UNIVERSITY OF CALIFORNIA, IRVINE

Reappraisal Mitigates Overestimation of Remembered Pain in Anxious Individuals

THESIS

submitted in partial satisfaction of the requirements

for the degree of

MASTER OF ARTS

in Social Ecology

by

Arpine Hovasapian

Thesis Committee:

Professor Linda J. Levine, Chair

Professor Sally Dickerson

Professor Belinda Campos

2014

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I am grateful for the opportunity to work with my advisor and committee chair, Professor Linda Levine. She has been an inspiring influence on my professional development, career goals, and growth as a researcher. Her continued support, encouragement, and compassion have been invaluable to my progress on this project and in my graduate studies.

I would also like to thank my committee members – Professors Belinda Campos, for her valuable guidance and advice and Professor Sally Dickerson, for her expertise and willingness to always help. I feel fortunate to receive training from such accomplished and caring researchers.

In addition, I would like to express gratitude to my research assistants, who worked diligently and professionally on carrying out our experiment: Claire Arakelian, Jenny Fong, Chelsea Holmes, Karishma Katakia, Jennifer, Tsai, Anne Waddell, and Irada Wattanavitukul,

I thank the Department of Psychology and Social Behavior, including the faculty, staff, and graduate study body, whose training and friendly support helped make the completion of this project possible.

ABSTRACT OF THE THESIS

Reappraisal Mitigates Overestimation of Remembered Pain in Anxious Individuals

By

Arpine Hovasapian

Master of Arts in Social Ecology

University of California, Irvine, 2014

Professor Linda J. Levine, Chair

Anxiety sensitivity, a trait characterized by fear of anxiety-related body sensations, has been linked to heightened attention to pain, appraising body sensations as threatening, and remembering threat-related information. We assessed whether individuals with greater anxiety sensitivity overestimate in remembering pain. We also assessed whether emotion regulation strategies that direct attention away from pain (distraction) or appraisals of pain (reappraisal) would alleviate memory bias. Participants (N = 125) completed a measure of anxiety sensitivity. They were randomly assigned to one of two emotion regulation conditions (distraction, reappraisal) or to a control condition prior to taking part in a cold pressor task. They rated the intensity of pain during and immediately after the task. Memory for pain was assessed 3 to 7 days later. Greater anxiety sensitivity was associated with an increase in threat-related appraisals over time and with remembering pain as having been more intense than originally reported. Engaging in reappraisal mitigated this memory bias but engaging in distraction did not. These findings suggest that health-care practitioners can encourage reappraisal to promote more

positive memories of procedural pain, particularly in highly anxious patients, who tend to misremember pain experiences as worse than experienced.

Reappraisal Mitigates Overestimation of Remembered Pain in Anxious Individuals

Chapter 1: Introduction

Overestimated memories of pain can increase sensitivity to subsequent pain experiences, contribute to the development of chronic pain, and affect future health seeking behavior (Asmundson, Wright, & Hadjistavropoulos, 1997; von Baeyer, Marche, Rocha, & Salmon 2004). The trait of anxiety sensitivity has been linked to negative pain experiences in laboratory trials and clinical settings (Keogh & Birkby 1999; Lang, Sorrell, Rogers, Lebeck, 2006) and may play a role in the development of bias in memory for pain. Anxiety sensitivity refers to the tendency to be fearful of anxiety-related body sensations and is characterized by beliefs that these sensations are signs of danger (Reiss, Peterson Gursky & McNally, 1986). While anxiety sensitivity is correlated with general trait-anxiety, it is a more specific to anxiety-related body sensations and predicts greater pain experiences above and beyond the effects of trait anxiety (Esteve & Camacho, 2008). Anxiety sensitivity has been linked to an information processing system that generally favors threatening information, such as heightened memory for threatening words in memory tasks (Lundh, Czyzykow, & Ost, 1997; Teachman, 2005). This suggests that the trait could also be implicated in the development of more extreme memories of physical pain experiences, as has been found in children's pain (Noel, Chambers, Chambers, McGrath, Klein, & Stewart, 2012).

In the present study, we predicted that higher levels of anxiety sensitivity would be related to misremembered memory for pain and increases in negative appraisals over time. In addition, we predicted that reappraisal, but not distraction, would mitigate memory bias as it would encourage individuals to develop less threatening appraisals of past pain.

Anxiety Sensitivity and Memory for Pain

Anxiety sensitivity may bias memory for pain via two types of information processing, attention and appraisal. First, anxiety sensitivity has been linked to increased attention to threatening information. During a dot-probe task, chronic pain patients who were low in anxiety sensitivity shifted attention away from pain-related stimuli whereas those who were high in the trait responded similarly to pain and non-pain related cues (Asmundson, Kuperos, & Norton, 1997). In a cold pressor pain study, anxiety sensitivity predicted hypervigilant monitoring of internal physical sensations (Esteve & Camacho, 2008). Second, the link between anxiety sensitivity and pain may be mediated by negative appraisals -- the tendency to interpret ambiguous information, such as body sensations, as threatening (Richards, Austin, & Alvarenga, 2001). Both increased attention to pain and negative appraisals of body sensations have been shown to contribute to heightened pain experiences in individuals with anxiety sensitivity. Thus, these information processing biases may also render anxious individuals vulnerable to bias in remembering past experiences of pain, though this memory bias is not well-established.

Because attention and appraisal processes are implicated in anxiety sensitivity, emotion regulation strategies that target these processes might moderate the effect of anxiety sensitivity on pain and memory for pain. Namely, distraction (shifting attention away) and reappraisal (changing appraisals) are two common emotion regulation strategies employed during pain. Few studies have investigated such moderating effects, though there is evidence that distraction is more effective than sensory focusing in highly anxious individuals (Thomson, Keogh, & French, 2011). However, to our knowledge, the interaction of emotion regulation strategies and anxiety sensitivity on *memory* for pain has yet to be investigated. In the present research, we hypothesize

that emotion regulation strategies targeting these attentional and interpretive cognitive biases (distraction and reappraisal) can affect memories for pain experiences.

Support for delayed effects of emotion regulation strategies comes from research showing that reappraisal can influence development of memories. In a study testing memory for emotions after a stressful high school exam, students who reappraised the situation in a positive way later underestimated their previous negative emotions, while those who used distractions during this stressful period did not show this positive memory bias (Levine, Schmidt, Kang, Tinti, 2012). Because memory for emotion fades over time, people draw on current appraisals of past events to remember how they felt. Thus, the emotion regulation strategy of reappraisal can change interpretations of emotional events to be more positive, which can then affect memory for the event. Distraction, on the other hand, shifts attention away from stimuli but does not affect subsequent interpretations of events.

Ample research on the effects of emotion regulation strategies on alleviating pain has been published. These studies have employed a variety of different types of methodologies, regulation instructions, pain induction techniques and pain measures, often yielding mixed findings for emotion regulation effectiveness. The following section provides a review of two of these strategies – distraction and reappraisal.

Emotion regulation and pain

Common ways that people regulate emotions during pain include distracting oneself and reappraising the event in a more positive light. Distraction is perhaps the most commonly used and widely studied method of regulating emotions during pain, with a large majority of people preferring distraction over other coping strategies (McCaul & Haugtvedt, 1982). Distraction involves focusing attention on stimuli and information irrelevant to pain. There is considerable

empirical support for the effectiveness of distraction as a pain alleviating tool. In a meta-analysis of cognitive coping strategies, Fernandez and Turk (1988) found that, in general, cognitive methods are effective in alleviating pain compared to no treatment conditions, and that imagery distraction was the most effective among a class of studied cognitive strategies. Across 61 studies, effect sizes were highest for neutral and pleasant imaginings, followed by external focus of attention, rhythmic cognitive activity, and pain acknowledging, though no significant differences across any pair-wise comparisons were found. Fernandez and Turk explain these findings in terms of attentional demand. Imagery strategies may be more effective than acknowledging pain because they require more attentional resources. More recently, in a review of 11 studies, Malloy and Milling (2010) found that virtual reality distraction significantly reduced pain as well as discomfort. In addition, using a cold pressor task to induce pain, Mitchell, MacDonald and Knussen (2008) found that listening to preferred music during pain significantly increased tolerance, increased control, and decreased anxiety compared to a silence condition.

Other studies have found small or no effects of distraction on pain (e.g., Read & Loewenstein, 1999; Martin, 2006). For example, Haythornwaite, Lawrence, and Fauerback (2001) found that musical distraction produced no effects on ratings of experienced pain or retrospective pain. Similarly, in a study comparing distraction stimuli that required various levels of attention, McCaul, Monson and Maki (1992) found that greater distraction failed to reduce responses to a painful cold pressor task. It should be noted that inconsistencies across studies seem to indicate that the strength of the effect of distraction on pain seems to be sensitive to various methodological and procedural variations, including the type of distraction being used and when the rating of pain is taken (also see Eccleston, 1995).

A second type of emotion regulation involves changing the way one thinks about an emotion eliciting event. Reappraisal involves changing appraisals of an aversive situation in a way that reduces its negative emotional impact (Gross & John, 2003). Reappraisal has received much attention in psychological literature as a stress reducer (Augustine & Hemenover, 2009), but has been applied much less often to the study of pain reduction. Reappraisal is a strategy that is likely employed spontaneously in clinical settings (convincing oneself that the pain is not so bad). Using a meta-analysis on the general effectiveness of emotion regulation strategies, Augustin and Hemenover (2009) find that reappraisal, followed by distraction, is the most effective strategy. In addition, Hoffman, Heering, Sawyer and Asnaani (2009) compared reappraisal, suppression and acceptance-based regulation strategies while having participants give an impromptu speech in front of a video camera. They found that reappraising and accepting anxiety reduced physiological arousal more than suppressing anxiety and that overall, reappraisal was the most effective in regulating anxiety.

Though reappraisal has been studied more extensively in stress research, there is indication that it can also be an effective pain relieving tool. For example, in a meditation and pain study, two experiments attested to the more powerful pain relieving effect of meditation in comparison to distraction and relaxation (Zeidon, Merchant & Goolkasian, 2010). In the meditation instructions, participants were instructed to focus on the flow of breath while nonjudgmentally becoming aware of thoughts, senses, and feelings. The authors contend that this approach also encourages people to view aversive sensations as fleeting. This nonjudgmental approach to negative experiences may represent a reappraisal process in which the negative impact of pain is diminished.

Extending on these findings that reappraisal could alleviate the immediate experience of pain , there is also indication that changing appraisals could have long term, or delayed, effects. As discussed in the previous section, changing appraisals to be more positive during a stressful period could promote more positive memories of the experience over time (Levine, Schmidt, Kang, Tinti, 2012). As memories for emotions (or pain) fade over time, people tend to rely on current appraisals and experiences to remember how they must have felt (see also Kent, 1985). Thus, if anxious individuals have overestimated memories of pain experiences, encouraging them reappraise during the pain experience could encourage more positive memories in the longer term.

Chapter 2 : Method

This study investigated whether greater anxiety sensitivity was associated with an overestimation in memory for pain using a cold pressor task. We also tested the effects of two emotion regulation strategies (distraction and reappraisal) on experienced and remembered pain. We tested whether the use of emotion regulation strategies that target the attention to, and appraisals of, pain mitigated bias in memory for pain in anxious individuals. All study materials and procedures were approved by the Institutional Review Board at the University of California, Irvine. A waiver of written consent was approved and verbal consent was obtained from each participant.

Participants

The initial sample consisted of 151 undergraduates who received course credit for participation. Cases were excluded from analyses if the participant removed his or her hand from water before 2 minutes elapsed (12 cases). The remaining sample consisted of 139 participants, of which 125 completed the follow up assessment within 7 days (3 completed in over 7 days). The final sample (106 female, 19 male; mean age = 20.49 years, range = 18 to 41 years) reported their ethnicity as predominantly Asian (55%), Latino (21%), and White (17%). Following safety guidelines for the cold pressor task (von Baeyer, 2005),, individuals were screened and not allowed to participate if they had (a) cuts or sores on their nondominant hand; (b) a history of cardiovascular disorder, fainting, seizures, or frostbite; or (c) experienced chronic pain lasting 4 months or more.

Design

Participants were randomly assigned to one of two emotion regulation conditions (distraction, reappraisal) or to a control condition prior to taking part in a cold pressor task. They

rated the intensity of pain during and immediately after the task and completed questionnaires that assessed their appraisals of the task (see below). An online questionnaire, sent three days later, assessed memory for pain, current appraisals of the cold pressor task and anxiety sensitivity. This study was part of a larger research project which assessed feelings of distress, spontaneous use of emotion regulation strategies, appraisals related to catastrophizing, and in a separate group of participants, responses to empathy. Questions about distress and spontaneous emotion regulation followed those about pain, and these variables did not interact with ratings or appraisals of pain, which were the focus of the present study.

Anxiety Sensitivity Index.

The Anxiety Sensitivity Index (ASI) is a 16-item scale that measures fear of anxiety-related body sensations (Reiss, Peterson, Gursky, M& cNally, 1986). The ASI has been shown to have high internal consistency and test-retest reliability. Items include, "Unusual body sensations scare me," "It scares me when my heart beats rapidly," and "It scares me when I am nervous." Items are rated on a 5-point scale from 0 *(very little)* to 4 *(very much).* An averaged total ASI score was used for analyses.

Cold Pressor Task

The cold pressor apparatus consisted of a 2 gallon tub divided into two compartments. A water pump in the bottom compartment kept the water circulating. The water was kept at a temperature of 9-11º Celsius. Pilot testing indicated that this temperature was painful, yet tolerable enough to ensure that most participants would keep their hand in for the full two minutes. Participants were told that they could withdraw from the study at any point without penalty and they could remove their hand from the water if it became unbearable.

Procedure

Participants completed a 45 minute experimental session, and three to seven days later (*M* = 4.05, *SD*= 1.35) completed a 10 minute online questionnaire. The experimental session was conducted by a female experimenter. Before providing verbal consent, participants were told that the purpose of the study was to examine reactivity to cold temperatures. They were told that brief exposures to cold temperatures can increase the body's capacity to adjust to cold temperatures. This statement was later repeated to participants in the reappraisal condition and provided a rationale as to how the cold pressor task might benefit them.

At the start of the study, participants completed a neutral task (sorting a playing card deck) to induce a neutral mood state. Participants then immersed their left hand in luke-warm water (35-37º Celsius) for two minutes in order to familiarize them with the procedure and reduce differences in hand temperature between participants. A computer screen displayed a morphing 3-D box screen saver for all participants, though only the distraction condition was explicitly instructed to attend to the screen saver.

Emotion regulation instructions. Participants were then given emotion regulation instructions and subsequently underwent the cold pressor task. Control participants did not receive any instructions to regulate emotions. Instructions were given verbally by the research assistant and differed only with respect to emotion regulation:

Distraction: "While your hand is in the water, you'll see a picture on the computer screen. Even though the cold water can be painful, try not to pay attention to the feelings in your hand. Instead, focus on the shapes and colors you see on the screen. Remember to focus only on the pictures on the screen."

Reappraisal: "While your hand is in the water, think about how brief exposure to cold helps the body adjust to cold temperatures. So even though the cold water can be painful, this is good for your health. Remember to focus on the benefits to your body."

Pain measures. Pain was assessed at four time points (every 30 seconds) during lukewarm and cold water hand immersions, using a scale ranging from 0 *(no pain)* to 10 *(extreme pain).* Participants were asked, *"How much pain do you feel right now?"* They completed the ratings on a computer using their right hand. Immediately after hand removal, participants reported the average pain they had experienced during the cold pressor task using the same scale. Questions regarding their appraisals during pain, and their attempts to regulate emotion, were then asked to determine how the instructions had influenced participants' thoughts and feelings during the task.

Appraisal measures. An 18-item questionnaire was developed for this study to assess changes in appraisals about the task and as an emotion regulation manipulation check. Ratings were made using a scale ranging from 0 (*not at all*) to 7 *(all the time).* Items were adapted from the Pain Catastophizing Scale (Sullivan, Bishop & Pivik, 1995). Two items measured the implementation of distraction and reappraisal strategies. The remaining 16 items, which are shown in Table 3.3 in the Results section, measured appraisals concerning future threat (e.g., *I was afraid the pain would get worse*), present experience (e.g., *I thought about how much it hurt*), and past experience (*I thought about other painful experiences I've had*).

Memory assessment. A link to an online questionnaire was emailed to participants three days after the experimental session. Participants were asked to recall the average pain they had experienced during the cold pressor task. The questionnaire included the same pain and appraisal

questions they had completed immediately following the cold pressor. Participants also completed a series of individual difference measures, including the ASI.

Chapter 3 – Results

Emotion Regulation Manipulation Check

Analysis of variance tests indicated that participants in the distraction and reappraisal condition followed emotion regulation instructions. Significant group differences were observed for endorsement of the statement, "I paid attention to the picture on the computer screen," $F(2, 118) = 26.05$, $p < .001$, $\eta^2 = .31$. Post hoc analyses using Games-Howell statistics for unequal variances indicated that participants in the distraction condition ($M = 5.54$, $SD = 1.25$) endorsed this statement more than participants in the reappraisal ($M = 2.82$, $SD = 2.50$) and control conditions ($M = 2.43$, $SD = 2.31$), $ts > 5.69$, all $ps < .001$. Group differences were also seen for the statement, "I thought about how this experience would help me cope with cold weather," $F(2, 118) = 4.95$, $p = 0.009$, $\eta^2 = 0.08$. Tukey post hoc tests indicated that participants in the reappraisal condition ($M = 3.74$, $SD = 2.06$) endorsed this statement significantly more than participants in the distraction ($M = 2.31$, $SD = 2.41$) and control conditions ($M = 2.34$, $SD = 2.37$), $ts > 2.73$, all $ps < .02$.

Pain Intensity

Table 3.1 displays overall descriptives for all pain measures. Repeated measures analysis of variance tests on experienced and remembered pain showed that, as a group, participants showed no significant bias in memory for pain, $F(1, 121) = 0.40$, $p = .53$, $\eta^2 = 0.003$, and no significant effect of emotion regulation on average pain intensity, $F(2, 120) = 1.01$, $p = .39$, $\eta^2 = 0.08$, or ASI scores, $F(2, 122) = .46$, $p = 0.63$, $\eta^2 = .007$. In addition, ASI scores were not correlated with average experienced pain ($r = .07$, $p = .47$) or with experienced pain ratings every 30 seconds during the cold pressor task ($r's < .08$, $p's > .18$).

Table 3.1

Descriptive statistics for pain and ASI (N=125)

	Mean	*SD*	*Range*
Pain at 30 seconds	4.30	1.65	(0,7)
Pain at 60 seconds	4.85	1.56	(1,7)
Pain at 90 seconds	4.45	1.58	(0,7)
Pain at 120 seconds	3.82	1.74	(0,7)
Average pain	4.43	1.33	(0,7)
Remembered average pain	4.44	1.48	(0,7)
ASI score (averaged)	1.31	0.71	(0,4)

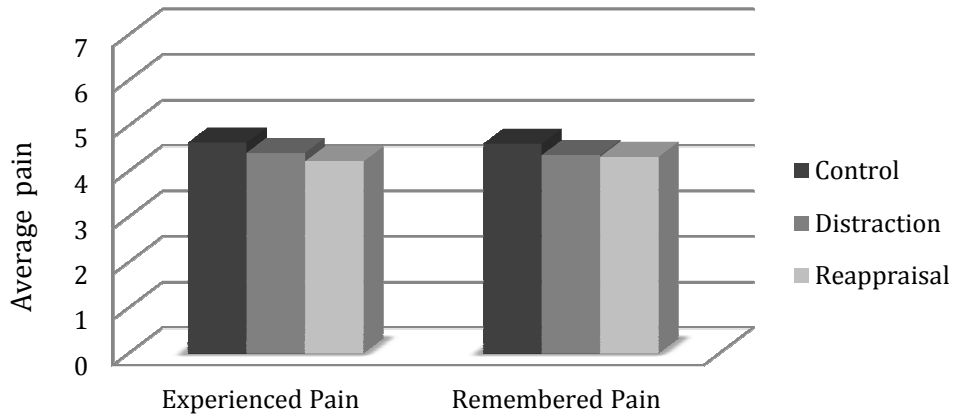

Figure 3.1. No differences were found for pain across emotion regulation conditions during cold pressor (experienced pain) nor at follow-up (remembered pain). There were also no overall memory changes for pain across all groups collapsed nor for each group separately.

Change in appraisals

Anxiety sensitivity predicted changes in memory for three items related to *future-oriented threat.* For example, for the item "I was worried about what the cold was doing to my hand," a one unit increase in average anxiety sensitivity score was associated with a .79 unit increase in endorsement of the item at recall after controlling for initial appraisal and experienced pain, β = .22, $t(99)$= 3.01, p = .003. Similar memory biases for anxiety sensitivity were found for the items "I was afraid that the pain would get worse," β = .25, $t(100)$ = 2.82, p = .006, and for the item "I thought I wanted the pain to go away," β = .19, $t(100)$= 2.86, p =.02.

Table 3.2

Appraisals Items for Pain

Type	**Appraisal items**
Future-oriented threat	
	I wondered whether this was bad for my hand.
	I worried about what the cold was doing to my hand.**
	I was afraid that the pain would get worse. **
	I thought that I wanted the pain to go away.*
	I worried about how long I'd have to be in pain.
Past-oriented thoughts	I thought of other painful experiences I've had.
Present-oriented	
	I tried not to think about the pain.
-Attention to pain	I thought about the pain I was experiencing.
	I felt like I couldn't stand the pain anymore.
	I thought about how much it hurt.
	I couldn't keep the pain out of my mind.
	I thought about things not related to the pain.
	I told myself I could handle this.
	I thought about how this was an interesting experience.
-Positive	I reminded myself that the pain would end soon.
	I challenged myself to be strong.

*$p < .05$. **$p<.01$.

Anxiety sensitivity and bias in memory for pain

To assess the relation of anxiety sensitivity and emotion regulation strategies to remembered pain, we conducted a hierarchical linear regression. Remembered average pain was entered as the dependent variable and experienced average pain was entered in Step 1. After controlling for experienced pain, the remaining variance in remembered pain represented memory bias. Anxiety sensitivity and dummy-coded variables for reappraisal and distraction were added in subsequent steps with the control condition serving as the comparison group. Interaction terms for anxiety sensitivity and each of the dummy-coded emotion regulation variables were entered at the last step to assess whether emotion regulation strategies moderated the association between anxiety sensitivity and memory bias. Residual plots for multiple regression analyses indicated that homoscedasticity assumptions were met.

As can be seen in Table 2, experienced pain was the strongest predictor of remembered pain, $\beta = 0.85$, $t(116) = 18.05$, $p < 0.001$. Step 2 shows that anxiety sensitivity was a significant predictor of remembered pain after controlling for experienced pain, indicating a memory bias, $\beta = 0.12$, $t(120) = 0.2.59$, $p = .01$. Thus, the greater participants' anxiety sensitivity, the more they overestimated when remembering pain.

Table 3.3

Predictors of Remembered Pain (N = 123)

	Step 1			Step 2			Step 3			Step 4		
Predictors	*b*	*SE(b)*	*β*	*b*	*SE(b)*	*β*	*b*	*SE(b)*	*β*	*b*	*SE(b)*	*β*
Experienced Ave Pain	.96***	.05	.85	0.95***	.05	.85	.95**	.05	.85	0.96**	.05	.85
Anxiety Sensitivity				.26*	.10	.12	.26*	.10	.12	.421*	.15	.20
Reappraisal							.14	.17	.04	.88*	.37	.28
Distraction							.04	.17	.01	.14	.35	.04
Reappraisal*ASI										-.55*	.24	-.26
Distraction*ASI										-.05	.24	-.02
Constant	.20	.25		-.10	.27		-0.18	.31		-.43	.35	
ΔR^2	.72			.02			.002			.01		
F(df)	312.393(2, 121)***			166.85(2, 120)***			82.73(4, 118)***			57.77(6, 116)***		

*$p < .05$. **$p < .01$. ***$p < .0$

Reappraisal moderates the relation between anxiety sensitivity and memory bias

Step 3 of Table 3.3 shows that distraction and reappraisal did not predict remembered pain. However, as can be seen in Step 4, the relation between anxiety sensitivity and memory bias was moderated by reappraisal, β = -0.26, $t(116)$ = -2.25, p = 0.03. This interaction is depicted in Figure 1. Higher scores on anxiety sensitivity were related to greater memory bias, indicating that participants overestimated in remembering pain. The exception was participants who were instructed to engage in reappraisal. A simple slopes analysis revealed that, as anxiety sensitivity increased, no significant change in remembered pain was found for those who reappraised (p = .51), but significant increases in remembered pain were observed for participants in the control condition (p = .005) and in the distraction condition (p = .05).

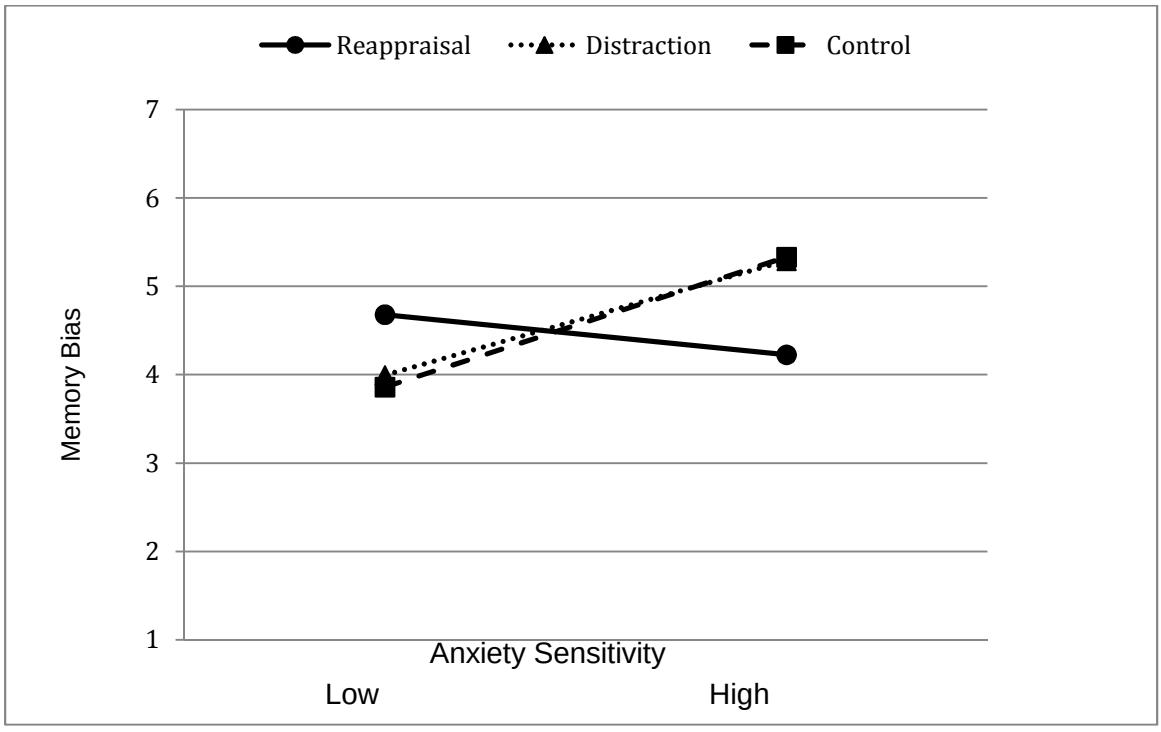

Figure 3.2 Memory bias and anxiety sensitivity across emotion regulation conditions. Memory bias refers to the intensity of pain remembered controlling for the intensity of pain experienced.

Chapter 4 – Discussion

Anxious individuals often show biases toward attending to and remembering threatening information. This study investigated the relation between anxiety about body sensations, known as anxiety sensitivity, and overestimation in remembering pain. We also investigated whether engaging in common emotion regulation strategies, distraction and reappraisal, would mitigate bias in memory for pain. These strategies were selected because they have been shown to be effective in coping with pain and because they target the attentional and interpretive processes that characterize individuals with anxiety sensitivity and that may promote memory bias. This study is the first to assess whether adults with anxiety sensitivity are prone to overestimation in remembering pain, and whether distraction and reappraisal protect against this memory bias.

Memory bias was observed. The greater participants' anxiety sensitivity, the more they overestimated in remembering the intensity of pain they had experienced during a cold pressor task relative to their reports immediately after the task. Past research has shown that anxiety sensitivity is associated with a memory bias towards threat-related information. Such studies typically have participants recall a list of neutral or threat-related words. The present study extended this effect to memory of physical pain. Just as those high in anxiety sensitivity selectively remember threat-related words, this study found that they selectively remember threat-related thoughts during a pain experience.

When comparing appraisals made during pain induction to memories of appraisals up to one week later, higher anxiety sensitivity was related to changes in appraisals related to future-oriented threat. One explanation for this finding is that when people recall pain, they have limited access to actual physical experience and rely instead on their current thoughts or

appraisals of the experience. This is supported by the delayed effect of reappraisal on remembered pain. An interaction between instructions to engage in positive reappraisal and anxiety sensitivity was observed such that reappraisal mitigated the relationship between anxiety sensitivity and overestimated memories for pain. Thus, when anxious individuals were instructed to appraise pain in a positive way, they did not overestimate later in remembering their pain. Distraction, which targets attention but not interpretation, did not protect against memory bias. The delayed positive effect of reappraisal suggests that engaging in reappraisal was not powerful enough to counter the intense pain felt during the cold pressor task but had the long term benefit of affecting memories for pain.

Anxiety sensitivity was not correlated with initially-reported pain intensity. This result is consistent with Esteve and Camacho's (2008) findings that anxiety sensitivity predicted a behavioral measure of pain tolerance (time at which participant removed hand from water), but did not predict immediate self-reports of pain.

In addition, no significant differences were found for any real-time pain measures across emotion regulation conditions. Though distraction and reappraisal have been shown to be effective emotion regulation strategies in many studies (Malloy & Milling, 2010; Zeidan Gordon, Merchant, & Goolkasian, 2010) some studies have observed no effects on pain reduction (Haythornthwaite, Lawrence, & Fauerback, 2001). In a review, Eccleston concluded that the strength of the effect of emotion regulation strategies on pain is sensitive to methodological and procedural variations, including the content of the strategy being taught, experimenter instructions, pain induction procedure and the type of measure taken (1995). It is possible that the emotion regulation strategies in the present study were too subtle to produce an effect on experienced pain. The content of the strategies was designed to be easily implemented in a

medical setting; reappraisal instructions were brief and the distraction stimulus was subtle. Future studies can investigate these same questions using more powerful emotion regulation methods, such as using a distraction stimulus that is more attentionally demanding or longer and more thorough reappraisal instructions. Additionally, other emotion regulation strategies not investigated in the current study could be tested. For example, past research has investigated relaxation techniques and sensory monitoring (e.g., Zeidan Gordon, Merchant, & Goolkasian, 2010).

Several limitations should be noted. First, the present research identified anxiety sensitivity as a predictor of memory bias for pain. As noted above, this trait is associated with general anxiety and other anxiety disorders (Keogh & Birkby, 1999), but predicts negative experiences of pain above and beyond general anxiety (Esteve & Camacho, 2008). Despite this, it is possible that the kinds of biases investigated here also characterize people who are more generally anxious. Anxiety sensitivity is likely to be more specifically related to individuals' appraisals of ambiguous bodily sensations than general anxiety, but reappraisal may be beneficial for individuals with other forms of anxiety as well. Clinicians are more likely to have information about their patients' histories with general anxiety than anxiety sensitivity in particular, thus, this possibility has important implications for clinical practice and should be investigated in future research.

A second limitation concerns the emotion elicitation instructions. Manipulation check questions asked immediately after the cold pressor task indicated that participants in the reappraisal condition reported more positive appraisals of their pain than did participants in the other conditions. Participants in the distraction condition reported attending more to the image on the computer screen than did than participants in the other conditions. However, the reappraisal

instructions were subtle and having participants in the distraction condition provide online pain ratings likely decreased the effectiveness of the distracting stimulus, a problem that is difficult to preclude. More powerful emotion regulation manipulations may influence experienced as well as remembered pain, even in people low in anxiety. Finally, consistent with the gender ratio of undergraduates in the subject pool, this study used a largely female sample, and thus gender comparisons could not be made. Since gender has been shown to affect pain tolerance as well as the association between anxiety sensitivity and pain (Keogh, Barlow, Mounch & Bond, 2006), it is possible that effects in the present study vary across gender.

In conclusion, this study demonstrated a bias towards overestimated memories of pain in individuals high in anxiety sensitivity. Instructions to engage in positive reappraisal during a painful experience led to changes in appraisals over time that favored less threatening interpretations of the experience. Moreover, engaging in reappraisal mitigated the tendency of more anxious individuals to overestimate in remembering the intensity of pain they had experienced. This effect should be investigated more thoroughly in future studies, by assessing appraisals across several time points and across a longer stretch of time. Although this study was able to capture memory changes 3-5 days later, future studies can increase this retention interval to capture longer-term memory biases. With these precautions, these findings suggest that health-care practitioners can use reappraisal instructions to promote more positive attitudes towards procedural pain, particularly in highly anxious patients.

References

Asmundson, G. J., Kuperos, J. L., & Norton, G. R. (1997). Do patients with chronic pain selectively attend to pain-related information?: preliminary evidence for the mediating role of fear. *Pain*, *72*(1-2), 27–32.

Asmundson, G. J. G., Wright, K. D., & Hadjistavropoulos, H. D. (2005). Hypervigilance and attentional fixedness in chronic musculoskeletal pain: consistency of findings across modified stroop and dot-probe tasks. *The Journal of Pain*, *6*(8), 497–506. doi:10.1016/j.jpain.2005.02.012

Augustin, A.A., Hemenover, S.H. (2008). On the relative effectiveness of affect regulation strategies: A metaanalysis. In *Cognition and Emotion*. London: Pschology Press.

Chorney, J., Hammell, C., Blount, R., McLaren, C.E., Chen, W., & Kain, Z.N. (2009). Healthcare provider and parent behavior and children's distress and coping at anesthesia induction. *Anesthesiology, 111*, 1290-6.

Christenfeld, N. (1997). Memory for pain and the delayed effects of distraction. *Health Psychology, 16,* 27-330.

Fernandez, E. & Turk, D.C. (1989) The utility of cognitive coping strategies for altering pain perception: a meta-analysis. *Pain, 38,* 123-135.

Eccleston, C. (1995). The attentional control of pain: methodological and theoretical concerns. *Pain, 63,* 3-10.

Esteve, M. R., & Camacho, L. (2008). Anxiety sensitivity, body vigilance and fear of pain. *Behaviour research and therapy*, *46*(6), 715–27. doi:10.1016/j.brat.2008.02.012

Gross, J.J. & John, O.P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85,* 348-363. doi: 10.1037/0022-3514.85.2.348

Haythornthwaite, J.A., Lawrence J.W., & Fauerback J.A. (2001) Brief interventions for burn pain. *Annals of Behavioral Medicine*. *23*(1), 42-49.

Hoffman, S.G., Heering, S., Sawyer, A.T., Asnaani, A. (2009). How to handle anxiety: The effects of reappraisal, acceptance, and suppression strategies on anxious arousal. *Behaviour Research and Therapy. 47* .389–394

Kent, G. (1985). Memory of Dental Pain. *Pain, 21,* 187-194.

Keogh, E., Barlow, C., Mounce, C., & Bond, F. W. (2006). Assessing the relationship between cold pressor pain responses and dimensions of the anxiety sensitivity profile in healthy men and women. *Cognitive behaviour therapy*, *35*(4), 198–206. doi:10.1080/16506070600898330

Keogh, E., & Birkby, J. (1999). The Effect of Anxiety Sensitivity and Gender on the Experience of Pain. *Cognition & Emotion*, *13*(6), 813–829. doi:10.1080/026999399379096

Keogh, E., & Cochrane, M. (2002). Anxiety sensitivity, cognitive biases, and the experience of pain. *The Journal of Pain*, *3*(4), 320–329. doi:10.1054/jpai.2002.125182

Lang, A. J., Sorrell, J. T., Rodgers, C. S., & Lebeck, M. M. (2006). Anxiety sensitivity as a predictor of labor pain. *European journal of pain (London, England)*, *10*(3), 263–70. doi:10.1016/j.ejpain.2005.05.001

Levine, L. J., Schmidt, S., Kang, H. S., & Tinti, C. (2012). Remembering the silver lining:

Reappraisal and positive bias in memory for emotion. *Cognition and Emotion.*

Lundh, L., Czyzykow, S., & Ost, L. (1997). Explicit and implicit memory bias in panic disorder with agoraphobia. *35*(11), 1003–1014.

Malloy, K.M. & Milling, L.S. (2010). The effectiveness of virtual reality distraction for pain reduction: A systematic review. Clinical Psychology Review. 30. 1011-108. doi:10.1016/j.cpr.2010.07.001.

Martin, G.N. (2006). The effects of exposure to odor on the perception of pain. *Psychosomatic Medicine, 68,* 613-616.

McCaul, K. D., & Haugtvedt, C. (1982). Attention, distraction, and cold pressor pain. *Journal of Personality and Social Psychology, 43*, 154-162.

McCaul, K. D., Monson, N., & Maki, R. (1992). Does distraction reduce pain-produced distress among college students? *Health Psychology, 11*, 210-217.

McNally, R. J., Hornig, C. D., Hoffman, E. C., & Han, E. M. (1999). Anxiety sensitivity and cognitive biases for threat. *Behavior Therapy*, *30*(1), 51–61. doi:10.1016/S0005-7894(99)80045-8

Mitchell, L.A., MacDonald R.A.R., Knussen C. (2008). An investigation of the effects of music and art on pain perception. *Psychology of Aesthetics, Creativity, and the Arts*, *2*(3), 162-170.

Noel, M., Chambers, C. T., McGrath, P. J., Klein, R. M., & Stewart, S. H. (2012). The role of state anxiety in children's memories for pain. *Journal of pediatric psychology*, *37*(5), 567–79. doi:10.1093/jpepsy/jss006

Read, D. & Loewenstein, G. (1999). Enduring Pain for Money: Decisions Based on the Perception and Memory of Pain. *Journal of Behavioral Decision Making,* 12, 1-17.

Reiss, S., Peterson, R. a, Gursky, D. M., & McNally, R. J. (1986). Anxiety sensitivity, anxiety frequency and the prediction of fearfulness. *Behaviour research and therapy*, *24*(1), 1–8. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3947307

Richards, J. C., Austin, D. W., & Alvarenga, M. E. (2001). Interpretation of Ambiguous Interoceptive Stimuli in Panic Disorder and Nonclinical Panic, *25*(3), 235–246.

Sullivan, M.J.L, Bishop, S.R., & Pivik, J. (1995). The Pain Catastrophizing Scale: Development and Validation. *Psychological Assessment, 7*(4), 524-532

Teachman, B. a. (2005). Information Processing and Anxiety Sensitivity: Cognitive Vulnerability to Panic Reflected in Interpretation and Memory Biases. *Cognitive Therapy and Research*, *29*(4), 479–499. doi:10.1007/s10608-005-0627-5

Thompson, T., Keogh, E., & French, C. C. (2011). Sensory focusing versus distraction and pain: moderating effects of anxiety sensitivity in males and females. *The journal of pain : official journal of the American Pain Society*, *12*(8), 849–58. doi:10.1016/j.jpain.2011.01.004

Vallerand, a H. (1995). Gender differences in pain. *Image--the journal of nursing scholarship*, *27*(3), 235–7. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7590808

Von Baeyer, C. L., Marche, T. A, Rocha, E. M., & Salmon, K. (2004). Children's memory for pain: overview and implications for practice. *The Journal of Pain*. 5(5), 241–9. doi:10.1016/j.jpain.2004.05.001

Von Baeyer, C.L., Piira, Tiina, Chambers, C.T., Trapanotto, M., & Zeltzer, L.K. (2005). Guidelines for the cold pressor task as an experimental pain stiumul for use with children. *The Journal of Pain*, 6, 218-227. doi: 10.1016/j.jpain.2005.01.349.

Zeidan, F. Gordon, N. Merchant, J. Goolkasian, P. (2010). The Effects of Brief Mindfulness Meditation Training on Experimentally Induced Pain. *The Journal of Pain*, 11(3), 199-209. Doi:10.1016/j.jpain.2009.07.015

Appendix A: Anxiety Sensitivity Index

(Reiss, Peterson, Gursky, M& cNally, 1986).

Please rate the extent to which the following statements describe how you feel in general.

0	1	2	3	4
(very little)	(a little)	(some)	(much)	(very much)

It is important to me not to appear nervous

When I cannot keep my mind on a task, I worry that I might be going crazy

It scares me when I feel ‘shaky’ (trembling)

It scares me when I feel faint

It is important to me to stay in control of my emotions

It scares me when my heart beats rapidly

It embarrasses me when my stomach growls

It scares me when I am nauseous

When I notice that my heart is beating rapidly, I worry that I might have a heart attack

It scares me when I become short of breath

When my stomach is upset, I worry that I might become seriously ill

It scares we when I am unable to keep my mind on a task

Other people notice when I feel shaky

Unusual body sensations scare me

When I am nervous, I worry that I might be mentally ill

It scares me when I am nervous

Appendix B: Experimental Script

Thank you for signing up for our experiment today. Before you begin, I'd like to ask you to turn your phone off or put it on silent.

Ok, great. This study has 2 parts. This first part is the experimental session, and it will take about 45 minutes. The second part is a follow-up survey that we'll email you in 3 days, and it will take about 10-15 minutes to complete. To get the full credits, you'll have to complete both parts of the study. Before we begin today, I'd like to give you some more information about the study and make sure that you qualify for the experiment.

- In this study, we are looking at how being exposed to cold water for a short time can help people better tolerate cold temperatures.

- Scientists have found that people who live in very cold regions become accustomed to the cold weather, and their bodies become better able to handle these cold temperatures. This is because being exposed to cold temperatures leads to physiological changes that help the body regulate cold temperatures. For example, with cold temperatures, the body produces chemicals to help it adjust and these chemical can be found in saliva.

- During this experiment, we will be looking at improvement in reactivity to cold by using a procedure called the cold pressor task. The cold pressor task is a safe, widely used and well-studied procedure that involves briefly submerging one's hand in cold water. This task has been used thousands of times in research settings and has shown no lasting harmful effects.

- In the procedure today, you will place your hand in a tub of water at two time points. First, you'll place your hand in Lukewarm water and later you will place your hand in ice cold water for a short period of time. We ask that you keep your hand in the water for the full time, but you can pull your hand out of the water if it becomes unbearable and this will not affect your credit. While your hand is in the water, you'll be rating how much pain and distress you are feeling at various time points.

- During the experiment, we will we also ask you several questions about your feelings and behavior. We will be taking two saliva samples in order to measure your physiological responses to the task.

This information sheet gives you some more details about the experiment. I'll give you some time to read over it. Let me know when you are done reading.

Great. Do you agree to participate in the study?

This next form asks you some questions about your health. Many of these questions are there to make sure you qualify for the study. Let me know when you are done.

Hand participant Screening questionnaire.

No, does not qualify: Based on the health questionnaire, you do not qualify for the experiment today. However, you will still receive 1 credit for your participation so far. Thank you for coming in.

Yes, qualifies:

First, I'd like you to sort this deck of playing cards by suits (diamonds, hearts, clubs, spades).

Hand participant mixed deck of cards.

Ok, the next task is a questionnaire on the computer. Make sure you read all the directions for each question. You can click "next" and let me know when you get to the page that says "stop."

Before we continue, I'd like to ask you to switch any jewelry you have on your left hand to your right hand.

Wait until participant switches jewelry
Bring Lukewarm water tub

Next, you'll be placing your left hand in Luke-warm water for a few minutes. This tub has water that is at body temperature. While one hand is in the water, you'll be answering some questions on the computer with your other hand. The questions on the computer will ask you how much pain and distress you are feeling at various time points. You'll know when its time to answer questions on the computer when you hear a beep. So when you hear the beep, that means its time to click the "next" button and make a rating. When you are done with the questions, keep your hand in the water, and I will let you know when you can take it out.

We'd like you to refrain from talking during the task, so before we get started, do you have any questions about what you'll be doing?
(If subject asks how long it will be, tell them the hand immersion will take a few minutes.)

Ok, now place your hand in the water. Make sure you put your hand in up to the wrist.

Make sure P's hand is in water until the wrist*. Click "Next" on the screen.*

Ok, it is time to take your hand out of the water.
Give participant towel to dry hand. Move tub to corner.

At this time, we'll be collecting the first saliva sample. I'm going to give you a tube that looks like this. This tube has a cotton swab inside that you'll be putting in your mouth to collect the saliva. First you'll pull off the ribbed cap like this (show participant), then put the swab in your mouth without touching it and bite on it for about **2** minutes until it's completely soaked. I'll you when the **2** minutes is up. Then, without touching the cotton, put it back in the tube, making sure the smaller tube is inside the larger outer tube and replace the cap. I will let you know when to take the cotton out of your mouth. Here are some magazines you can look at while doing that.
Wait until participant does this.
Indicate to the subject when 2 minutes is up. Record time of saliva collection on Salivette.

Reappraisal or Distraction Group
Ok, before you put your hand in the water, I'm going to give you instructions. In a few minutes, I'll ask you to do 3 things. First, you will put your hand in the cold water. Just like last time, I'd like you to keep your hand in the water until I tell you to take it out. Second, when you hear beep, click "next" and answer the questions just like before. Third...

(Based on condition, give subject one of the following instructions. Place X next to condition. Make sure not to read this part or look at notes.)

___Distraction

While your hand is in the water, you'll see this screen saver on this computer. Even though the water can be painful, try not to pay attention to the feelings in your hand. Instead, focus on the shapes and colors you see on the computer screen. The picture will stay on, so remember to focus back on the screen after each set of questions.

___*Reappraisal*
While your hand is in the water, think about how brief exposures to cold helps the body adjust to cold temperatures. So even though the cold water can be painful, this is good for your health. Remember to focus on the benefits to your body.

Bring cold pressor

I just want to make sure you understand what you'll be doing during the task, can you briefly repeat to me what you'll be doing during the cold water task?

Make sure they mention:

- *put hand in water*
- *answer questions throughout task*

Say one of the following ***even if P mentions it***

- *(for distraction only)*- **Remember to focus on the screen when not answering** questions
- *(for reappraisal)* - **Remember, think about how this can help your body adjust to cold temperatures.**

All groups
Ok, there's one more question for you to answer before you put your hand in the water. Click "next" and let me know when you are done.

Ok, now we'll be doing the cold water task. As soon as you place your hand in the water, click next. Just like last time, we'd like you to refrain from talking during the task. Make sure you place your hand all the way up to the wrist.

Start timer

After last rating, **stop timer.**
Ok, you can now remove your hand from the water.
Give participate towel to dry hand

Record Cold pressor hand immersion time

When you're done drying your hand, there are a few more questions we'd like you to answer. Just click "Next" and it will take you to the questions. Again, make sure you read all the directions for each question thoroughly.

Start timer

Ok, we need to wait a few more minutes before taking the next saliva sample. You can look at these magazines while we wait.

The last part of the experiment is another saliva sample. We'll just be doing the same thing as last time. Put the swab in your mouth and bite on it until I tell you to stop.

Indicate to the subject when 2 minutes is up. Place closed tube in Ziplock bag and record on bag the time of saliva collection and participant number.

Ok, we are all done with the experimental session of this study. Thank you for your participation so far. Remember, for the second part of the study, we'll be emailing you a link to a questionnaire in exactly 3 days. It will only take about 10 minutes. It's very important for the study that you complete the follow-up questionnaire. Once you do, we will assign you the points for the study.

So please watch out for the email we'll send you in 3 days. I know its important for you to get your points, so if it's alright with you, we'd like to send you a reminder text in a few days along with an email. In the meantime, it's really important that you don't talk to others about your details of the study. We'd like everyone to come into the experiment with the same expectations.
Thank you again for your participation. If you have any questions or concerns in the meantime, you can email Arpine, the study coordinator. (arpine26@gmail.com if they ask).

Appendix C: Photo of distraction stimulus