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# Reappraisal mitigates overestimation of remembered pain in anxious individuals

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Anxiety sensitivity, a trait characterised 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 alter appraisals of pain (reappraisal), alleviate memory bias. Participants ( $N = 137$ ) were randomly assigned to one of two emotion regulation conditions or to a control condition before taking part in a cold pressor task. Greater anxiety sensitivity was associated with overestimation in remembering pain. Engaging in reappraisal mitigated this memory bias but engaging in distraction did not. This is the first study to examine the relations among anxiety sensitivity, emotion regulation and memory for pain. The findings suggest that health-care practitioners can encourage reappraisal to promote more positive memories of procedural pain, particularly in patients high in anxiety sensitivity.

*Keywords:* Anxiety sensitivity; Memory; Pain; Emotion regulation; Reappraisal.

Overestimation in remembering pain can increase sensitivity to subsequent pain experiences, contribute to the development of chronic pain, and affect future health-seeking behaviour (Asmundson, Wright, & Hadjistavropoulos, 2005; Chen, Zeltzer, Craske, & Katz, 2000). Anxiety sensitivity, a trait that has been linked to negative pain experiences in research and clinical settings (Keogh & Birkby, 1999; Keogh & Cochrane, 2002; Lang, Sorrell, Rodgers, & Lebeck, 2006), may play a role in the development of this memory bias.

Anxiety sensitivity refers to the tendency to be fearful of anxiety-related body sensations and is characterised by beliefs that these sensations are

signs of danger (Reiss, Peterson, Gursky, & McNally, 1986). Though correlated with trait anxiety, anxiety sensitivity is specific to body sensations and predicts greater pain experience even after controlling for personality traits such as trait anxiety and neuroticism (Esteve & Camacho, 2008). Evidence suggests that anxiety sensitivity acts as a vulnerability factor for negative pain experiences and is implicated in psychopathological responses to pain such as hypochondriasis, recurring headaches and musculoskeletal pain (Keogh & Cochrane, 2002).

Individuals with greater anxiety sensitivity tend to process information in a manner that favours

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threatening information, for instance, showing heightened memory for threatening words in memory tasks (McNally, Hornig, Hoffman, & Han, 1999; Teachman, 2005). This literature suggests that this trait may also be implicated in the development of overestimation in remembering physical pain experiences.

Memory for pain is susceptible to distortion (Redelmeier & Kahneman, 1996) and anxiety can contribute to memory bias (Noel, Chambers, McGrath, Klein, & Stewart, 2012; Rocha, Marche, & von Baeyer, 2009). Studies further show an association between anxiety and memory specifically for pain. Greater state anxiety predicted overestimation of past pain experiences in dental patients (Kent, 1985) and, in a small sample, a nonsignificant trend was found towards overestimating labour pain among women who were low in trait anxiety but high in anxiety sensitivity (Curzik & Jokic-Begic, 2011). Thus, the first aim of the present study was to assess whether anxiety sensitivity is associated with overestimation in recalling pain.

Distorted memories of pain are important because they can contribute to fear and avoidance of medical care and play a role in the development of chronic pain syndromes (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer 2005; Noel et al., 2012). Additionally, clinicians often rely on accurate memory of pain as an important measure of symptom severity (Kent, 1985). Therefore, understanding memory biases for pain, and identifying emotion regulation strategies that can mitigate this bias, may have clinically relevant consequences.

Our second aim was to determine whether altering the cognitive processes by which anxiety sensitivity affects memory serves to mitigate memory bias. Anxiety sensitivity may bias memory for pain via two cognitive processes, attention and appraisal. In a cold pressor pain study, anxiety sensitivity predicted hypervigilant monitoring of physical sensations (Esteve & Camacho, 2008). 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 attended similarly to

pain and non-pain related cues (Asmundson, Kuperos, & Norton, 1997). Anxiety sensitivity also involves negative appraisals—the tendency to interpret ambiguous information, such as body sensations, as threatening (Richards, Austin, & Alvarenga, 2001). Thus, both increased attention to pain and negative appraisals of body sensations have been shown to contribute to heightened pain experience in individuals with anxiety sensitivity. These cognitive processes may also render anxious individuals vulnerable to overestimation when they remember past experiences of pain, though this memory bias is not well-established.

Attention and appraisal processes are implicated in anxiety sensitivity, so distraction and reappraisal, two emotion regulation strategies that target attention and appraisal respectively, may moderate the effect of anxiety sensitivity on memory for pain. The relations among anxiety sensitivity, emotion regulation strategies and memory for pain have yet to be investigated but some findings suggest that reappraisal would have a greater positive effect on memory than distraction. Because memory for emotion fades over time, people must draw on current appraisals of past events to remember how they felt (Levine, 1997; Robinson & Clore, 2002). The emotion regulation strategy of reappraisal changes the interpretation of emotional events which in turn may influence how those events are later remembered. In contrast, distraction shifts attention away from negative events but does not affect their interpretation.

Consistent with this view, one study assessed students' memories for the emotions they experienced while preparing for a stressful high school exit exam. The more students engaged in reappraisal while preparing for the exam, framing the exam as an opportunity for learning and growth, the more they later underestimated in recalling pre-exam negative emotion, and overestimated in recalling pre-exam positive emotion, relative to how they reported having felt at the time. Unlike reappraisal, greater use of distraction to regulate pre-exam emotions did not predict this positive memory bias (Levine, Schmidt, Kang, & Tinti, 2012). In another study, patients were instructed to regulate their emotions during painful

burn treatments. Compared to a distraction group and usual care group, patients who were instructed to reappraise the pain by focusing on the ebb and flow of sensation, and by limiting their appraisals to the sensory experience, reported a reduction in remembered pain. Additionally, across all patients, catastrophic thinking predicted heightened pain memories (Haythornthwaite, Lawrence, & Fauerback, 2001). These studies suggest that appraisals influence memory for emotions. The present study builds on this research by assessing relations among reappraisal, anxiety sensitivity and memory for pain, which have not been previously investigated.

In the present research, we hypothesised that higher levels of anxiety sensitivity would be associated with bias in remembering pain. We further hypothesised that instructions to engage in reappraisal, but not distraction, would mitigate this memory bias by encouraging individuals to develop less threatening appraisals of past pain.

## METHOD

This study assessed the relations among anxiety sensitivity, emotion regulation and memory for pain using a cold pressor task. All study 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 subject. We report how we determined the sample size as well as all data exclusions, manipulations and measures below.

### Design and participants

This was a two-part study that consisted of an experimental session and an online follow up questionnaire.<sup>1</sup> The initial sample consisted of 151 undergraduates who received course credit for participation. Eleven participants did not complete the follow-up assessment and three completed it after 7 days and were thus removed

from analyses. The final sample of 137 (117 females, 20 males; mean age = 20.42 years, range = 18–41 years) reported their ethnicity as Asian (54%), Latino (19%), or White (16%), or reported other ethnicities (11%). Following safety guidelines for the cold pressor task (von Bayer et al., 2005), individuals were screened and not allowed to participate if they (a) had cuts or sores on their left hand; (b) had a history of cardiovascular disorder, fainting, seizures, or frostbite; or (c) had experienced chronic pain lasting over 4 months.

### Pain induction technique

A cold pressor task, during which participants submerged their left hand in cold water for 2 minutes, was used to induce pain. The apparatus consisted of a two gallon tub divided into two compartments. A water pump in the bottom compartment kept water circulating. The water was kept at a temperature of 9–11°C. After pilot testing 12 subjects using various temperatures, we found that this temperature was rated as very painful yet tolerable enough to ensure that most participants would keep their hand submerged for the full 2 minutes. This water temperature also falls in the range of temperatures used in other cold pressor studies (e.g., Kahneman, Fredrickson, Schreiber, & Redelmeier, 1993). Participants were told that they could withdraw from the study at any time without penalty. Twelve participants removed their hand before the full 2 minutes (either momentarily or near the 1 minute mark). These cases remain in all analyses, as their removal did not change the general pattern of results.

## Measures

### *Pain measures*

Average pain was assessed immediately after pain induction. Participants reported the average pain they had experienced during the cold pressor task

<sup>1</sup>This study was part of a larger research project that 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.

using a scale ranging from 0 (*no pain*) to 10 (*extreme pain*). Pain was also assessed every 30 seconds during cold water immersion using the same 11-point scale.<sup>2</sup> Three days later, participants were asked to recall the average pain they had experienced during the cold pressor task using the same scale. One concern in studies of memory for pain is whether participants recall their original pain or their *rating* of pain. Therefore, in the current study, we had participants complete a number of ratings after the cold pressor task to reduce the likelihood that they would later recall their rating of the pain. After rating their average pain, they also completed ratings concerning their appraisals and attention during the task and answered questions about demographics.

#### *Reappraisal and distraction manipulation check*

Questions about appraisals and attention assessed whether participants followed emotion regulation instructions. One item assessed adherence to reappraisal instructions: "I thought about how this experience could help me cope with cold weather". One item assessed adherence to distraction instructions: "I paid attention to the picture on the computer screen". All participants rated both items. Ratings were made using a 7-point scale ranging from 1 (*not at all*) to 7 (*all the time*).

#### *Anxiety sensitivity index*

The Anxiety Sensitivity Index (ASI) is a 16-item scale that measures fear of anxiety-related body sensations (Reiss et al., 1986). The ASI has been shown to have high internal consistency and test-retest reliability. Items include, "Unusual body sensations scare me", and "It scares me when I am nervous". Items were rated on a 5-point scale from 0 (*very little*) to 4 (*very much*). The ASI has been found to follow a hierarchically organised factor structure with a higher order, general factor accounting for a considerable amount of variance in ASI scores (Zinbarg, Barlow, & Brown, 1997).

Thus, a total ASI score was calculated for each participant.

#### **Procedure**

Prior to the experimental session, participants were randomly assigned to emotion regulation conditions: distraction ( $n = 42$ ; 35 females), reappraisal ( $n = 49$ ; 44 females) and control ( $n = 46$ ; 38 females). The session was conducted by a female experimenter and lasted approximately 45 minutes. 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 given to all participants but later repeated only to participants in the reappraisal condition to provide a rationale for 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. They then immersed their left hand in lukewarm water (35–37°C) for 2 minutes to familiarise them with the procedure and to reduce differences in hand temperature among participants. On a nearby computer screen, a morphing 3-D box screen saver was on display for all participants, though only those in the distraction condition were explicitly instructed to attend to the screen saver. This distracting stimulus was chosen because it is similar to what patients might see in medical offices. The screen saver was on display for the entire experimental session.

#### *Emotion regulation instructions*

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

<sup>2</sup> Online pain ratings were not related to anxiety sensitivity scores, did not differ by emotion regulation condition, and are not discussed further.

*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.

Participants subsequently underwent the cold pressor task. They rated the intensity of pain during and immediately after the task and then completed a questionnaire that assessed their appraisals and attention during the task. Three days later participants were emailed an online questionnaire that assessed memory for pain and anxiety sensitivity. Only those who responded within 7 days of the experiment day were included ( $M = 4.03$  days,  $SD = 1.31$ ).

## RESULTS

### Manipulation check

Participants reported engaging in the emotion regulation strategies to which they were assigned. For comparisons across conditions, alpha levels denoting statistical significance were Bonferroni corrected for multiple comparisons;  $p < .016$  (.05/3). Post hoc Tukey tests ( $t_s > 2.94$ ,  $p_s < .004$ ) indicated that those in the reappraisal condition ( $M = 3.82$ ,  $SD = 2.14$ ) reported thinking about the benefits of the pain task more than those in the distraction condition ( $M = 3.32$ ,  $SD = 2.37$ ), or in the control condition, ( $M = 3.41$ ,  $SD = 2.34$ ),  $F(2, 129) = 6.04$ ,  $p = .003$ ,  $\eta^2 = .09$ . Participants in the distraction and control conditions did not differ on their responses to the reappraisal question,  $t(129) = 0.96$ ,  $p = .84$ . For the question assessing

adherence to distraction instructions, Games-Howell post hoc tests were used to account for unequal variances across groups (all  $t_s > 6.80$ ,  $p_s < .001$ ). Participants paid more attention to the computer screen in the distraction condition ( $M = 5.56$ ,  $SD = 1.24$ ) than in the reappraisal condition ( $M = 2.73$ ,  $SD = 2.51$ ) or in the control condition ( $M = 2.57$ ,  $SD = 2.36$ ), *Welch's F*(2, 80) = 6.37,  $p < .001$ ,  $\eta^2 = .29$ . Participants in the reappraisal and control conditions did not differ on their responses to the distraction question,  $t(129) = 0.37$ ,  $p = .71$ .

### Pain intensity

A repeated measures analysis of variance was conducted on experienced and remembered average pain intensity by emotion regulation condition. Overall, experienced pain ( $M = 4.53$ ,  $SD = 1.37$ ) did not differ significantly from remembered pain ( $M = 4.53$ ,  $SD = 1.51$ ),  $F(1, 132) = 0.07$ ,  $p = .93$ ,  $\eta^2 < .001$ . Pain intensity did not differ by condition for experienced pain (reappraisal:  $M = 4.48$ ,  $SD = 1.57$ ; distraction:  $M = 4.44$ ,  $SD = 1.34$ ; control:  $M = 4.65$ ,  $SD = 1.18$ ) or for remembered pain (reappraisal:  $M = 4.50$ ,  $SD = 1.61$ ; distraction:  $M = 4.41$ ,  $SD = 1.56$ ; control:  $M = 4.67$ ,  $SD = 1.37$ ),  $F(2, 132) = 0.04$ ,  $p = .96$ ,  $\eta^2 < .001$ . No gender differences were found for experienced pain,  $t(133) = 1.45$ ,  $p = .15$ , or for remembered pain,  $t(135) = 0.91$ ,  $p = .36$ .<sup>3</sup>

### Anxiety sensitivity, emotion regulation and memory for pain

Each participant's total ASI rating across all items was calculated ( $M = 21.62$ ,  $SD = 11.54$ , range = 0–64). This mean has been categorised as a medium level of anxiety sensitivity (Keogh & Cochrane, 2002). Cronbach's alpha for the 16 items was .90 in our sample. ASI score did not differ by emotion regulation condition,  $F(2, 134) = 1.16$ ,  $p = .32$ ,  $\eta^2 = .02$ , and was not significantly correlated with experienced pain,  $r = .07$ ,  $p = .43$ .

<sup>3</sup> Because of the low number of males in the sample ( $n = 20$ ), analyses on gender differences should be interpreted with caution.

Greater ASI scores tended to be associated with greater remembered pain, but this correlation did not reach traditional levels of statistical significance,  $r = .16$ ,  $p = .07$ . A gender difference was observed such that males reported significantly lower ASI scores ( $M = 14.65$ ,  $SD = 11.46$ ) than females ( $M = 22.81$ ,  $SD = 11.18$ ),  $t(135) = 3.0$ ,  $p = .003$ .

To assess the relation of anxiety sensitivity and emotion regulation to remembered pain, we conducted a hierarchical linear regression analysis. Remembered average pain was the dependent variable and experienced average pain was entered in Step 1 of the analysis. To test for potential sources of memory bias, anxiety sensitivity was added in Step 2, and dummy-coded variables for reappraisal and distraction were added in Step 3 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 in Step 4 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. Because the sample included few males, gender was not included in the final model. However, adding gender to the model did not

predict additional variance in remembered pain and did not change the pattern of findings in the regression analysis.

As can be seen in Table 1, experienced pain was the strongest predictor of remembered pain,  $\beta = 0.84$ ,  $t(133) = 18.17$ ,  $p < .001$ , indicating that participants' memories were fairly accurate. In Step 2, anxiety sensitivity predicted remembered pain after adjusting for experienced pain, indicating memory bias,  $\beta = 0.12$ ,  $t(132) = 2.34$ ,  $p = .02$ . Thus, the greater participants' anxiety sensitivity, the more they overestimated when remembering pain. This effect is shown in Figure 1(a), with low and high anxiety sensitivity groups created for illustrative purposes using a median split in ASI scores (median = 22). Remembered pain was greater than experienced pain for those who were higher in anxiety sensitivity.

Step 3 of Table 1 shows that the distraction and reappraisal experimental conditions did not predict remembered pain. However, as can be seen by the interactions entered in Step 4, the relation between anxiety sensitivity and bias in remembering pain was moderated by the reappraisal condition,  $\beta = -0.15$ ,  $t(128) = -2.46$ ,  $p = .02$ . This interaction is depicted in Figure 1(b). A simple slopes analysis revealed that, as anxiety sensitivity increased, no significant change in remembered

Table 1. Hierarchical regression analysis predicting remembered average pain ( $N = 135$ )

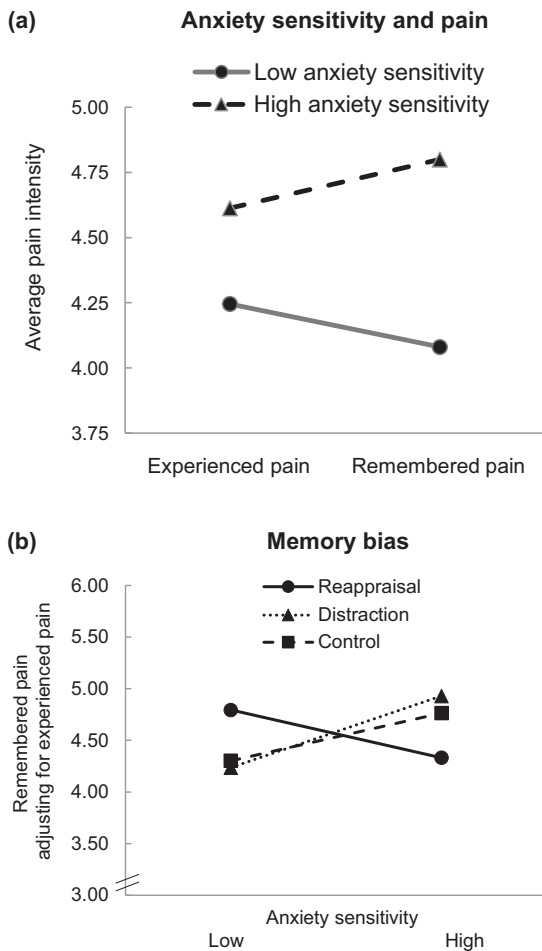
Predictors	Step 1			Step 2			Step 3			Step 4			
	<i>b</i>	<i>SE(b)</i>	$\beta$	<i>b</i>	<i>SE(b)</i>	$\beta$	<i>b</i>	<i>SE(b)</i>	$\beta$	<i>b</i>	<i>SE(b)</i>	$\beta$	
Experienced pain <sup>a</sup>	.93	.05	.84**	.92	.05	.84**	.92	.05	.84**	.93	.05	.84**	
Anxiety sensitivity <sup>b</sup>				.01	.01	.11*	.01	.01	.12*	.02	.01	.19*	
Emotion regulation <sup>c</sup>													
Reappraisal							.01	.17	.01	.03	.16	.01	
Distraction							-.01	.17	-.01	.05	.17	.01	
Reappraisal*ASI										-.04	.01	-.15*	
Distraction*ASI										.01	.02	.01	
Constant	.32	.24		.36	.24		.36	.27		.32	.26		
$\Delta R^2$		.71**			.01*			<.001			.02*		
$\Delta F(df)$		330.07(1, 133)**			5.48(1, 132)*			.004(2, 130)			4.01(2, 128)*		

<sup>a</sup>Experienced pain refers to participants' ratings of their average pain immediately following the cold pressor task. <sup>b</sup>Mean centred ASI score.

<sup>c</sup>Control condition served as the reference group.

\* $p < .05$ . \*\* $p < .001$ .





**Figure 1.** *Anxiety sensitivity and bias in memory for pain.* (a) Low and high anxiety sensitivity groups were created for illustrative purposes using a median split in ASI scores (median = 22). (b) Reappraisal mitigated the overestimation of remembered pain that was associated with greater anxiety sensitivity. Memory bias refers to remembered pain after adjusting for experienced pain in the regression analysis. Low and high anxiety sensitivity were defined as 1 standard deviation below and above the mean.

pain was found for participants in the reappraisal condition ( $p = .31$ ), but significant increases in remembered pain were observed for participants in the distraction condition ( $p = .01$ ) and in the control condition ( $p = .01$ ). Thus, individuals with higher scores on anxiety sensitivity overestimated in remembering pain unless they were instructed to engage in reappraisal.

## DISCUSSION

Anxious individuals show biases towards attending to and remembering threatening information (Teachman, 2005). This study investigated relations between anxiety about body sensations, known as anxiety sensitivity, and bias in remembering pain. We also investigated whether engaging in common emotion regulation strategies, distraction and reappraisal, mitigate bias in memory for pain. These strategies were selected because they have been shown to be effective in coping with pain (Fernandez & Turk, 1989) and because they target the attentional and interpretive processes that characterise individuals with anxiety sensitivity and that may promote memory bias. Memory bias was observed. The greater participants' anxiety sensitivity, the more they overestimated 3–7 days later when 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 greater anxiety sensitivity is associated with a bias towards remembering threat-related information when participants are asked to recall lists of neutral or threat-related words (McNally et al., 1999; Teachman, 2005). The present study extends this finding to physical pain. Not only do individuals high in anxiety sensitivity selectively remember threat-related words, but they also selectively remember pain as worse than initially reported.

One explanation for this finding is that, when people recall pain, they have limited access to episodic memory of their actual physical experience and rely instead on their current thoughts or appraisals of the experience (Levine & Safer, 2002; Robinson & Clore, 2002). The significant association found between anxiety sensitivity, reappraisal and bias in remembered pain is consistent with this view. Specifically, an interaction between instructions to engage in positive reappraisal and anxiety sensitivity was observed such that reappraisal mitigated the relationship between anxiety sensitivity and overestimation in remembering pain. When anxious individuals were instructed to appraise pain in a positive way, they did not overestimate later in remembering their

pain. Instructions to engage in distraction, which influenced participants' attention to pain but not their interpretation of pain, did not protect against memory bias. The delayed positive effect of reappraisal for individuals high in anxiety sensitivity suggests that engaging in reappraisal was not powerful enough to counter the intense pain felt during the 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 behavioural measure of pain tolerance (time at which participant removed hand from water), but not self-reports of pain. Though distraction and reappraisal have been shown to be effective emotion regulation strategies in many studies (Fernandez & Turk, 1989) some studies have shown no effects of these strategies on real-time pain reduction (Haythornthwaite et al., 2001). It is possible that the emotion regulation instructions in the present study were too understated to produce an effect on experienced pain. The strategies were designed to be easily implemented in a medical setting; reappraisal instructions were brief and the distraction stimulus was subtle.

One limitation of this study is the possibility that participants remembered their *rating* of average pain rather than the experience of pain. Reducing this likelihood, participants also rated a number of other feeling states (distress, peak pain and appraisals of pain) immediately after rating their average pain. Some of these questions used the same 11-point scale as average pain. Though the possibility that participants recalled their previous rating of average pain cannot be excluded, there is no reason to expect this to have occurred differentially in one experimental group versus another or in participants high versus low in anxiety sensitivity.

This study opens important avenues for future research. First, the present research identified anxiety sensitivity as a predictor of biased memory 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 characterise 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 direction for future research is to examine the effect of more powerful emotion regulation instructions on experienced pain. The reappraisal instructions were subtle and having participants in the distraction condition provide online pain ratings may have decreased the effectiveness of the distracting stimulus somewhat. Importantly, immediately after the cold pressor task, 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. Moreover, for individuals high in anxiety sensitivity, even subtle instructions to engage in reappraisal mitigated the tendency to overestimate in remembering pain. Future research should explore whether stronger emotion regulation manipulations influence experienced as well as remembered pain, even in people low in anxiety.

Finally, analyses on gender differences should be taken with caution given the predominantly female sample. Nonetheless, the only gender difference observed in this sample was in anxiety sensitivity scores, in which females scored higher than males. Past research has found that females are less tolerant of pain, particularly at high levels of anxiety sensitivity (Keogh & Birkby, 1999). This suggests that the effect of anxiety sensitivity on overestimation of pain may also be more pronounced in females, though this was not observed in our sample. Gender differences in

memory for pain are an important issue for future research.

In conclusion, this study demonstrated a bias towards overestimation in remembering pain in individuals high in anxiety sensitivity. Instructions to engage in positive reappraisal during a painful experience led to 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. Overestimating past pain can lead to avoiding needed procedures. The current findings suggest, however, that health-care practitioners can use reappraisal instructions to promote more positive attitudes towards procedural pain, particularly in highly anxious patients.

### Disclosure statement

No potential conflict of interest was reported by the authors.

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