppression may, in some cases, be an effective regulation technique for pain” (pp. 1017) after finding that suppression was just as effective as acceptance in reducing pain and anxiety ratings.

At this time, it is unclear why these inconsistencies exist. Examination of pre-existing studies did not reveal systematic differences in the measures, designs, controls/comparison groups, or pain induction techniques. It may be necessary to conduct highly-controlled investigations of suppression, whereby several variables are held constant, in order to tease apart the features that are causing the inconsistent results. More research should be conducted to determine the relationship between suppression and pain.

**Self-reported Emotional Regulation Tendencies**

Contrary to hypothesis II, there was no significant relationship between the self-reported typical tendencies to use ER strategies (i.e., suppression or reappraisal as measured by the ERQ) and pain tolerance or threshold during the acute, phasic pain task. Although researchers have found a relationship between self-reported typical ER tendencies and pain variables (Gilliam et al., 2010; Hamilton, Zautra, & Reich, 2007; Quartana et al., 2010; Ruiz-Aranda, Salguero, & Fernandez-Berrocal, 2010), some discrepancies have been identified. As noted earlier (see literature review), these discrepancies may be a result of the imprecise quantification of self-reported typical ER strategy use. Namely, prior studies did not involve direct measurement of ER strategies, but rather inferences of ER function from more general measures of affect (e.g., Connelly et al., 2007; Paquet et al., 2005). Other studies lacked psychometric rigour (e.g.,
assessment of ER strategies using a single question that has not been validated; Quartana et al., 2010). Finally, some investigations focused on constructs that are not directly related to the specific ER strategies, such as general emotional intelligence (e.g., the ability to control, perceive, facilitate, understand, and manage emotions; Agar-Wilson & Jackson, 2012; Ruiz Aranda et al., 2011) or included items assessing characteristic features of ER strategies other than suppression or re-appraisal (e.g., self-distraction; Gilliam et al., 2010).

It is important to note that the threshold and tolerance tasks used in this study may not have been a sufficient duration to allow for the typical application of ER tendencies. In this study, both the threshold and tolerance tasks were brief; lasting a maximum of 23 seconds. In some previous studies, the relationships between self-reported typical ER strategies and pain outcomes was found after a longer exposure to pain (e.g., a cold-pressor task lasting up to 300 seconds, chronic pain). Moreover, in the anxiety literature, the effect of self-reported ER use has often been examined in relationship to external stressors of much greater duration (e.g., Carleson, Dikecligil, Greenberg, & Mujica-Parodi, 2012; Egloff, Schmukle, Burns, & Schwerdtfeger, 2006; Memedovic, Grisham, Denson, & Moulds, 2010; Moore, Zoellner, & Mollenholt, 2008). It is possible that pain duration may affect the extent to which ER strategies can be effectively employed.

Although self-reported typical ER tendencies were not found to impact pain tolerance, sex was found to significantly predict this pain variable. Namely, males were significantly more likely to demonstrate a higher pain tolerance than females. This is consistent with previous research that has demonstrated the effect of sex on pain outcome.
(e.g., Burns et al., 2010; Fillingim et al., 2009; Robinson, Gagnon, Riley, & Price, 2003) and is likely related, at least in part, to cultural expectations (Rollman, 2004).

**Exploratory Analyses**

An interaction between a person’s typical, self-reported ER strategy use and experimentally induced strategy was not found. This suggests that people have the capacity to alter their typical, self-reported tendencies and use other ER strategies. Hence, at least in an acute, phasic pain context, individuals can use both suppression and reappraisal to regulate a painful event, regardless of their self-reported typical tendencies. Since clinical implications from this study may only be cautiously proposed, given the laboratory nature of this investigation, it can be tentatively suggested that providing effective ER instructions may be a promising feature in pain management initiatives because their effectiveness may not be dependent on one’s self-reported typical tendencies.

Although no hypotheses were generated concerning the impact of ER strategies on the frequency of emotional facial expressions, (i.e., neutral, happiness, anger, sadness, fear, disgust, and surprise), an interaction was identified for percent of disgust. It was found that participants’ in the suppression condition expressed significantly more facial displays related to disgust at baseline compared to participants in either the monitoring or reappraisal conditions. Moreover, participants in the suppression condition expressed significantly more disgust at baseline than during the pain task or recovery. Since no demographic differences among conditions were identified, nor did any other baseline differences emerged for the other outcome measures (e.g., pain intensity, pain unpleasantness, anxiety, tension, and general and pain-related facial activity), at this time,
it is unclear why this baseline difference in disgust occurred. This may have been a chance finding. Future research could help shed additional light on this issue.

Based on prior investigations (e.g., Hale & Hadjistavropoulos, 1997), it was expected that participants would express significantly more negative emotional expressions (e.g., disgust) and less positive emotional expressions (e.g., happiness) during exposure to noxious stimuli. Yet, no such differences emerged. Since this finding contradicts previous investigations (e.g., Hale & Hadjistavropoulos, 1997), it may be speculated that different pain induction protocols employed may affect the frequency of emotional facial expressions. Namely, this study employed an experimental thermal pain task. In contrast, Hale and Hadjistavropoulos (1997) involved a venepuncture procedure. This pain induction protocol may elicit a stronger emotional reaction since injections are related to self-report of disgust (Kleinknecht, Kleinknecht, & Thorndike, 1997; Olatunji et al., 2010).

**Theoretical Contributions**

Consistent with biopsosychosocial formulations of pain, this study was grounded in the communications model (Hadjistavropoulos et al., 2011). In line with Hadjistavropoulos et al. (2011) and other biopsychosocial viewpoints, results from this study demonstrated that a noxious stimulus can initiate a sequence that leads to an internal experience of pain (Step A), which is subsequently expressed through both verbal (e.g., pain intensity, pain unpleasantness ratings) and nonverbal (i.e., facial expressions) expressions (Step B) that can then be decoded through the use of standardized assessment tools (i.e., DDS, FACS; Step C). Findings from this study help add specificity to the communications model of pain by providing further clarification
with respect to the way that ER (a psychological process) can affect the experience and encoding of pain. Most of the specificity added to the model by these results concern reappraisal-type strategies. The findings concerning suppression are more difficult to integrate into our understanding of pain at this time because of discrepancies with previous research.

Based on this study it is suggested that once reappraisal is consciously applied, it can affect both the more automatic expressions of pain (e.g., pain-related facial activity) and the more cognitively controlled expressions of pain (e.g., verbal report). Namely, the application of reappraisal (following instructions) significantly reduced facial expressions and self-reported pain and affect ratings compared to not using an ER strategy. Essentially, using reappraisal to regulate a painful task appears to alter the encoding of both the automatic and cognitively mediated expressions of pain. This, in turn, is bound to affect the decoding of pain by observers.

From a clinical standpoint, consider two individuals receiving a painful vaccine injection (or undergoing another noxious medical procedure). Verbal instructions could prompt one patient to utilize reappraisal (e.g., “re-interpret the stimuli in a way that will help you to stay calm”). This patient may begin to re-evaluate the injection pain as resulting from an innocuous static electric shock, and not as an invasive procedure involving a long needle. Reappraising the injection may affect both cognitively-mediated processing and the automatic processing of the sensations. In turn, this patient may perceive the painful event as less intense and less unpleasant, reflected in lower subjective self-report ratings of pain as compared to a patient who is not given such instructions.
Limitations and Future Directions

In the first instance it is acknowledged that this investigation included a sample composed of well-educated individuals of a young age range. As such, results may not generalize to a more diverse population, including those who are older. This is important since older and younger adults differ in their experiences of pain; older persons may show a somewhat increased pain threshold and pain tolerance as well as increased stoicism, which, in turn have been related to lower self-reported pain intensity (Helme & Gibson, 2001; Yong, 2006). Hence, the impact of reappraisal and suppression should be tested in more diverse populations, including older adults.

Although this investigation has made contributions by expanding this area of investigation beyond the almost exclusive reliance on the cold-pressor task, only thermal pain was examined in this study. Hence, future studies should focus on the impact of ER strategies and emotional facial expressions as a function of different pain tasks (e.g., electrical), given that pain stimulation modalities may impact results (e.g., Prkachin, 1992). Furthermore, as previously identified, the effects of self-reported typical tendencies were only examined during a brief pain task (i.e., 23 second threshold and tolerance tasks). It was speculated that the duration of the task may moderate the conscious elicitation of strategies. This could be tested by conducting a laboratory study where participants are administered the ERQ and different durations of pain induction stimulation. Furthermore, participants may be explicitly asked how/if they regulated the pain experience following the tasks (e.g., a version of the manipulation check questionnaire may be used). Moreover, self-reported typical ER strategies use should be
tested incremental to other, similarly related constructs, such as general emotional intelligence.

Despite this being the first pain-related investigation that focused on the interaction between typical, self-reported ER tendencies and experimental ER induction condition placement, other moderating factors may be explored. For instance, a multitude of psychological processes may interact with the experimental ER induction conditions, such as catastrophizing and self-efficacy (Arnstein, Caudill, Mandle, Norris, & Beasley, 1999; Arnstein, 2000; Borsbo, Gerdle, & Peolsson, 2010; Denison et al., 2007).

Finally, this investigation only examined the effects of two primary ER strategies; however, a variety of ER strategies exists. Researchers may also evaluate the effectiveness of reappraisal in comparison to other ER strategies including distraction (Kohl, Rief, & Glombiewski, 2013; Prins, Decuypere, & Van Damme, 2014), mindfulness (Day, Thorn, & Rubin, 2014; Senders, Yadav, & Shinto, 2014), and acceptance (Braams et al., 2012; Branstetter-Rost, Cushing, & Douleh, 2009; Paez-Blarrina et al., 2008).

**Implications and Concluding Thoughts**

This investigation expanded on current understanding of the relationship between psychological processes and pain. Ultimately, the unique conceptual and methodological features of this study provide greater meaning to the results and allow for increased specificity in the communications model of pain (Hadjistavropoulos et al., 2011) that includes the impact of reappraisal on pain expressions. Namely, results suggest that consciously applying reappraisal (and potentially suppression) during a painful task is adaptive, in that it moderates both cognitively mediated and automatic expressions of
pain regardless of a person’s self-reported typical reappraisal tendencies. Reappraisal may, therefore, be a potentially important strategy to include in pain management initiatives. For instance, applying reappraisal to regulate an acute, painful medical procedure (i.e., an injection) may help reduce the pain experience, more so than not using an ER strategy. Although these clinical implications are tentatively proposed, future clinical research can investigate these possibilities.
References


Borsbo, B., Gerdle, B., & Peolsson, M. (2010). Impact of the interaction between self-efficacy, symptoms and catastrophising on disability, quality of life and health in


Cai, B., & Oderda, G. M. (2012). The association between pain and depression and some determinants of depression for the general population of the united states. *Journal of*


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10.1016/j.brat.2008.05.001


10.1016/j.pain.2011.01.047


Appendix A

Ethics Approval

Certificate of Approval

University of Regina
Research Ethics Board

PRINCIPAL INVESTIGATOR
Amy Hampton

DEPARTMENT
Psychology

REB#2051314

SUPERVISOR
Dr. Thomas Hadjistavropoulos

FUNDER(S)
Canada Foundation for Innovation

TITLE
The Effect of Emotion Regulation Strategies on the Pain Experience

APPROVAL OF
Poster
E-Mail Template
Consent Form
Demographics
Emotion Regulation Questionnaire (ERQ)
Descriptor Differential Scale
Emotion Visual Analogue Scales
Untrained Observer Visual Analogue Scales
Manipulation Check Questionnaire

APPROVED ON
November 7, 2013

CURRENT EXPIRY DATE
November 7, 2014

Full Board Meeting
Delegated Review

CERTIFICATION
The University of Regina Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol, consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS
In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion.

Please refer to the following website for further instructions: http://www.uregina.ca/research/REB/main.shtml

Dr. Larena Hoeber, Chair
University of Regina
Research Ethics Board

Please send all correspondence to:
Office for Research, Innovation and Partnership
University of Regina
Research and Innovation Centre 109
Regina, SK S4S 0A2
Telephone: (306) 585-4775
Fax: (306) 585-4893
research.ethics@uregina.ca
HEALTHY PARTICIPANTS NEEDED FOR RESEARCH IN PAIN

We are looking for volunteers to take part in a study of emotion regulation and pain.

As a participant in this study, you would be asked to: engage in an emotion regulation strategy while completing a pain task. We will be assessing self-reported pain ratings, facial expressions, heart rate, galvanic skin response (i.e., sweating of your skin), and blood pressure.

If you would like more details about the study go to: http://uregina.ca/~hamptoam/

Your participation would involve 1 session, which will last approximately 45 minutes.

In appreciation for your time, you will receive credit towards your psychology class.

For more information about this study, or to volunteer for this study, please sign up at the Department of Psychology Research Participant Pool or contact:
Amy Hampton
Email: hamptoam@uregina.ca

This study has been reviewed and received approval through the Research Ethics Board, University of Regina.
Appendix C

Email Template

Hello,

Thank you for signing up to participate in the study *The Effect of Emotion Regulation Strategies on the Pain Experience*.

The time slot you have signed up for is XXXX. The study should take no longer than 45 minutes to complete.

The location of the study is the second floor of the classroom building: Room CL206

Please ensure that you do not meet the following exclusion criteria:

- Any current cardiovascular disorder (e.g., heart or blood pressure problems)
- Current use of medications that affect cardiovascular function (e.g., beta blockers)
- Daily use of analgesic medication (i.e., pain killers)
- Chronic pain in the last year (daily pain for 3 or more months)
- Skin sensitivities

Additionally, please do not ingest caffeine or alcohol for at least 3 hours before your schedule time.

Your participation is greatly appreciated. Please contact me if you have any questions or concerns.

Thank you,

Amy Hampton, B.A. (Hons.)
Graduate Student in Clinical Psychology
University of Regina
(306) 585-5684
Appendix D

Demographic Questionnaire

These questions are about your demographic information. These items are very important for our research. Responses are confidential. Please answer honestly.

1. Age: ________

2. Date of Birth: ______________

3. Sex:  □ MALE  □ FEMALE

4. Highest Level of Education:
   a. Some high school
   b. Completed high school
   c. Some undergraduate or post-secondary education
   d. Completed undergraduate degree/post secondary certificate
   e. Some graduate education
   f. Completed graduate education

5. Please indicate if any of the following apply to you? (Please circle YES or NO for every item).
   a. Suffer from any cardiovascular disorders      YES  NO
   b. Currently using any cardiovascular medications (e.g., beta blockers)  YES  NO
   c. Currently using analgesic medications daily  YES  NO
   d. Suffered from any chronic pain in the last year
      (e.g., pain that last for more than 3 months)  YES  NO
   e. Currently suffering from psychotic or bipolar disorder  YES  NO
   f. Currently suffering from depression or anxiety  YES  NO
   g. Currently suffering from alcohol or substance abuse  YES  NO

6. Have you ingested caffeine or alcohol in the past 3 hours?  YES  NO
Appendix E

Emotion Regulation Questionnaire (ERQ)

We would like to ask you some questions about your emotional life, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotional life. One is your emotion regulatory strategy, or what you feel like inside. The other is your emotional expression, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the following scale:

1. ____ When I want to feel more positive emotion (such as joy or amusement), I change what I’m thinking about.
2. ____ I keep my emotions to myself.
3. ____ When I want to feel less negative emotion (such as sadness or anger), I change what I’m thinking about.
4. ____ When I am feeling positive emotions, I am careful not to express them.
5. ____ When I’m faced with a stressful situation, I make myself think about it in a way that helps me stay calm.
6. ____ I control my emotions by not expressing them.
7. ____ When I want to feel more positive emotion, I change the way I’m thinking about the situation.
8. ____ I control my emotions by changing the way I think about the situation I’m in.
9. ____ When I am feeling negative emotions, I make sure not to express them.
10. ____ When I want to feel less negative emotion, I change the way I’m thinking about the situation.
Appendix F

descriptor differential scale (DDS)

Please circle one word or word-pair on each of the scales below:

<table>
<thead>
<tr>
<th>Sensory</th>
<th>Unpleasantness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Extremely Intense</td>
<td>A. Very Intolerable</td>
</tr>
<tr>
<td>B. Very Intense</td>
<td>B. Intolerable</td>
</tr>
<tr>
<td>C. Intense</td>
<td>C. Very Distressing</td>
</tr>
<tr>
<td>D. Strong</td>
<td>D. Slightly Intolerable</td>
</tr>
<tr>
<td>E. Slightly Intense</td>
<td>E. Very Annoying</td>
</tr>
<tr>
<td>F. Barely Strong</td>
<td>F. Distressing</td>
</tr>
<tr>
<td>G. Moderate</td>
<td>G. Very Unpleasant</td>
</tr>
<tr>
<td>H. Mild</td>
<td>H. Slightly Distressing</td>
</tr>
<tr>
<td>I. Very Mild</td>
<td>I. Annoying</td>
</tr>
<tr>
<td>J. Weak</td>
<td>J. Unpleasant</td>
</tr>
<tr>
<td>K. Very Weak</td>
<td>K. Slightly Annoying</td>
</tr>
<tr>
<td>L. Faint</td>
<td>L. Slightly Unpleasant</td>
</tr>
<tr>
<td>M. No Sensation of Pain</td>
<td>M. No Discomfort</td>
</tr>
</tbody>
</table>
### Scoring of the Descriptor Differential Scale

<table>
<thead>
<tr>
<th>Sensory</th>
<th>Unpleasantness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Extremely Intense</td>
<td>A. Very Intolerable 44.8</td>
</tr>
<tr>
<td>B. Very Intense</td>
<td>B. Intolerable 32.8</td>
</tr>
<tr>
<td>C. Intense</td>
<td>C. Very Distressing 18.3</td>
</tr>
<tr>
<td>D. Strong</td>
<td>D. Slightly Intolerable</td>
</tr>
<tr>
<td>E. Slightly Intense</td>
<td>E. Very Annoying 12.1</td>
</tr>
<tr>
<td>F. Barely Strong</td>
<td>F. Distressing 11.4</td>
</tr>
<tr>
<td>G. Moderate</td>
<td>G. Very Unpleasant 10.7</td>
</tr>
<tr>
<td>H. Mild</td>
<td>H. Slightly Distressing</td>
</tr>
<tr>
<td>I. Very Mild</td>
<td>I. Annoying 5.7</td>
</tr>
<tr>
<td>J. Weak</td>
<td>J. Unpleasant 5.6</td>
</tr>
<tr>
<td>K. Very Weak</td>
<td>K. Slightly Annoying 3.5</td>
</tr>
<tr>
<td>L. Faint</td>
<td>L. Slightly Unpleasant</td>
</tr>
<tr>
<td>M. No Sensation of Pain</td>
<td>M. No Discomfort 0</td>
</tr>
</tbody>
</table>
Appendix G

Emotion Visual Analogue Scales (VASs)

Instructions: Please rate the way you feel at this moment on the following three scales. The line labeled from 0 to 5 represents the full range of each emotion. Rate the intensity of your feeling by placing circling the point that best indicates how you are feeling at this moment.

0-------------------1-------------------2-------------------3-------------------4-------------------5
NOT AT ALL           EXTREMELY           ANXIOUS            ANXIOUS
TENSE               TENSE
Appendix H

Manipulation Check Questionnaire

These questions are about you the emotion regulation strategy that you were asked to engage in throughout the experiment. These items are very important for our research. Responses are confidential. Please answer honestly.

Please rate each question on the following scale:

1--------------------------2---------------------3-------------------4------------------5
Not at all

1. ____I tried to re-evaluate any thoughts about discomfort
2. ____I tried to reappraise my thoughts about discomfort
3. ____I tried to think in a way that kept me calm
4. ____How hard did you try to re-evaluate your thoughts
5. ____How successful were you at re-evaluating your thoughts
6. ____How often did your mind wander from trying to re-evaluate your thoughts
7. ____I tried to suppress my thoughts about discomfort
8. ____I tried to ignore my thoughts about discomfort
9. ____I tried to not pay attention my thoughts about discomfort
10. ____How hard did you try to suppress your thoughts
11. ____How successful were you at suppressing your thoughts
12. ____How often did your mind wander from trying to suppress your thoughts
Appendix I

Pain Threshold Instructions

“The thermode will now begin to slowly produce heat. I would like you to stop the task, by pressing the green button, as soon as you begin to feel any pain stimulus. So as soon as you feel any pain, press the green button”.
Appendix J

Pain Tolerance Instructions

“In this task, stimulus safety limits will not be exceeded. The thermode will now begin to slowly produce heat. I would like you to stop the task, by pressing the green button, as soon as you feel that you can no longer tolerate the pain. So as soon as you feel you can no longer tolerate the task, press the green button”.
Appendix K

Experimental Manipulation Instructions for Each Condition

Suppression Instructions

“During the experiment, it is very important that you try as hard as you can not to think about any discomfort that you may be experiencing. In other words, ignore and do not think about the pain and discomfort on your arm. Do not think about any behaviours like facial expressions, and physical reactions like your heart rate that may be related to the discomfort.

In using this strategy, for example, an individual with low back pain would try to ignore and not think about that pain. He or she would remove any thoughts about it from his or her mind. He or she would try to not think about the discomfort nor about any physiological and behavioural responses, like sweating, or grimacing related to the pain.

Let’s practice. I want you to imagine that you can feel the heat of the sun on your skin which is protected by sunscreen; you know that you will be out of the sun soon. Now, instead of focusing on any discomfort associated with the heat of the sun, try to stop thinking about the discomfort all together. Do not feel or show any discomfort associated with the heat of the sun. For example, try to ignore any thoughts and physiological reactivity that may be associated with the discomfort. If you can feel your heart rate and blood pressure increasing and feel an increase in sweatiness, try to just ignore the sensations. Really concentrate on ignoring any thoughts associated with heat of the sun.

Like you did with the heat of the sun example, I am asking that you suppress any thought related to pain or the anticipation of pain throughout the study period. Remain
focused on ignoring your thoughts, behaviours, and physiological arousal. Following the thermal stimulation, please remain seated and continue to suppress your thoughts, behaviours, and physiological arousal until the experimenter indicates “end of task”. The physiological recording being taken will help us determine whether you are trying to follow these instructions.”

**Reappraisal Instructions**

“During the experiment, it is very important that you try as hard as you can to think about any discomfort in such a way that will help you remain calm and dispassionate. Change your thoughts, and the way you are thinking about your behaviours like facial expressions, and physical reactions like heart rate, in such a way that you don’t feel any discomfort at all.

In using this strategy, for example, an individual lying down with low back pain would try to reinterpret that sensation of pain so that he or she would not think of it as pain but as something else. He or she, for example, would imagine that he or she were lying on a beach listening to the soothing sounds of the waves and feeling the warmth of the sun on his or her skin. He or she would reinterpret the sensation in his or her lower back as warm rock that was underneath the towel he or she was lying on and not as pain. He or she would think of the rock as slightly annoying but as not taking away the enjoyment of the surroundings. Others may try to think of this experience as an opportunity to learn about psychological experiments rather than as a painful event.

Let’s practice. I want you to imagine that you can feel the heat of the sun on your skin which is protected by sunscreen; you know that you will be out of the sun soon. Now, instead of focusing on any discomfort associated with the heat of the sun, try to
reappraise your thoughts about the discomfort all together. Try to think that you are
relaxing in a warm pool and calmness surrounds you. Reinterpret any thoughts and any
physiological reactivity that may be associated with the discomfort. For example, if you
feel your heart rate and blood pressure increasing and feel an increase in sweatiness, try
to calm yourself by imagining that you are completely relaxed wading in a warm pool.
Really concentrate on reinterpreting your thoughts.

Like you did with the heat of the sun example, I am asking that you reappraise
any thoughts related to pain or the anticipation of pain throughout the study period.
Remain focused on changing your thoughts, behaviours, and physiological arousal in
such a way that you remain calm. Following the thermal stimulation, please remain
seated and continue to reappraise your thoughts, behaviours, and physiological arousal
until the experimenter indicates “end of task”. The physiological recording being taken
will help us determine whether you are trying to follow these instructions.”

**Monitoring Instructions**

“During the experiment, it is very important that you try as hard as you can to
focus on any discomfort that you may be experiencing. Generate a state of total openness
in which the mind is a vast sky. Maintain clear awareness and presence open to the
surrounding space. In other words, when thoughts arise about any discomfort on your
arm simply let them pass through your mind without leaving a trace. When you perceive
physical sensations like facial expressions and heart rate, let them be as they are without
engaging in them or rejecting them. Specifically, observe the thinking process itself and
treat all thoughts as equal in value.
In using this strategy, for example, an individual who experiences low back pain would notice and pay attention to that pain. He or she would closely examine the location, quality, and intensity and allow his or her mind to have thoughts about those sensations. He or she would be very aware of any physiological or behavioural responses that were associated with the pain.

Let’s practice. I want you to imagine that you can feel the heat of the sun on your skin which is protected by sunscreen; you know that you will be out of the sun soon. Now, instead of focusing on any discomfort associated with the heat of the sun, try to allow thoughts about the discomfort to pass through your mind. Accept all thoughts as equal and neither pursue nor reject them. Be aware of any thoughts and physiological reactivity that may be associated with the discomfort. For example, if you feel your heart rate and blood pressure increasing and feel an increase in sweatiness, try to be aware of this and allow the thoughts to pass through your mind. Really concentrate on being aware of your thoughts.

Like you did with the heat of the sun example, I am asking that you monitor any thoughts related to pain or the anticipation of pain throughout the study period. Remain focused on being aware of your thoughts and allow your mind to be calm and relaxed. Pay attention to any thoughts about your behaviours and physiological arousal and allow the thoughts to go through your mind. Following the thermal stimulation, please remain seated and continue to monitor your thoughts, behaviours, and physiological arousal until the experimenter indicates “end of task”. The physiological recording being taken will help us determine whether you are trying to follow these instructions.”