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Cognitive reappraisal is not always successful during pain anticipation: Stimulus-focused and goal-based reappraisal effects on self-reports and peripheral psychophysiology

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ABSTRACT

The present study aims at comparing the effects of two subtypes of cognitive reappraisal (i.e., stimulus-focused vs. goal-based reappraisal) to reduce anticipatory anxiety of pain. Affective ratings, startle reflex, and autonomic measures (electrodermal and heart rate changes) were used as a measure of emotion regulation success. A total of 86 undergraduate students completed an anticipatory task in which they had to regulate their negative emotions or react naturally when faced with the possibility of receiving a painful thermal stimulus. Participants were randomly assigned to two experimental groups to compare the stimulus-focused and goal-based strategies explored here. Our results revealed enhanced self-reported anxiety, electrodermal activity and eyeblink response when participants tried to voluntarily down-regulate their negative emotions, compared to the control instruction. Differences between both cognitive reappraisal groups were not found. These unexpected findings suggest that brief reappraisal instructions may not necessarily be favorable for regulating emotions during anticipation of aversive events. Moreover, these results are further explained in terms of the pain expectation, the painful stimuli modality, and emotion regulation instructions.

1. Introduction

Current models describe pain as a multidimensional and complex experience that involves not only sensory components, but also affective, cognitive, and evaluative factors (Melzack and Wall, 1965). One of the factors that has been identified as a critical one for pain experience is fear of pain. The Fear-avoidance model (Vlaeyen and Linton, 2000) propose that, when individuals misinterpret pain as a catastrophizing situation, the perception of pain as a threatening stimulus increases, resulting in fear of pain. This fear of pain leads to hypervigilance, emotional distress, and increased pain severity in subacute, acute, and chronic pain (Jackson et al., 2014; Vlaeyen and Linton, 2000; Zale et al., 2013). Thus, a vicious fear-avoidance cycle is created, that promotes avoidance behaviours such as disengage of daily activities and disability, contributing to the maintaining and chronicity of pain (Leeuw et al., 2007; Vlaeyen and Linton, 2000). Therefore, the reduction of fear-avoidance beliefs and catastrophizing has become a main target in first line interventions for chronic pain management (Vlaeyen et al., 2002; Williams and McCracken, 2004).

One of the psychological mechanisms that has shown to be effective to reduce fear is cognitive reappraisal (Liao and Zheng, 2016; Wolgast et al., 2011). This strategy involves reframing a stimulus or situation to change the emotional experience (Gross, 1998). Research has used this strategy in several ways giving rise to different classifications of cognitive reappraisal instructions (see Webb et al., 2012; McRae et al., 2012). Importantly, previous studies focused on reappraising negative emotions have shown that the use of different reappraisal subtypes can lead to different effects on subjective and psychophysiological responses. For example, McRae et al. (2012) showed that reappraisal strategies focused on increasing positivity were more effective than reappraisal focused on decreasing negative circumstances, increasing valence responses such as positive affect but prompting smaller decreases in skin conductance (i.e., arousal). Cristea et al. (2012) compared positive reappraisal with negative functional reappraisal. This is, comparing a reappraisal focused

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on changing the negative aspects of the situation, with a reappraisal strategy focused on enhancing a functional emotional mode that allows the individual to engage in goal-directed behaviours where the situation maintains its negative character. This study revealed that negative functional reappraisal was more efficient to reduce negative emotions than positive reappraisal, as well as to reduce irrational beliefs and increase rational beliefs. However, they did not include psychophysiological responses in their study.

Specifically in pain research, several laboratory studies have also shown the efficacy of cognitive reappraisal strategies for reducing self-reported pain, autonomic responses to painful stimulation, as well as for increasing pain tolerance level in response to induced pain (Fardo et al., 2015; Hampton et al., 2015; Lapate et al., 2012). However, any research has not compared reappraisal strategies for the management of pain or fear of pain so far. In addition, research focused on the peripheral physiological effects of using ER strategies on threatening feelings produced by the anticipation of a pain stimulus is still scarce and has shown inconsistent results. For example, Kalisch et al. (2005) found that emotional detachment –a modality of reappraisal that consists of denying the relevance of the stimuli taking a detached perspective– reduced heart rate and electrodermal activity when participants were threatened by the possibility of receiving an electric pain stimulus. Also, Holmes and Houston (1974) conducted a task composed of anticipation and stimulation (electric shocks) periods, in which reappraising the stimuli ("these aren't shocks; they are vibrations") was effective in reducing electrodermal activity during anticipation and stimulation periods. However, heart rate differences were found for induction, but not for anticipation periods. In this sense, the inconsistences found in previous studies suggest that emotion regulation success depend not only on the emotion regulation strategy that is used, but also on the moment when reappraisal is implemented (Jaén et al., 2021a).

In addition, the high heterogeneity in the reappraisal instructions used in laboratory settings, as well as the lack of consistency in the operationalization of the emotion regulation strategies makes it difficult to draw general conclusions on each strategy (Jaén et al., 2021a). Consequently, there is the urgent need to deepen our understanding of the mechanisms underlying clinical interventions to manage negative emotions, and to examine the commonalities and differences of each of these specific processes (Jaén et al., 2021a; Arch and Craske, 2008).

The present study aimed to progress on this goal, testing the effects of two types of cognitive reappraisal to manage anticipatory anxiety of pain through self-reports, autonomic measures of emotion (i.e., electrodermal activity and heart rate changes) and startle reflex modulation. In this way, this study aims to compare two reappraisal strategies that are commonly used for managing the anticipation of pain through evidence-based treatments such as the Cognitive Behavioral Therapy (Beck et al., 1979) and the Acceptance and Commitment Therapy (Hayes et al., 1999). More specifically, we compare a situational reappraisal strategy commonly used in the traditional Cognitive Behavioral Therapy that is based on changing the negativity of the stimulus through decatastrophizing, with a mixed reappraisal instruction that combines acceptance with negative functional reappraisal based on the goals, which is closer to 3rd generation therapies as the Acceptance and Commitment Therapy. This last strategy encourages the individual to accept the subjective experiences such that the individual is not dominated by thoughts, so that s(he) recognizes that the threat can be true, but it is accepted, in such a way that it facilitates to engage with the task. From now on, we will refer to these two strategies as stimulus-focused reappraisal and goal-based reappraisal, respectively. According to previous literature (McRae et al., 2012; Cristea et al., 2012), we hypothesize that both reappraisal strategies will be effective in reducing anticipatory anxiety. The emotion regulation success will be reflected by lower anxiety self-reports in the down-regulate condition, compared to the control condition, in which participants were instructed to react naturally. In addition, following the cascade model (Lang et al., 1997) the success in regulation will be physiologically associated to a decreased defensive response. This will be reflected in lower startle reflex and electrodermal activity, as well as an increased heart rate bradycardia. In addition, we expect that goal-based reappraisal will be more effective than stimulus-focused reappraisal in reducing anxiety self-reports and as well as modulating valence measures (i.e., reducing startle reflex and increasing heart rate bradycardia). Also, goal-based reappraisal will produce more decreases than stimulus-focused reappraisal in the arousal measure (i.e., electrodermal activity) when faced with the possibility to receive a painful thermal stimulus.

2. Method

2.1. Participants

An optimal sample size of 66 participants was calculated a priori using G*Power (Faul et al., 2009), assuming a small to medium effect size of Cohen's *f* of 0.2 (Braams et al., 2012; Jaén et al., 2021b), an alpha error of 0.05 and a power of 0.95. Because potential drop-out was considered, the final sample was incremented with 20 participants. Thus, a total of 86 undergraduate students (69.4% females) of the Universitat Jaume I were recruited to participate in our study, with a range age of 19 to 30 (*Mean* = 20.15; *SD* = 2.08). Exclusion criteria were: (a) inability to understand or speak Spanish well enough to understand the task; (b) current cardiovascular disorder; (c) medical or psychological disease; (d) current use of medications that affect psychophysiological measures; (e) diagnostic of chronic pain. From the initial sample, one participant was excluded because of general methodological failures during startle reflex data acquisition, and further 17 participants due to excessive noise in the raw EMG signal collection. Additionally, 8 participants were excluded as they responded in the post-experimental query that spontaneously switched to another ER strategy during the task. Therefore, statistical analyses were conducted with 78 participants for affective ratings, heart rate, and electrodermal activity, whereas 60 participants were finally included for startle reflex data analyses. This study has been carried out in accordance with the Declaration of Helsinki for experiments involving humans. Ethical approval from the Deontological Committee at Universitat Jaume I was obtained, and all participants provided informed consent forms before starting the experiment.

2.2. Stimuli and design

Our experimental design is a modified, combined version of Grillon et al. (1991) and Lissek et al. (2007) paradigms. More specifically the current experiment consisted in an anticipatory task including cues signalling the possibility of receiving (or not) an aversive stimulus (safe vs. threat trials), in which participants had to regulate their emotions or react naturally (maintain vs. down-regulate). The task was composed of 4 blocks with 9 trials each (3 safe, 3 threat/maintain, 3 threat/decrease). An extra pain trial was presented at the end of the task. Additionally, 3 practice trials were included at the beginning of the task after instructing the participants about how to regulate their emotions and how to rate the stimuli.

Each trial started with a fixation cross in the centre of a black screen, followed by another screen with a coloured frame (blue/yellow) around, which indicated whether the painful stimulus will be delivered or not (safe/threat periods). Frame colours (blue/yellow) signalling safety or threat trials were counterbalanced across participants to control for colour effects. Each black screen with the coloured-framed around contained also a word written in white letters in the centre of the screen (maintain/ decrease), which indicated to participants what to do during the 12-s that was presented. Then, subjective ratings of both *anxiety* and *effectiveness using the strategy* were collected using a 10-point scale. For *anxiety* ratings, 0 was "I do not feel anxious" and 9 "I feel extremely anxious", whereas for *effectiveness using the strategy* 0 was "I was not effective using the strategy" and 9 corresponded to "I was very effective using the strategy". Inter-stimulus interval (ITI) ranged at 15 or 18-s to reduce its predictability along the task.

Digitized probes (50 ms, 105 dB) were presented binaurally over Sennheiser HD-25 headphones. A total of 24 probes were presented at 6 or 10-s after cue onset to prompt startle reflex responses. Moreover, 2 additional probes were included in the practice trials to reduce overall blink amplitude before the task began. During ITIs, 8 probes were presented at 9-s from trial onset.

2.3. Thermal pain stimulation

Thermal pain was induced to participants by using a thermal stimulator TSA-II (Medoc, Ramat Yishai, Israel) with a 3 × 3 cm2 surface thermode. Prior to the task, a work-up procedure was conducted to determine their threshold tolerance, based on three trials in which the sensor heated at a rate of 1.0 °C per second from a baseline of 32°, and increased to a maximum temperature of 50° (Hampton et al., 2015). Participants were instructed to press a button to stop the increase when they reached a level of thermal sensation that went from hot to just painful. The average of these three temperatures plus 1° was used as the pain threshold for the pain trial presented at the end of the task. This trial was used to prevent participants from thinking that there was no aversive stimulus during the task, asking them at the end of the task how many thermal heat stimuli they had received and how intense and unpleasant they found it.

2.4. Psychophysiological data acquisition and reduction

Raw signals were recorded using the Biopac MP150 system, and EMG100C, GSR100C, and ECG100C amplifiers. Acqknowledge 4.2 software was used to collect, rectify, integrate, and smooth the physiological data. Psychophysiological data reduction and obtaining parameters of interest for each measure for subsequent statistical analysis was conducted using Matlab R2018a and JMP Pro 15 software.

Eyeblinks were recorded electromyographically through the orbicularis oculi muscle using two Ag/AgCl electrodes (4-mm diameter) placed directly below the left eye. The raw EMG signal was continuously sampled at 2000 Hz and filtered online with a high-pass (30 Hz) and a low-pass (500 Hz) filter, being then integrated and rectified also online using Root Mean Square (RMS) integration with a time constant of 20 ms. Blink responses were visually inspected, with peaks detected using Acqknowledge 4.2 software. Eyeblink amplitude was calculated as the difference between baseline (average over 20 ms before the startle probe onset) and peak (within 21 to 180 ms after probe onset). Trials in which eyeblinks were outside this range or could not be discerned from surrounding noise were classified as missing in the posterior statistical analyses. Raw values were standardised (separately for each participant) based on the mean and standard deviation of blinks elicited during ITIs. Blinks were expressed as T-scores ($[z * 10] + 50$). In this standardisation technique, a T-score of 50 indicates reflexes identical to those elicited during the ITI, and experimental blinks are not in the same distribution as the reference (ITI), providing independent standardisation (Bradford et al., 2015).

Electrodermal activity (EDA) was recorded through two Lead110S-R electrode leads with disposable snap electrodes placed on the left palm hand. Electrodes were attached 10 min before beginning the experiment to ensure the stability of the recording. Previously, the hand was gently cleaned using a tissue with distilled water. The signal was recorded using a sampling rate of 2000 Hz with a low-pass filter (10 Hz) and DC recording (high-pass). Data were reduced offline for each trial by averaging EDA corresponding to half-second bin periods across the 12 s of trial duration, and change scores were calculated as the difference between baseline (1-s prior to cue onset) and each 0.5-s bin. Logarithms of raw scores, log (EDA changes +1), were calculated to normalize the data distribution.

Electrocardiogram (ECG) was recorded though the Lead II derivation, using Ag/AgCl electrodes (6-mm diameter) filled with electrolyte paste. A sampling rate of 2000 Hz was used to obtain the raw ECG-signal, which was band-pass filtered (0.5–35 Hz). HR was obtained online from the ECG-signal, which measured the time interval between consecutive R waves (cardiac period). R-waves were detected and interbeat intervals were obtained using the Acqknowledge 4.2 software. Visual inspection was conducted, and artifacts correction was performed prior to statistical analyses. HR data were reduced as half-second bins periods across the cue presentation (12 s). For each trial, change scores were calculated as the difference between baseline (1 s prior to excerpt onset) and each half-second bin.

2.5. Procedure

Before arriving at the laboratory, participants were assigned randomly to one of these two experimental groups: stimulus-focused reappraisal and goal-based reappraisal. After signing the written consent, the thermic sensor was attached in the middle of their left forearm and the participants completed the work-up procedure, to determine their pain threshold. Afterward, they were instructed about the task structure and completed a practice session where they were trained on the ER instructions as well as the anxiety and effectiveness ratings.

Regarding the ER instructions, participants received the following instruction: *when you perceive physical sensations and/or physiological changes, react naturally, without getting involved in them or rejecting them.* This condition was signalled with the word "Maintain" on the screen. Regarding the "Decrease" instruction, participants in the goal-based reappraisal group were instructed to *think that they agree with feeling pain, because it is something important for them.* Conversely, participants in the stimulus-focused reappraisal group were instructed to *think that it was not so terrible and there were no negative consequences from experiencing pain*. Reappraisal strategies were discussed during the practice session to ensure that those used during the task were consistent with the condition strategy. For example, for the goal-based reappraisal group, the reason why the participants would accept pain was discussed with them before starting the study (e.g., monetary retribution, collaboration with research, learning about research procedures). If, during training, participants' responses suggested that they were using another strategy (e.g., distraction or suppression) the experimenter offered corrective instructions and explained again the strategy described above. Then, the anticipation task started, which lasted approximately between 25 and 30 min in total. After the task, participants completed a post-experimental query developed ad-hoc for this study in which they should describe what they did meanwhile the instructions of maintain and decrease were shown on the screen.

2.6. Data analysis

In order to test and compare the effects of using each cognitive reappraisal subtype on self-reported measures and startle reflex responses, two separate 3 (C*ondition:* safe-maintain, threat-maintain, threat-down) x 2 (G*roup:* stimulus-focused reappraisal, goal-based reappraisal) repeated measures ANOVAs were performed with Condition as within-subjects factor and ER Group as between-subject factor. For electrodermal activity and heart rate, two separate mixed repeated measures ANOVAs 3 × 20 × 2 (Condition × Time × Group) were conducted, with Condition and Time as within-subject factors and ER Group as between-subjects factor.[1] Means (SD) and confidence intervals by

[1] For statistical analyses, trials in which probes were presented at 6 s after the cue onset were eliminated so that these auditory stimuli did not affect neither EDA nor HR results. In addition, time course analyses for both autonomic measures were performed including only 10 s after cue onset, instead of the 12 s corresponding to the total trial duration, to avoid the effects of the probes presented at 10s during the anticipatory periods.

condition for each measure are reported in Table 1.

Assumptions of normality, homoscedasticity, sphericity, and equality of variances were explored using the Mauchly test and the Greenhouse-Geisser correction, where appropriate. *Post-hoc* comparisons were performed with pairwise *t*-tests when significant differences in main effects were found. Partial eta squared (η_p^2) and Cohen's *d* are reported as measures of effect size. All statistical tests were conducted using SPSS IBM Statistics version 23.

3. Results

3.1. Anxiety and effectiveness ratings

For *anxiety ratings*, a main effect was found for Condition, $F(2,103) = 120.13$, $p < .0001$, $\eta_p^2 = 0.61$, but not for ER group ($F < 1$) (see Fig. 1). The Condition x ER group interaction was not significant either, $F(2, 103) = 1.52$, $p = .22$, $\eta_p^2 = 0.2$. Post-hoc comparisons showed that reported anxiety was significantly lower in Safe-maintain compared to Threat-maintain, $t(77) = 10.93$, $p < .0001$, $d = 7.08$, and Threat-down, $t(77) = 12.09$, $p < .0001$, $d = 8.39$, conditions. In addition, anxiety during Threat-down trials was rated higher compared to Threat-maintain condition, $t(86) = 2.95$, $p = .01$, $d = 1.16$.

In terms of *effectiveness*, no significant main effects for Condition, $F(2, 119) = 1.69$, $p = .19$, $\eta_p^2 = 0.02$, nor for ER group, $F(1, 76) = 1.48$, $p = .23$, $\eta_p^2 = 0.02$ were found (see Fig. 1). The interaction Condition x ER group was again not statistically significant, $F(2, 119) = 1.82$, $p = .17$, $\eta_p^2 = 0.02$.

3.2. Startle reflex

A main effect for Condition was found, $F(2, 116) = 15.85$, $p < .0001$, $\eta_p^2 = 0.22$ (Fig. 1). However, the repeated measures ANOVA reflected no significant main effect for ER group, nor for the Condition x ER Group interaction (*Fs* < 1). Post-hoc tests showed enhanced eyeblink amplitude for both Threat-maintain, $t(59) = 4.01$, $p < .001$, $d = 0.55$), and Threat-down, ($t(59) = 4.96$, $p < .0001$, $d = 0.70$, conditions as compared to Safe-Maintain trials. However, differences between Threat-down and Threat-maintain conditions were not statistically significant, $t(59) = 1.76$, $p = .08$, $d = 0.18$.

3.3. Electrodermal activity

The results for the repeated measure ANOVA showed a main effect of Condition, $F(2, 152) = 13.32$, $p < .0001$, $\eta_p^2 = 0.15$, and Time, $F(19, 127) = 7.22$, $p < .01$, $\eta_p^2 = 0.08$ (Fig. 2). However, no main effect was found for ER group, $F(1, 76) = 1.22$, $p = .27$, $\eta_p^2 = 0.02$. The interaction between Condition × Time was significant, $F(3, 255) = 7.41$, $p < .0001$, $\eta_p^2 = 0.09$. For all groups an EDA increase is shown from the seconds 2 to 4 (Fig. 2). As shown in Table 2, post-hoc comparisons showed that electrodermal activity was enhanced for Threat-maintain condition compared to Safe-maintain from 3.5 to 6.5 s, and from 9 to 10 s. Likewise, increased EDA was found for Threat-down condition compared to Safe-maintain control condition from 2.5 to 10 s. Unexpectedly, Threat-Down also prompted significantly higher EDA changes compared to Threat-maintain by the end of the trial (from 9 s to 10 s).

3.4. Heart rate

The analyses performed for Heart Rate revealed no main effects for Condition, $F(2, 152) = 2.16$, $p = .119$, $\eta_p^2 = 0.03$, nor for ER group ($F < 1$) (see Fig. 2). However, a main effect was found for Time, $F(3,223) = 29.56$, $p < .0001$, $\eta_p^2 = 0.29$. In addition, the interaction Condition x Time was marginally significant, $F(38, 592) = 1.85$, $p = .068$, $\eta_p^2 = 0.02$. As shown in Table 3, post-hoc comparisons revealed greater HR changes for Threat-maintain compared to Safe-maintain condition from 5 to 10 s. Differences between Safe-maintain and Threat-down conditions, as well as between Threatening trials (maintain vs. down-regulate) did not reach the significant level. These results suggested that certain HR acceleration was specifically found when naturally reacting to the plausible upcoming pain stimulus during threatening trials compared to the safe control condition.

4. Discussion

The present study aimed to explore the effects of two subtypes of reappraisal on subjective measures and peripheral physiology during an experimental task in which participants anticipated an upcoming painful thermal stimulation. To our knowledge, this is the first study that compares the effect of these two cognitive reappraisal strategies on self-reports and psychophysiological correlates of pain anticipation.

Table 1
Means (±SD) and confidence intervals (CI) for subjective ratings and psychophysiological measures during emotion regulation, separately for each cue condition.

	All groups			Stimulus-focused reappraisal group			Goal-based reappraisal group		
	Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI	
		Lower	Upper		Lower	Upper		Lower	Upper
Anxiety ratings									
Safe-Maintain	1.39 (1.60)	1.03	1,75	1.28 (1.53)	0.77	1.78	1.51 (1.67)	1.00	2.03
Threat-Maintain	3.34 (2.09)	3.13	4.07	3.37 (2.11)	2.70	4.03	3.32 (2.09)	2.65	4.00
Threat-Down	3.60 (2.09)	2.87	3.82	3.75 (2.06)	3.09	4.41	3.44 (2.14)	2.77	4.13
Effectiveness ratings									
Safe-Maintain	7.76 (1.41)	7.44	8.06	8.02 (1.11)	7.58	8.46	7.48 (1.64)	7.03	7.93
Threat-Maintain	7.57 (1.30)	7.27	7.86	7.73 (1.26)	7.32	8.14	7.40 (1.35)	6.98	7.82
Threat-Down	7.61 (1.28)	7.32	7.90	7.67 (1.30)	7.27	8.08	7.54 (1.26)	7.13	7.95
Startle reflex									
Safe-Maintain	49.64 (8.36)	47.47	51.83	49.41 (8.54)	46.38	52.44	49.90 (8.30)	46.77	53.03
Threat-Maintain	53.58 (9.35)	51.13	56.00	54.14 (9.77)	50.75	57.52	52.99 (9.02)	49.49	56.49
Threat-Down	55.15 (10.29)	52.44	57.80	55.92 (9.98)	52.20	59.64	54.32 (10.73)	50.47	58.17
EDA									
Safe-Maintain	−0.04 (0.04)	−0.07	−0.01	−0.04 (0.04)	−0.08	0.002	−0.05 (0.04)	−0.09	−0.01
Threat-Maintain	0.02 (0.03)	−0.03	0.07	−0.02 (0.02)	−0.09	0.05	0.05 (0.05)	−0.02	0.12
Threat-Down	0.13 (0.08)	0.05	0.21	0.09 (0.06)	−0.03	0.20	0.17 (0.10)	0.05	0.29
HR									
Safe-Maintain	−0.34 (0.67)	−0.81	0.13	−0.49 (0.78)	−1.15	0.16	−0.19 (0.59)	−0.87	0.48
Threat-Maintain	1.00 (1.02)	−1.05	−0.49	−0.85 (1.08)	−1.56	−0.14	−1.15 (1.00)	−1.88	−0.42
Threat-Down	−0.60 (1.00)	−1.08	−0.12	−1.01 (1.23)	−1.68	−0.34	−0.19 (0.78)	−0.88	0.50

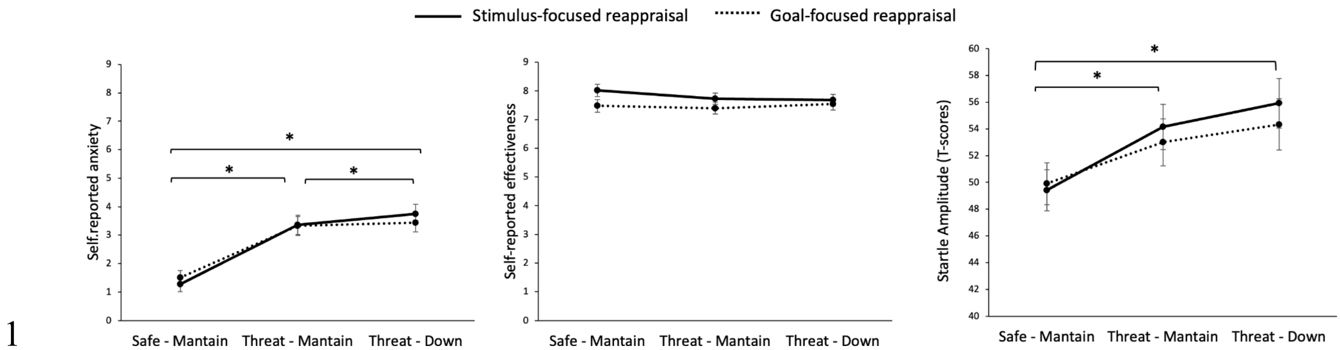

Fig. 1. Self-reported anxiety, effectiveness and startle reflex responses for each group and condition. (a) Self-reported anxiety (b) Effectiveness (c) Startle reflex reactivity. $*p < .01$.

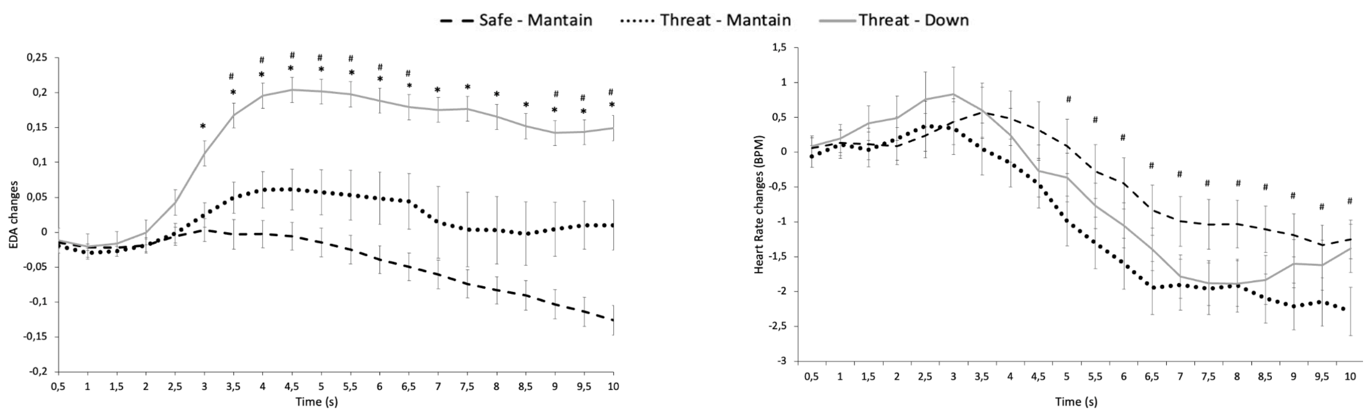

Fig. 2. Mean time course of electrodermal and heart rate with standard error bars for the first 10 s of the instruction screen presentation. $*p < .05$ in Safe-Maintain vs. Threat-Maintain/Down; $^{\#}\ p < .05$ in Threat-Maintain vs. Threat-Down.

Table 2
Post-hoc *t*-test comparisons between experimental conditions (Safe/Maintain, Threat/Maintain, Threat/Down-regulate) for each half second bin period during 10 s after cue onset for electrodermal changes.

Time (s)	Safe-maintain vs. Threat-maintain				Safe-maintain vs. Threat-down				Threat-maintain vs. Threat-down			
	t (77)	*p*	95% CI		*t* (77)	*p*	95% CI		*t* (77)	*p*	95% CI	
			Lower	Upper			Lower	Upper			Lower	Upper
0.5	1.12	0.27	<−0.01	0.01	−0.72	0.47	−0.01	0.01	1.38	0.17	<−0.01	0.02
1	1.12	0.27	<−0.01	0.02	−0.18	0.86	−0.02	0.01	1.07	0.29	−0.01	0.03
1.5	0.59	0.56	−0.01	0.02	−0.54	0.59	−0.03	0.02	0.93	0.36	−0.01	0.03
2	0.01	0.99	−0.03	0.03	−1.23	0.22	−0.05	0.01	1.12	0.27	−0.01	0.05
2.5	−0.23	0.82	−0.04	0.03	−2.18	0.03	−0.09	<−0.01	2.06	0.04	<0.01	0.09
0.3	−1.04	0.30	−0.06	0.02	−3.23	<0.01	−0.18	−0.04	2.92	<0.01	0.03	0.15
3.5	−2.00	0.05	−0.11	−0.001	−3.83	<0.01	−0.26	−0.08	3.01	<0.01	0.04	0.20
4	−2.28	0.03	−0.12	−0.01	−3.93	<0.01	−0.30	−0.10	2.92	<0.01	0.04	0.23
4.5	−2.14	0.04	−0.13	−0.01	−3.77	<0.01	−0.32	−0.10	2.86	<0.01	0.04	0.24
5	−2.09	0.04	−0.14	<−0.01	−3.74	<0.01	−0.33	−0.10	2.91	<0.01	0.05	0.24
5.5	−2.06	0.04	−0.15	<−0.01	−3.75	<0.01	−0.34	−0.10	2.94	<0.01	0.05	0.24
6	−2.23	0.03	−0.17	−0.01	−3.88	<0.01	−0.35	−0.11	2.91	<0.01	0.04	0.24
6.5	−2.231	0.03	−0.18	−0.01	−3.90	<0.01	−0.35	−0.11	2.91	<0.01	0.04	0.23
7	−1.29	0.20	−0.19	0.04	−4.02	<0.01	−0.35	−0.12	3.08	<0.01	0.06	0.27
7.5	−1.30	0.20	−0.20	0.04	−4.29	<0.01	−0.37	−0.13	3.22	<0.01	0.07	0.28
8	−1.70	0.09	−0.19	0.02	−4.19	<0.01	−0.37	−0.13	3.32	<0.01	0.07	0.26
8.5	−1.84	0.07	−0.18	0.01	−4.09	<0.01	−0.36	−0.13	3.38	<0.01	0.06	0.25
9	−2.62	0.01	−0.19	−0.03	−4.20	<0.01	−0.36	−0.13	3.32	<0.01	0.06	0.22
9.5	−3.23	<0.01	−0.20	−0.05	−4.33	<0.01	−0.38	−0.14	3.30	<0.01	0.05	0.21
10	−3.26	<0.01	−0.22	−0.05	−4.35	<0.01	−0.40	−0.15	3.02	<0.01	0.05	0.23

In terms of ER effects, this study showed that the use of both stimulus-focused reappraisal and goal-based reappraisal during the anticipation of pain were associated with higher anxiety levels measured by self-reports in comparison to reacting naturally to the plausible upcoming pain stimuli. These results are in contrast with previous literature that revealed reductions in subjective and psychophysiological responses when voluntarily down-regulating their emotions (i.e. Holmes and Houston, 1974; Kalisch et al., 2005). The findings obtained in our research suggest that reappraisal strategies might not be effective when instructions are brief, and/or the anticipation of pain produces a

Table 3
Post-hoc *t*-test comparisons between experimental conditions (Safe/Maintain, Threat/Maintain, Threat/Down-regulate) for each half second bin period during 10 s after cue onset for heart rate changes.

Time (s)	Safe-maintain vs. threat-maintain				Safe-maintain vs. threat-down				Threat-maintain vs. Threat-down			
	t (77)	*p*	95% CI		*t* (77)	*p*	95% CI		*t* (77)	*p*	95% CI	
			Lower	Upper			Lower	Upper			Lower	Upper
0.5	0.66	0.51	−0.25	0.50	−0.1	0.90	−0.47	0.41	0.67	0.51	−0.30	0.60
1	0.09	0.93	−0.49	0.54	−0.23	0.82	−0.57	0.45	0.30	0.77	−0.48	0.64
1.5	0.29	0.77	−0.47	0.63	−0.97	0.34	−0.92	0.32	1.15	0.26	−0.28	1.04
2	−0.31	0.76	−0.79	0.58	−1.09	0.28	−1.13	0.33	0.79	0.43	−0.45	1.03
2.5	−0.33	0.74	−0.96	0.69	−1.13	0.26	−1.44	0.40	0.92	0.36	−0.45	1.22
3	0.21	0.84	−0.79	0.98	−0.75	0.46	−1.44	0.65	1.17	0.25	−0.34	1.31
3.5	1.16	0.25	−0.38	1.43	−0.05	0.97	−1.15	1.10	1.24	0.22	−0.33	1.44
4	1.41	0.16	−0.26	1.55	0.45	0.66	−0.84	1.33	0.85	0.40	−0.54	1.34
4.5	1.61	0.11	−0.19	1.74	1.08	0.29	−0.50	1.68	0.38	0.71	−0.80	1.18
5	2.36	0.02	0.17	1.97	0.92	0.36	−0.52	1.41	1.29	0.20	−0.34	1.59
5.5	2.21	0.03	0.10	1.95	1.14	0.26	−0.37	1.37	1.15	0.25	−0.39	1.45
6	2.60	0.01	0.27	2.03	1.39	0.17	−0.26	1.45	1.21	0.23	−0.36	1.45
6.5	2.54	0.01	0.24	1.99	1.36	0.18	−0.26	1.38	1.24	0.22	−0.33	1.44
7	2.16	0.03	0.07	1.75	1.82	0.07	−0.08	1.66	0.28	0.78	−0.74	0.97
7.5	2.14	0.04	0.06	1.78	1.89	0.06	−0.05	1.73	0.19	0.85	−0.77	0.93
8	2.09	0.04	0.04	1.72	1.89	0.06	−0.05	1.75	0.06	0.95	−0.88	0.94
8.5	2.38	0.02	0.16	1.83	1.65	0.10	−0.15	1.62	0.56	0.58	−0.68	1.20
9	2.71	<0.01	0.27	1.77	0.99	0.33	−0.41	1.22	1.37	0.17	−0.28	1.50
9.5	2.17	0.03	0.07	1.56	0.71	0.48	−0.51	1.08	1.13	0.26	−0.40	1.45
10	2.74	<0.01	0.28	1.78	0.33	0.74	−0.65	0.92	1.97	0.05	−0.01	1.82

low anxiety level. Clinical experience shows that ER strategies are sometimes difficult to learn, so the instructions used in this study were brief and could be unfortunately insufficient to obtain the benefits found in other studies exploring cognitive reappraisal (e.g., Holmes and Houston, 1974; Kalisch et al., 2005; Lapate et al., 2012). Also, it may be possible that the cognitive demands of using an ER strategy, which may be not familiar to participants, diminish the self-regulatory resources during anticipatory processes, increasing in turn the participants emotional arousal and the corresponding associated autonomic changes (see Evans et al., 2014). Accordingly, the down-regulate threatening condition was in fact accompanied here by greater subjective anxiety ratings and electrodermal reactivity. Therefore, we encourage to compare the effects of reappraisal subtypes using more comprehensive training sessions rather that brief reappraisal instructions in which emotion regulation is initiated by an explicit and conscious instruction.

Regarding the anxiety level produced by the stimulus, it was low for all the conditions. Previous studies focused on anticipatory phases usually use electric shocks (Braams et al., 2012; Holmes and Houston, 1974; Kalisch et al., 2005). However, in this study we use thermal stimulation. Heat stimulation has shown to be perceived as less unpleasant than other modalities of pain (Rainville et al., 1992), which might indeed affect studies like the present one that intended to induce fear to the pain stimuli. In this line, a recent study revealed that emotion regulation success is associated with high levels of stress (Langer et al., 2020). Therefore, results of the present study might indicate that reappraisal strategies may not be effective for managing anticipation of pain when anxiety is low. In addition, some studies have reported that the presentation of warning cues is related to changes in the state of attention (Correa et al., 2006; Weinbach and Henik, 2012). To this extent, it is possible that in the context of low anxiety levels, the instructions regarding the down-regulation condition might lead to enhanced alertness and preparation to use the reappraisal strategy, compared to the control condition. Thus, the observed higher subjective anxiety and enhanced autonomic activity –potentially linked to increases in emotional intensity– might be resulting from top-down processes occurring during the expectancy periods.

Finally, empirical evidence supports that different control instructions can also result in differences in subjective experience and physiological activation (Diers et al. (2014). The instructions given for the control condition (threat-maintain) in this study could be similar to mindfulness approaches where participants are instructed to observe their emotions using cognitive defusion. Subjective anxiety and psychophysiological responses could have been diminished during this threatening control condition due to the use of a more familiar and/or flexible approach somehow similar to mindfulness techniques, which have shown to be beneficial for managing pain (Zeidan et al., 2010). Also, a meta-analysis conducted by Zaehringer et al. (2020) revealed no significant effects of reappraisal decreasing autonomic measures (i.e. skin conductance and heart rate) when the control instruction was "respond naturally". Additionally, it is important to note that the sample included in this study was composed of healthy participants, who could make an effective use of their ER resources during the maintenance condition or could not benefit from voluntary ER instructions. For example, Kohl et al. (2012) found that the strategy of acceptance was more effective limiting acute distress in clinical but not healthy samples. Therefore, in our study, differences between the maintain and down-regulation threatening trials could have been diminished by the characteristics of the experimental sample.

Regarding the comparison between both reappraisal subtypes, we expected to find that goal-based reappraisal would be more effective than stimulus-focused reappraisal, similarly to the results obtained by Cristea et al. (2012) and McRae et al. (2012). However, our study did not find differences between both ER strategies neither in self-reported ratings nor in the psychophysiological measures. In this sense, it is worth mentioning that in the emotion regulation tasks conducted by those authors participants had to reappraise their emotions meanwhile they were watching videos and pictures, respectively. However, in this study the reappraisal instruction was not implemented during the presentation of a negative stimulus, but participants had to use it in an anticipation task. Therefore, differences between our study and those previous works could be related to the use of different paradigms in which the negative stimulus is present or is being anticipated. Specifically, goal-based reappraisal could be more beneficial than stimulus-focused reappraisal when the negative stimulus is present than in the anticipatory period. For example, an individual may find it more difficult and/or less beneficial to make a stimulus less negative when it is already present. However, stimulus-focused reappraisal could be as effective as goal-based reappraisal during the anticipation, being the differences between both reappraisal instructions diminished or disappeared. If so, these finding would have clinical relevance, since it would mean that goal-based reappraisal trainings are more beneficial for managing fear of pain when it is most of the time present (i.e. chronic pain), meanwhile both strategies are equally effective for managing the anticipation of a future pain, as fear of medical procedures.

Of note, our study has some limitations. First, a between-group design was used to compare the reappraisal strategies instead of a within-subject design in which participants would have had to switch the strategy in different trials. In this line, the fact that the participants could only use one brief strategy during the entire task provides methodological accuracy but at the cost of less ecological validity, since the experience of the threat of pain management could vary with respect to what each person experiences naturally in daily life. Future studies should adapt the research designs allowing the participants to flexibly use a variety of ER strategies. For example, studying the emotion regulation strategies in a natural context or adapting the ER strategy in the task to the participant's thoughts. Another limitation of the present study is that the assessment of the usual ER strategies used by the participants was not included in the experimental protocol. Previous literature has shown that the strategies that are regularly used in daily life could moderate the efficacy of the instructions provided to regulate emotions in laboratory settings (Mauersberger et al., 2018). Therefore, it would be important for future investigations to assess the frequency of use of individuals' regulatory strategies to achieve a better understanding of the emotion regulation processes.

5. Conclusions

In conclusion, the present study found that the use of reappraisal strategies during anticipation of pain increased self-reported anxiety, electrodermal activity, and startle reflex responses. Moreover, this study did not find differences between stimulus-focused and goal-based reappraisal. The results obtained in this research suggest that reappraisal strategies might not be effective when instructions are brief, and the anticipation of pain produces low anxiety levels. Also, we highlight the difficulty of finding adequate control conditions to compare emotional regulation strategies. Future research should design new paradigms that allow a greater control of the comparator conditions to study the specific psychological processes that underlie each specific ER instruction and which strategies are more effective to manage fear of pain.

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Declaration of competing interest

The authors declare no conflicts of interest.

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