Comparing the effects of thought suppression and focused distraction on pain-related attentional biases in men and women

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(accepted version: The Journal of Pain)

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Running title: Cognitive pain inhibition, pain, and attention

Disclosures

Dr Kreddig reports grants from German Research Foundation (DFG), during the conduct of the study, in the form of a research fellowship, KR 4928/1-1. Prof Keogh reports unrelated research funding from UKRI and Versus Arthritis. The authors have no relevant conflicts of interest to declare.

Abstract

Increasing attentional focus away from pain can affect pain experience, suggesting that cognitive strategies that move attentional allocation may be a moderator of pain. In a pre-post-design, the present study examined the effects of two cognitive strategies used in pain contexts, thought suppression and focused distraction, on subsequent pain-related attention. Thought suppression was hypothesized to increase pain-related attention, whereas focused distraction was expected to reduce it. Influences of both anxiety and sex were also considered, as secondary questions. 139 (86 women, 53 men) healthy, pain-free participants were randomly assigned to use either thought suppression or focused distraction during a mild cold pressor test (CPT). Pain-related attention was examined using a dot-probe and an attentional blink task, pre- and post-CPT. Questionnaires about relevant cognitive and emotional aspects, demographics, and pain were completed. Results showed no difference in the effect of the two pain inhibition strategies on pain-related attention. The hypothesized rebound effect in thought suppression on pain-related attention did not emerge. However, thought suppression showed a short-term benefit in comparison to focused distraction regarding reported pain and perceived threat during the cold pressor test. Few sex differences were found. Thus, the cognitive strategies affected pain outcomes, but did not influence pain-related attention.

Perspective: Cognitive strategies could help with pain through changing attention allocation. In this study, the effects of the two cognitive strategies thought suppression and focused distraction on pain-related attention in men and women were examined. Elucidating mechanisms that lie behind pain strategies that focus on changing attention may help improve treatments.

Key Words: pain, attention, thought suppression, distraction, experimental pain

1. Introduction

Pain captures attention and elicits motivated responses to reduce threat[13]. However, attention to pain can become intrusive, resulting in cognitive interference, and may in the long term contribute to disability. Understanding how individuals allocate attention to pain, and the factors that influence this allocation, is relevant to intervention development.[6,13,17,54] Attentional bias paradigms offer insights into the way pain intrudes on cognition. Such biases reflect the preferential allocation of attention towards stimuli related to relevant concerns[9] at the cost of other information.[64] Attentional biases have been found in acute and chronic pain[10,58,59] and changes in biases are related to changes in pain.[4,10,62,69] However, patterns vary[62,69,70] and there are individual differences e.g., sex differences.[27,53] Greater clarity around the circumstances, as well as the processes that underpin such biases, is required.[72]

One source of variation is that attentional biases might be influenced by the type of cognitive strategies people use to deal with their pain.[71] For example, thought suppression involves trying not to think about unwanted thoughts,[76,81] yet seems to paradoxically increase unwanted thoughts, producing a "rebound effect".[50,51,71,79,80] The Ironic Process Theory[76] aims to explain the rebound effect with two processes: a nonconscious, automatic search for the unwanted thought within the mind, constantly renewing the unwanted thought, and a conscious, effortful search for distractors. With both processes running smoothly, suppression appears possible for a short time.[1,8,14] However, cognitive demands can disrupt the effortful distractor search, while the target search keeps running effortlessly,[49,51,79,83] resulting in the "rebound effect".[1,80] Increased pain-related thought suppression is related to increased anxiety, depression, and pain,[16,20,21,32] and so might result in heightened attentional biases. An alternative strategy that might also affect attentional biases is focused distraction.[73] Here, specific thoughts, unrelated to the current concern, are used as a distraction.[78] Focused distraction seems to reduce unwanted thoughts, pain, distress, and even the rebound effect.[7,16,38,48,71,81] Thought suppression and focused distraction are conceptually subtly different, as focused distraction gives a clear alternative thought, and thought suppression does not (for a more detailed distinction, see Wegner[78]). As Cioffi and Holloway[7] state: "The goal of suppression is to remove a thought from mind, and the goal of distraction is to replace one thought with another." A differential impact on pain[7] and on attentional biases in anxiety[38] has been observed. However, these approaches have yet to be compared in their effect on attentional biases towards pain.

The primary aim of the current study was to fill this gap, and compare the effects of thought suppression and focused distraction on pain-related attentional biases. Pain context was provided using a cold pressor test (CPT). We hypothesized that thought suppression would result in a rebound effect, reflected in an increased attentional bias towards pain as measured in two attentional bias tasks. We did not expect this effect in focused distraction, where we expected a reduction in attentional bias. Since anxiety typically amplifies attentional biases,[29,41,46,60] a secondary aim was to explore how anxiety relates to these biases. We also predicted that anxiety would be associated with greater attentional biases in general, and specifically with a greater rebound effect. Finally, since there is also evidence for sex and gender differences in pain, pain-related coping and attentional biases,[25-7,30,68] differences between men and women were also explored. Previous investigations are somewhat mixed, but helped informed predictions. For example, attentional manipulation studies suggest men might benefit more from focusing attention[30-31], and women from adopting a more flexible, accepting, approach[26]. Women also seem faster at detecting emotional targets[28], and have their attention captured by pain stimuli[27]. From this we predicted that women would exhibit a stronger attentional bias to pain stimuli, especially following thought suppression.

2. Methods

Sample

The sample comprised of 139 (86 women, 53 men) pain-free, healthy adult participants, who were recruited from the University of Bath students and staff population. This number was informed by an a-priori power analysis based on our main goal to detect a small to medium sized difference (f(V)=0.20) between two independent groups i.e., thought suppression vs. focused distraction. This analysis suggested 124 participants would be sufficient, and so we set a target of 140 (in case of participant drop out). When we conducted this estimation there were few, if any, relevant studies for us to base our estimates on. The closest we could find were two meta-analyses on attentional biases effects,[9,59] who reported small to medium effect sizes. This was also partly informed by what was possible given timing and funding constraints, and that a sample of 140 was much larger than many similar studies of this type at the time. In hindsight our effect size assumption was premature. Indeed, a subsequent meta-analysis[70] suggests that the effects of induced pain on attentional biases are small. In addition, although we sought to explore whether men and women differ in the effect of thought suppression and focused distraction on pain-related attentional biases, we did not include this in our power estimations. We return to these points in the discussion.

Ethical approval was granted by the Department of Psychology Research Ethics Committee at the University of Bath, in accordance with the Declaration of Helsinki. Written consent was obtained from each participant. All participants confirmed that they are not currently in pain, not on any medication (including analgesics, excluding contraception), not suffering from a chronic pain condition, a heart condition, or a skin condition. In this study, which was conducted in 2016/17, we asked participants to write down their sex in a blank text box. All participants answered with either “female” or “male”. We did not ask about gender, and recognize this limitation in our work. Sex is used here, as it reflects the question asked in the study, and does not make any assumption of underlying biological or psychosocial mechanism. Full sample characteristics are presented in Table 1 (see also supplementary material).

Design

The study had a mixed-groups factorial design. There were two between-groups factors: cognitive pain inhibition strategy (thought suppression vs. focused distraction), and sex (men vs. women), and two within-groups factors: time of testing (pre vs. post pain induction/CPT), and word valence (pain vs. negative vs. neutral). The dependent variable was performance on two attentional bias tasks: the dot-probe task and the attentional blink task.

Questionnaires

A series of questionnaires were administered to participants to assess aspects that previous studies reported as related to attention and pain experience. Pain-related anxiety can be a relevant predictor of experimental pain sensitivity[20] and can influence attention towards pain.[32] State anxiety shows an association with increased experimental pain[35] and threat.[40] Trait thought suppression mediates the relation between depression and pain.[21] A positive association between trait thought suppression and anxiety has been reported, and thought suppression and anxiety appear as important mediators of pain.[16] Therefore, pain-related anxiety, general mood state, cognitive intrusion, and trait thought suppression, as well as demographic details, and manipulation check questions (see Tables 1 and 2) were assessed.

Pain anxiety

The Pain Anxiety Symptoms Scale (PASS-20)[44] is a self-report questionnaire assessing aspects of pain anxiety. It comprises 20 items which are rated on a 6-point Likert scale ranging from 0 ('never') to 5 ('always'). The PASS-20 measures four specific aspects of pain anxiety: cognitive anxiety, fear, physiological anxiety and escape/avoidance. A higher score indicates greater anxiety. The PASS-20 is a short version of the original PASS[45] and retains the four-factor structure, excellent reliability (α= 0.95), and satisfactory validity of the original version.[44] In the current study, the PASS-20 showed high internal consistency with α= 0.92.

General mood state

The Depression Anxiety Stress Scale (DASS-21)[19] is a self-report scales designed to measure the negative emotional states of depression, anxiety and stress. Each of the three DASS-21 subscales contains 7 items. Participants are asked to use a 4-point severity/frequency scales to rate the extent to which they have experienced each state over the past week. A high score indicated higher levels of each mood. Internal consistency for each of the subscales is typically high (α= 0.84-0.97).[19] In the current study, the DASS showed high internal consistency with α= 0.92.

Cognitive Intrusion of Pain

The Experience of Cognitive Intrusion of Pain (ECIP) scale[3] is designed to assess cognitive intrusion of pain. The 10-item measure includes items that capture attentional interruption, dominance of pain thoughts, and difficulty disengaging attention from pain. Participants rate how much pain intrudes into their cognition on a 7-point Likert scale from 0 ('not at all applicable') to 6 ('highly applicable'). The ECIP shows unitary construct validity with adequate psychometric properties, high internal reliability (α= 0.96), and a unifactorial structure[3]. In the current study, the ECIP showed high internal consistency with α= 0.94.

Trait thought suppression

The Avoidance-Endurance Questionnaire (AEQ)[18] is a self-report questionnaire assessing pain-related cognitive, affective and behavioral responses to pain. It comprises 61 items which are rated on a 7-point Likert scale ranging from 0 ('never') to 6 ('every time'). The AEQ measures five specific aspects of fear-avoidance behavior (Anxiety/Depression, Help-/Hopelessness, Catastrophizing Thoughts, Avoidance of Social Activities, and Avoidance of Physical Activities), and four aspects of endurance behavior (Positive Mood despite Pain, Thought Suppression, Pain Persistence, and Humor/Distraction). The Thought Suppression Scale (TSS) was used in this study to assess thought suppression as a trait. The AEQ-TSS shows satisfactory reliability (α= .80) and validity[18]. In the current study, the AEQ-TSS showed satisfactory internal consistency with α= 0.73.

Pre-CPT and post-CPT questions

Before the cold pain induction via cold pressor test (CPT), pain, anxiety, and worry about the upcoming task were assessed using blank visual analogue scales (VAS) of 10 cm length (pre-CPT questions). The answers were rated from 0 "not at all" to 10 "very/highly". They were also used to assess post-CPT pain and anxiety, maximum and average pain experienced during the cold pressor, perceived threat associated with the cold pressor test, and frequency of cold or pain thoughts. As manipulation check questions, difficulty and success in following the instructions, thought intrusiveness, and external distractions were also assessed with VAS. For the full questions, see supplementary material.

Pain inhibition strategies

Two pain inhibition strategies were used in the current study: thought suppression and focused distraction. Participants were randomly assigned to one of the two pain inhibition groups. Randomization occurred when participants completed the baseline questionnaires, and so the experimenter had no previous knowledge of the condition. To allocate groups, participants were randomly allocated a unique number (between 1-140); even numbers receiving thought suppression, and odd numbers focused distraction. In the thought suppression group, participants were asked not to think about pain or cold sensations. In the focused distraction group, they were told to distract themselves by imagining their home in vivid detail (see supplementary material for complete instructions). All participants were tested by the same experimenter. Consistent with protocols adopted in previous attentional coping manipulation pain studies,[26,30,31,66,68] a control group (no strategy) was not included. This is because participants, when not given direction, will usually spontaneously adopt a strategy of their choice, such as distraction or suppression, which potentially confounds results.

Instruction development

The two pain inhibition instructions, thought suppression and focused distraction, were based on those used in previous studies.[7,13,30,34,48,55,67] Particular care was taken to ensure instructions would be as similar to each other as possible. For inducing thought suppression, the focus was on "NOT thinking about unwanted thoughts" rather than "suppressing unwanted thoughts", as the former is assumed to better induce the paradoxical effects of thought suppression by leaving an instructional void. The instructions were shared with several experts in the field and modified accordingly. In the experiment, the instructions were read to the participants, and provided with a visual cue card with their task displayed on it ("Do not think about pain or cold!" or "Think about your home!").

Pain inhibition context

In order to contextualize the two pain inhibition strategies, participants conducted a modified version of the cold pressor test. Participants initially placed their non-dominant hand and wrist in a warm water container at 36°C to ensure a uniform hand temperature, before submerging the same hand and wrist into 12°C cold water for two minutes. This temperature level was higher than would normally be used in a cold pressor test. However, the task was not used to explore pain-relevant outcomes, such as threshold and tolerance, but was instead used to provide a more realistic context in which to conduct the pain inhibition strategies. This followed the approach described by Verhoeven et al.[74] to ensure that a) most participants would be able to perform their pain inhibition strategy for a sufficient length of time, and b) both men and women would immerse their hand for a similar amount of time.[47] The intensity of the pain experience was considered less important than ensuring participants would maximize the time engaging in pain inhibition within a pain-related context. The length of immersion was not communicated beforehand. After two minutes (or before, if they reached pain tolerance), participants removed their hand, and quietly continued with their respective pain inhibition strategy for an additional two minutes. This ensured a sufficient amount of time had been spent conducting the pain inhibition strategy.[37] In total, the instructed use of thought suppression or focused distraction lasted four minutes, i.e., 2 minutes in cold water, plus an additional 2 minutes quiet period. If there was an early removal from the cold pressor test, the quiet period lasted until the total of four minutes had elapsed. This fixed immersion time was chosen over a pain tolerance paradigm, in which the hand is removed upon reaching pain tolerance.

Attentional bias tasks

Attentional bias towards pain was assessed using two computer-based tasks: the dot-probe task,[41] and the attentional blink task.[55] The two tasks were chosen to supplement each other, as they reflect different forms of attention and related biases: spatial (dot-probe) and temporal (attentional blink). This allows a comparison, and exploration of generalizability of effects. Stimuli for both tasks consisted of three different word categories: neutral (e.g., door), negative (e.g., stupid), and cold/pain-related (e.g., biting). A new set of words was generated for use in both attention bias tasks. We supplemented the original set of words used by Keogh et al.[29], which included pain-related, negative, and neutral (household-related) words, by including words specifically related to cold pain. The new word list was rated by five independent raters for negativity, pain, and cold representation (see supplementary material). The chosen neutral words on the list had to be rated as low in negativity, cold, and pain; the chosen pain words had to have relevant ratings in all three; and the chosen negative words had to have relevant ratings in negative, but low ratings in cold and pain. Words that did not fulfil these criteria were excluded.

To ensure a range of different words appeared in each task, the word lists were repeated across all tasks, and phases of testing. Repeating the words might have resulted in a lack of novelty of the targets. Repetition was intentionally chosen over compromising on either the distinctiveness of the words for each category or number in each group (see supplementary material). For both tasks, the target words needed to be common English words that participants would easily recognize. This was particularly the case for the attentional blink task, where it was important that the participants could identify the words even at very short presentation durations. The attentional tasks were controlled using E-Prime 2.0, and presented on a computer monitor. The participants sat at 60cm distance from the monitor.

Dot-probe task

The dot-probe task has been well used within pain studies, and is thought to reflect a selective attentional bias to pain (see Figure 1). Each trial began with a small fixation cross, presented in the middle of the screen for 500ms. Next, a word pair was concurrently presented, one word above and one below the center of the screen. The key manipulation was that in some trials one of the words was pain-related, and the other neutral. The other word pairings, negative/neutral, or neutral/neutral, served as reference categories. After a presentation time of 500ms, the word pair disappeared, and a dot-probe was displayed in the location of one of the words. The task was to indicate the location of the dot, here “above” or “below”. This was indicated with the key “z” for “above” and “m” for “below” on a standard QWERTY keyboard. The dot-probe remained on the screen until a response was made, or for a maximum of 3000ms. After a response was made, or when the 3000ms had elapsed, the next trial began. The words appeared in black on a white background, in Arial font size 50, with the word centers 6.8cm apart from the fixation cross, which appeared in the middle of the screen. The dot probes, 0.5cm in size, were each aligned with the word center. Instructions were given in Arial font size 20.

The dot-probe task used in the current study consisted of 120 trials (and an additional 10 practice trials at pre-CPT). Each word valence group comprised 40 word pairs. These were derived from 20 pain/neutral, 20 negative/neutral, and 20 neutral/neutral pairing words, each repeated twice. The locations of each word and the dot-probes were balanced across trials. Half of the word pairs for each valence (see supplementary material) appeared once in each location (up/down), with the dot probe always in the upper position, while the other half of the word pairs for each valence also appeared once in each location, with the dot probe always in the lower position. There was a break every 48 trials and the task took around 5-7 minutes to complete. Reaction time and accuracy was recorded. If reaction times to the dot-probe are faster when it appears in the location of the pain word, this suggests an attentional bias towards pain.[41]

- Insert Figure 1 here –

Attentional blink task

The attentional blink task was also used (see Figure 2).[39,55] The attentional blink measures aspects of attention by either showing a more pronounced or an attenuated "attentional blink". In the word version of the task, stimuli words are presented in a rapid visual stream, one at a time, with the aim of correctly identifying two target stimuli within the array. In each trial, participants were presented a rapid visual stream of 13 individual items, of which 2 were target words and 11 were distractor pseudowords (produced using a word generator program[33]). Each item in the array was presented for 110ms[61] in the middle of the screen. The two target words were printed in green, Arial font size 50, and comprised of 6 characters or less. The distractor pseudowords were displayed in black, Arial font size 50, and consisted of 8 characters or more, in order to mask the target words. Participants were instructed to correctly identify the two (green) target words, by typing them into the computer after each 13-item array. In this task, the first target stimulus (T1) is usually recognized or identified well, whereas recognition of the second target (T2) is usually poorer. This disrupted recognition of T2 is referred to as the "attentional blink" effect and describes a relative inability to perceive the second target properly.[42] This attentional blink is most apparent when T2 appears soon after T1 in the item array e.g., fewer number of distractor items between targets, or if the second target appears within a window of 200-500ms after the first.[39,55] However, when the second target follows the first target at a greater distance, for example, with six distractors in-between, or more than 500ms afterwards, it can be identified much better.[55] The temporal nature of the blink effect can therefore be explored by varying the distance between the two targets. This distance is referred to as the "lag" between targets. For example, if T1 and T2 were separated by one distractor this would be called lag 2, whereas if separated by seven distractors it would be called lag 8. The task is thought to be a measure of attentional regulation and control,[11,24,42] with a suppression of attentional deployment being found during the blink.[42]

- Insert Figure 2 here -

Importantly for the current study, the attentional blink effect can be modified by varying targets in the task in terms of their emotional content.[39,42,43,61] It has been found that when T1 is a threat word, identification rates of T1 and T2 can vary. Higher identification rates of T1 are therefore taken to reflect greater vigilance towards threat, while lower identification rates are indicative of avoidance. Responses to a neutral T2, following a threat-related T1, are also thought to reflect different attentional biases. Here, better identification of T2 is taken to reflect avoidance of or faster disengagement from T1, whereas lower T2 identification rates are interpreted as a difficulty to disengage from T1. In the present study, the key manipulation was that the first target word (T1) was varied in its emotional valence, i.e., pain, negative, or neutral. T1 randomly appeared at position 2 or 3 in the 13-word array. The second target word (T2) was always neutral and followed T1 either at lag 2 or lag 8 (see Figure 2).

The attentional blink task consisted of 120 trials (each containing a 13-word stream), equally distributed to each valence and lag, resulting in 20 trials x 3 valence groups (pain, negative, neutral) x 2 lags (lag 2 and 8). After each word array, the participants were asked to type in both T1 and T2 words separately, using the keyboard. If they were not sure, they could guess or leave the field blank. The rate of correct identification of both target words is used to determine the attentional blink effect. The rate of correct identification of T1 was expected to depend on the *valence* of the T1 word (pain, negative, or neutral). It was also expected that the rate of correct T2 identification would vary depending on a) the *valence* of T1 that preceded it and b) the *distance* to T1 (lag 2 or 8). Responses were not timed, meaning the participants could take as long as they needed to answer the prompts for each target word. After every trial, the participant could proceed by key press to the next trial as soon as they wished. There were breaks every 20 trials and the task took 20 minutes to complete.

Procedure

Following informed consent, participants completed the pre-CPT questionnaires, and dot-probe and attentional blink tasks (see Figure 3). After receiving instructions, participants completed the cold pressor test using their allocated cognitive strategy. They kept their hand in the cold water for 2 minutes, after which a signal from the researcher indicated they could remove their hand, but should continue with the cognitive strategy for another 2 minutes. After the task, participants immediately sat down at the desk and completed the brief post-CPT questions (see Table 2 and supplementary material), followed by a second dot-probe and attentional blink task. Participants rated their pain during the CPT retrospectively, which was a deliberate choice in order not to disturb the cognitive strategy during the CPT. The room was absolutely quiet during the CPT and pain inhibition strategy. The order in which participants received the two attention tasks was randomized between participants, but remained in the same order within each testing session. The second task was started by the experimenter immediately after the first one ended. Participants were not informed about the nature of words they would encounter. Participants were compensated with £10 for their time.

- Insert Figure 3 here -

Statistical analysis

A series of screening analyses were conducted. ANOVAs were conducted on the demographic data, pre-CPT, and post-CPT questionnaires to see if there were any unintended group (focused distraction vs. thought suppression) and sex (men vs. women) differences. As a follow-up, variables showing significant pre-existing group differences were correlated with the outcomes. Variables with significant correlations with outcomes were subsequently included in the analyses as covariates.

For self-reported pain, a MANCOVA was conducted on the pain variables with maximum pain, average pain, and threat as dependent variables, and group and sex as between-groups factors. Covariates were determined through the process outlined above.

For the dot-probe task, four attentional bias indices were calculated, reflecting the pain and negative word categories. Each index was also correlated with the demographic and questionnaire data, and pain outcomes. Given that we were interested in analyzing pre-post-CPT changes in attention bias while controlling for pre-existing (baseline) bias differences, we adopted an ANCOVA approach for the main analysis, where we included the pre-task index as a covariate, and the post-task index as the dependent variable.[75] To ensure clarity of effects, and avoid multivariate covariates, we opted for two separate, univariate ANCOVAs; one each on the pain bias and negative bias indices. In each, group and sex served as between-groups factors.

A similar ANCOVA approach was taken to analyze the attentional blink task. However, before the main analysis, it is traditional to first establish whether there was an attentional blink effect, separately for each of the two testing phases. Two separate preliminary mixed-groups ANOVAs were conducted, respectively on pre- and post-CPT data; each had target position (representing T1, T2 lag 2, and T2 lag 8) and valence as within-groups factors, and group and sex as between-groups factors. For the main analysis, a series of univariate ANCOVAs were conducted separately for T1 and T2 (lag 2 and 8), scores measured at the post-CPT phase, for each valence type (pain, negative, neutral). Group and sex served as between-groups factors, and the relevant pre-CPT scores as covariates.

To test the association of anxiety, correlations between the dot probe data and the attentional blink data and the anxiety variables were calculated, in three separate analyses (dot probe, T1, T2). Due to the number of correlations being conducted, a Bonferroni correction was applied.

3. Results

Sample characteristics

Means and standard deviations for participant characteristics and questionnaires can be found in Tables 1 and 2. As can be seen in Table 1, a number of participants did not have English as a first language. Both tasks were word-based and required fast processing, and all participants reported a good understanding of English. Participants reported little difficulty in following the instructions, and rated themselves successful in doing so, with no significant differences between the groups. The order in which the participants started the two attention tasks was not correlated to any of the outcomes.

A series of screening ANOVAs were conducted with the demographic data and the pre- and post-CPT questionnaires as dependent variables, and group (focused distraction vs. thought suppression) and sex (men vs. women) as factors. A pre-existing group difference in pain anxiety was found ($F(1,134)=5.01$, $p=.027$, $\eta^2_p=.04$). For the demographic and pre- and post-CPT measures, there were no significant main or interaction effects. Correlations revealed that pain anxiety was related to self-reported pain and threat after the cold pressor (maximum pain intensity: r= .356, p>.001; average pain intensity: r= .288, p>.001, threat r= .352, p>.001), but not to the attention task outcomes. There were no further significant correlations between measures. Pain anxiety was therefore included as a covariate to the analyses of the pain outcomes.

Self-reported Pain

Results showed a significant main effect of group on perceived threat ($F(1,133)=7.80$, $p=.006$, $\eta^2_p=.06$), as well as maximum ($F(1,133)=7.94$, $p=.006$, $\eta^2_p=.06$) and average ($F(1,133)=3.98$, $p=.048$, $\eta^2_p=.03$) self-reported pain during the cold pressor; those in the thought suppression group reported lower threat and pain (see Table 2). The covariate pain anxiety showed a significant influence in the analysis (maximum pain ($F(1,133)=24.77$, $p<.001$, $\eta^2_p=.16$), average pain ($F(1,133)=14.15$, $p<.001$, $\eta^2_p=.10$), threat ($F(1,133)=23.74$, $p<.001$, $\eta^2_p=.15$)). Sex, and the group and sex interaction, did not show any significant effects. Correlations between self-reported pain and attention bias indices showed no significant relationship.

- Insert Table 1 & 2 here -

Dot-probe

Dot-probe bias indices

All incorrect responses, and responses <200ms and >2000ms were filtered out as outliers.[29] Three participants with <90% overall correct responses were removed, resulting in a final sample of 136 participants (86 women, 50 men), comprising 69 in the thought suppression and 67 in the focused distraction group. Next, bias indices were calculated with the following formula:[29] Index = ((vudl – vldl) + (vldu – vudu))/2, where v= valenced word, d= dot, u= upper position, and l= lower position. A positive index score indicates selective attention (vigilance) towards the location of the valenced word (i.e., pain word or negative word), while a negative score indicates a bias away from it (avoidance) (for means, see Table 3, and supplementary material). Two bias indices were calculated for each testing phase i.e., pre-CPT pain index, post-CPT pain index, pre-CPT negative index, post-CPT negative index.

- Insert Table 3 here -

In order to examine whether effects could be attributed to the experimental manipulation, two ANCOVAs were calculated on the post-CPT bias indexes, while controlling for the pre-CPT values. Analyzing the pain bias index, no significant effects emerged. For the negative bias index, the covariate pre-CPT negative bias index emerged as significant ($F(1,131=4.01$, $p=.047$, $\eta^2_p=.03$), but there was no significant difference between the thought suppression and focused distraction groups. No other significant effects were found.

To explore the hypothesized positive association between attention biases and anxiety, the six assessed anxiety variables were correlated with the bias indices resulting from the dot-probe. The magnitudes of the resulting *r* mostly remained <.100, with one exception of a weak correlation between pre-CPT worry and pre-CPT pain bias (r=.177, p=.040). However, after a Bonferroni correction, no significant associations were found.

Attentional blink

In terms of data screening, obvious incorrect spellings were corrected, whereas ambiguous 'errors' were left uncorrected. For example, if the target word was "frame", the answer "frmae" would be corrected, while answers like "flame" or "fame" would not be. On average, 2.1% of T1 answers were corrected, and 0.9% of T2s. All trials in which T1 was not correctly identified were filtered out.[61] Four people were excluded due to outlier performance, identified with boxplots, leaving a sample of N=135, 69 in focused distraction and 66 in thought suppression. Percentages of correct identification of T1 and T2 are displayed in Table 4 (and the supplementary material).

- Insert Table 4 here -

To establish whether there was an attentional blink effect present, separate repeated measures ANOVAs were conducted separately on the pre- and post-CPT data. Target position (representing T1, T2 lag 2, and T2 lag 8) and valence were included as within-groups factors, and group, and sex, as between-groups factors in each analysis. As there was a T1 in every trial, and either a T2 lag 2 or a T2 lag 8 (but not both), T1 has a maximum of 40, and each T2 has a maximum of 20 (see Figure 2). Consequently, T1 was halved before the analysis, in order to avoid inflated results. In both cases, significant main effects for target position (pre: $F(1.15,150.94)=694.57$, $p<.001$, $\eta^2_p=.84$; post: $F(1.07,140.69)=302.73$, p=<.001, $\eta^2_p=.70$) showed that T1 was identified best, T2 lag 8 significantly worse, and T2 lag 2 again significantly worse (see Table 4). This demonstrates the presence of the attentional blink effect, as performance in T2 lag 2 is significantly worse than both T1 and T2 lag 8. There was no difference in group, sex, or group*sex. Since an attentional blink effect has been established, the next step is to explore the nature of the blink separately within T1 and T2.

T1 identification

Three univariate ANCOVAs, one for each valence type (either pain, negative or neutral), on T1 post-scores were conducted, while controlling for T1 pre-scores. Group and sex were included as between-groups factors and T1 pre-CPT scores (either pain, negative or neutral) as covariates. For pain T1, the pre-CPT pain T1 score was a significant covariate ($F(1,130)=181.16$, $p<.001$, η^2_p =.58), but no other significant effects emerged. For negative T1, the pre-CPT negative T1 score was also a significant influence ($F(1,130)=188.58$, $p<.001$, η^2_p =.59). Group also emerged as significant ($F(1,130)=6.39$, $p=.013$, $\eta^2_p=.05$). Those in the thought suppression group (mean= 37.27, SE= 0.27) identified significantly more negative T1 than those in the focused distraction group (mean= 36.32, SE= 0.27). For neutral T1, the pre-CPT neutral T1 score was again significant ($F(1,130)=140.72$, $p<.001$, η^2_p =.52). A significant main effect of sex was found ($F(1,130)=11.75$, $p=.001$, η^2_p=.08). Women (mean= 38.58, SE= 0.18) identified significantly more neutral T1 than men (mean= 37.59, SE= 0.23). No other significant effects were found (see Figure 4).

- Insert Figure 4 here -

To test the association of anxiety with T1 identification, correlations between T1 and the anxiety variables were calculated. Two weak correlations emerged, between the DASS Anxiety scale and pre-CPT identification of pain T1 ($r=-.172$, $p=.047$), and between pre-CPT anxiety and post-CPT pain T1 identification ($r=.201$, $p=.020$). However, after a Bonferroni correction, no significant associations were found.

T2 identification

As outlined above, lag 8 was recognized significantly better than lag 2, revealing the "attentional blink". A series of univariate ANCOVAs were conducted on each of the post-CPT T2 valence group conditions (i.e., pain, negative or neutral), with pre-CPT scores as the covariate. Group and sex were between-groups factors. Analyses were conducted separately for lag 2 and lag 8. It should be noted that when the term "valence" is used here, or "pain", "negative", and "neutral" in connection with T2, they refer to the valence of the T1 word preceding each T2 item (which was always neutral).

For pain T2 lag 2, the pre-CPT pain T2 lag 2 score was a significant covariate ($F(1,130)=269.26$, $p<.001$, η^2_p=.67). No other significant effects emerged. For negative T2 lag 2, the negative T2 lag 2 pre-CPT covariate was significant ($F(1,130)=254.90$, $p<.001$, η^2_p=.66). No significant main effects emerged. For neutral T2 lag 2, the neutral T2 lag 2 pre-CPT score was also significant ($F(1,130)=366.66$, $p<.001$, η^2_p=.74). In addition, sex had a significant effect ($F(1,130)=14.23$, $p<.001$, η^2_p=.10). Women (mean= 14.55, SE= 0.26) identified significantly more T2 at lag 2 following neutral T1 than men (mean= 12.95, SE= 0.33) did. No other significant effects emerged (see Figure 5).

- Insert Figure 5 here -

For T2 lag 8, the same analysis approach was used. For pain, pre-CPT pain T2 lag 8 score was a significant covariate ($F(1,130)=166.94$, $p<.001$, η^2_p=.56), but no other significant effects emerged. For negative T2 lag 8, again the negative T2 lag 8 pre-CPT scores were a significant covariate ($F(1,130)=168.53$, $p<.001$, η^2_p=.57). Group also showed as a significant effect ($F(1,130)=7.27$, $p=.008$, η^2_p=.05). Participants in the thought suppression group (mean= 17.97, SE= 0.20) identified significantly more T2 lag 8 following a negative T1 than those in the focused distraction group (mean= 17.23, SE= 0.19). No other significant effects emerged. For neutral T2 lag 8, the neutral T2 lag 8 pre-CPT scores were a significant covariate ($F(1,130)=87.52$, $p<.001$, $\eta^2_p=.40$). Sex also showed as a significant effect ($F(1,130)=6.55$, $p=.012$, $\eta^2_p=.05$). Women (mean= 18.88, SE= 0.16) identified significantly more T2 lag 8 following neutral T1 than men (mean= 18.23, SE= 0.20). No other significant effects emerged (see Figure 6).

- Insert Figure 6 here -

The anxiety variables were correlated with T2 identification scores. Two weak correlations emerged, between the DASS Anxiety scale and both pre- and post-CPT identification of T2 at lag 8 (pre: $r=-.174$, $p=.045$; post: $r=-.184$, $p=.034$). After a Bonferroni correction, no significant correlations were found.

4. Discussion

This study explored whether thought suppression and focused distraction would differentially affect pain-related attentional biases, using two different attention tasks and a cold pressor test (CPT) for pain context. Although participants in the thought suppression group reported significantly lower pain and threat after the CPT than those in the focused distraction group, no differential effect on pain-related attention was found on either attention task. The attentional blink effect was present equally in both groups. Anxiety was not significantly related to attention towards pain. Although there were no significant effects in attention towards pain, for the blink task there were group differences in attention towards negative content, and sex differences in attention towards neutral content.

Did cognitive strategy affect attentional biases towards pain and negative content?

The type of cognitive strategy did not differentially affect pain-related attentional biases in either of the two attention tasks, suggesting no pain-related rebound effect from thought suppression. This was not only inconsistent with predictions, but also with previous literature on thought suppression rebound effects in pain.[5,7,16,21,34,48,65] One explanation is that the expected rebound effects on pain do not translate to attentional biases and are limited to more sensory aspects. Indeed, although no differential group effect on pain-related attention was found, a beneficial effect of thought suppression was found for self-reported pain and threat following the cold pressor test, with a small to medium effect size. This was also unexpected, and contrasts with previous findings that focused distraction might reduce pain.[2,7,17] However, there are cases where focused distraction appears less useful.[14,57,73] In these studies, external distractions (e.g., tasks, or orientation towards environmental stimuli) were used, whereas the current study used internal distraction (participants' thoughts). Short-term beneficial effects of suppression have been reported to varying degrees previously.[7,8,37,51,77,82] Suppression might be successful when enough capacity can be devoted to it,[77] and so might also work, short-term, when pain intensity is low.

A different pattern was found for attention towards (non-pain-related) negative content. Data from the attentional blink task showed that the thought suppression group identified more negative T1 items, as well as T2 lag 8 following negative T1, than those in the focused distraction group, with a small to medium effect size. However, this result is also inconsistent with previous studies, which do not typically find target identification in the attentional blink to be affected by valence.[36,43,61] It is unclear to us why this materialized for negative, and not pain-specific, words, and why it only occurred when target word positions allowed for more conscious elaboration i.e., T1 and T2 lag 8.

Did anxiety and sex play a role?

While anxiety is positively associated with thought suppression[16], pain,[4,52,56] and attentional biases,[22,29,63] this was not found here. A meta-analysis[9] did not find anxiety to be related to pain-related attentional biases. Likewise, in the present study, anxiety was not related to attentional performance. It is possible that the non-pain sample recruited here was not anxious enough to produce an effect, or that attentional biases towards pain-related information are less robust than in those with chronic pain[9]. It is also possible that more pronounced effects would have been found with more emotive stimuli.[54] However, pain anxiety was associated with perceived pain and threat in the cold pressor test, with a medium effect size for maximum pain, and large effect sizes for threat and average pain.

Sex was also included in all analyses. In the attentional blink task, women showed a significantly stronger identification of all neutral T1, as well as T2 following neutral T1, than men, with medium effect sizes. No sex effects emerged for either pain or negative content, however, suggesting a better awareness in women for neutral words only. In a study on changes in attentional bias towards threat after a CPT, only women showed a heightened attention towards threat[6]. Whilst these findings were not replicated here, they do point towards the existence of sex differences in attentional bias, which are rarely considered in studies of this type. The current findings add to a small but emerging body of evidence that warrants further exploration.[6,27,53]

Strengths and limitations

Strengths of the current study lie in its sample size, careful design, and inclusion of distinct measures of spatial and temporal pain-related attention. However, there are also limitations to be considered. Manipulation check questions were answered retrospectively, as not to interrupt the cognitive strategy. We did not include a no strategy (control) group, as previous studies suggest people usually choose either a suppressive or distractive strategy, potentially confounding results. Thus, the groups could only be compared with each other, and with their own baseline. It is possible that both strategies had a similar effect upon attention biases, which could not be separated. Other design choices that may have had an unexpected effect include the cold pressor task being set to 12°C (following[74]), which may not have been painful enough. Although it was rated as high as 8.4/10 by some, and 4 participants did not last the duration, others did not find it painful. However, the CPT task was used to contextualize the instructions, not induce pain per se. Some effects may have been caused by the pain context provided by the CPT, but since the CPT was the same for all participants, we cannot speculate on this on the basis of our data. The word stimuli were repeated pre and post in the tasks, which may have resulted in habituation and influenced the results. It is also possible that the short-term beneficial effect of thought suppression that was found on pain and threat perception may not last, and even result in worse pain in the longer term.[5,7,14,37,48] However, we did not include a long term pain intensity assessment, and assumed the effect of the strategies would indeed last through to the completion of both attention bias tasks (roughly 20 minutes). It is also possible that the 4 minutes spent with the thought strategy was not long enough to have a strong effect, even though this was informed by Lambert et al.,[37] who found a thought suppression effect after a similar duration. As noted in the participant section, it is possible that we overestimated the size of effect, and in turn underestimated the numbers needed to detect an effect in the current study. In addition, we did not include the exploration of sex differences in our initial power estimations. Our result may therefore have suffered from a lack of statistical power.

Implications and future directions

Despite these limitations, and essentially a lack of consistent effects, there are some implications to consider. The findings from the current study suggest that cognitive strategies might differentially affect self-reported pain, and possibly attention to negative content, using attention-based tasks. Further research that utilizes other tasks known to be sensitive to pain could be considered, such as the Go-/No-Go task (inhibition), or n-back (updating). If the short-term benefit of thought suppression found here is reliable, and generalizes outside of the laboratory to clinical settings, then the current findings might help understand why its spontaneous use is often reported[16]. Whilst the initial usefulness of thought suppression might reinforce its use, long-term use might have a detrimental effect. Less clear is why focused distraction, shown to be largely helpful in acute pain[2,23] seemed less beneficial in this study. Further research on immediate effects of thought suppression is needed, as well as insight into effects of distraction on pain outcomes.

Cognitive strategies are thought to be influential in the maintenance of chronic pain,[15,17] and attentional bias modification may be related to changes in pain outcomes.[4,10,62,69] Allocation of attention might be a mechanism common to both. However, as the present results show, cognitive strategies might not influence attentional bias in all circumstances, or at least not in a differential manner. It would therefore be helpful to find out in which situations different cognitive strategies help or hinder. Clearly, differences exist between experimentally induced pain in healthy participants and the experiences of people with clinical pain,[9,71,73] and so examining for these differences between these groups would be an important next step. Even so, we believe that experimental behavioral studies such as the one current still have a place in pain science, as they enable more control and precision that is simply not often possible in the clinic.

Conclusions

This study compared two cognitive pain inhibition strategies that are frequently used in pain, regarding their potential influence on pain-related attentional biases. While thought suppression seemed beneficial in comparison to focused distraction regarding pain and threat, there was no differential effect of the strategies on attentional biases towards pain.

5. Acknowledgements

We would like to thank Prof. Christopher Eccleston from the University of Bath, and Prof. Geert Crombez and Prof. Stefaan van Damme from Ghent University for giving advice on the procedure, and Dr Samantha Wratten, Dr Elizabeth Kaplunov, and Dr Robert Edinburgh from the University of Bath for rating the word list.

6. Author contributions

All authors have contributed substantially to the conception and design of the study (NK, EK, MIH), acquisition of data (NK), analysis and interpretation of data (NK, EK, MIH) as well as the draft (NK), revision (NK, EK, MIH) and final approval (NK, EK, MIH) of the article. All authors discussed the results and commented on the manuscript.

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Figure and table legends

Figure 1. The dot-probe task.

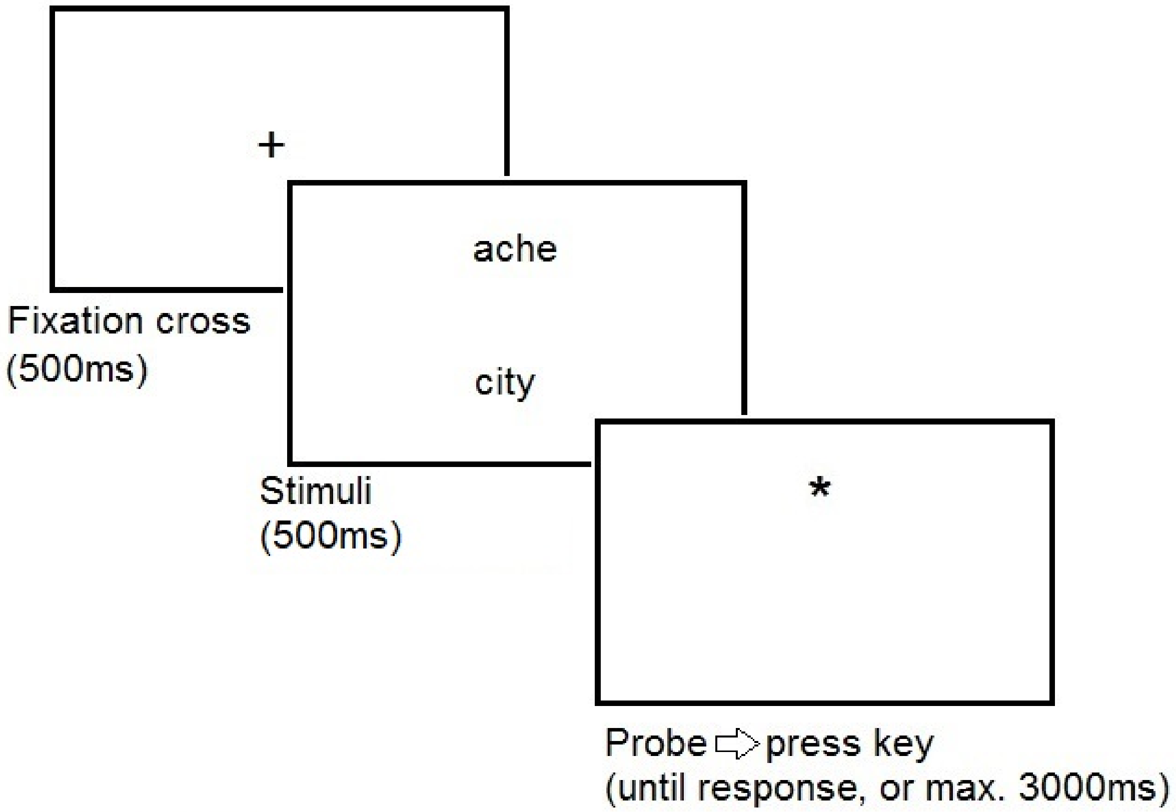

Figure 2. The attentional blink task. Lag refers to the distance between T1 and T2. T1= target 1, T2= target 2.

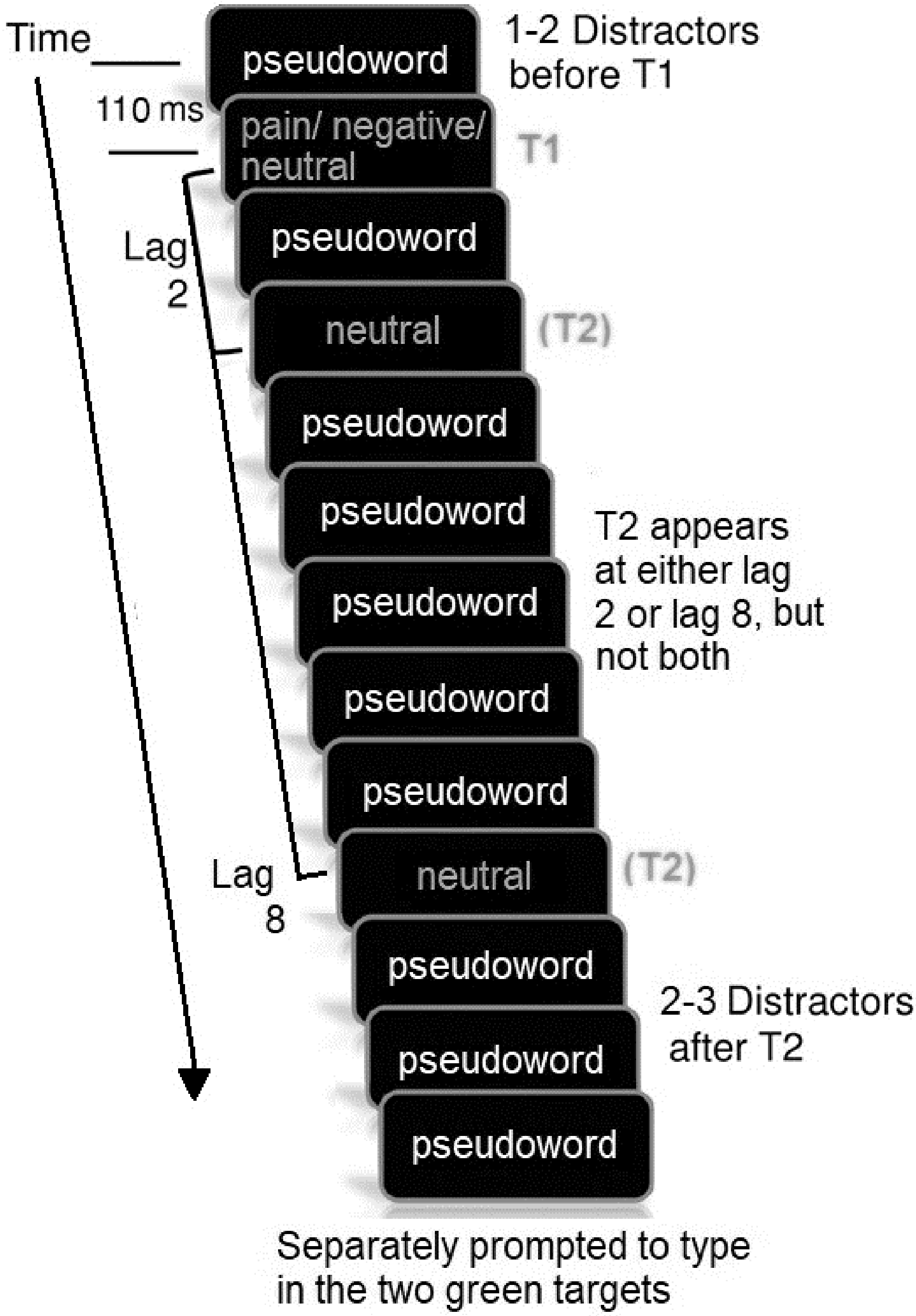

Figure 3. Figure 3. Study procedure. TS= thought suppression, FD= focused distraction, CPT= cold pressor test.

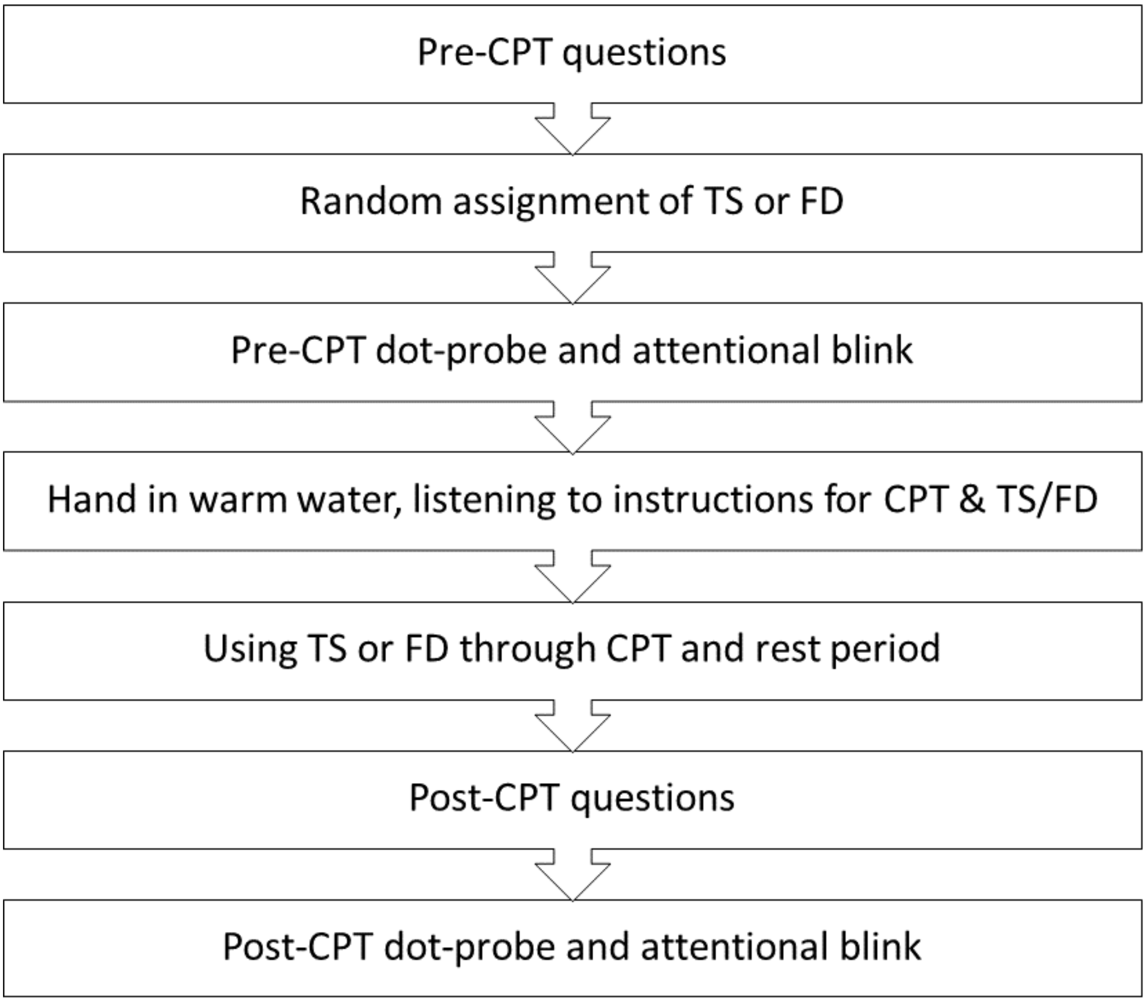

Figure 4. Attentional blink T1 pre- and post-CPT. Error bars represent +/- 1SD.

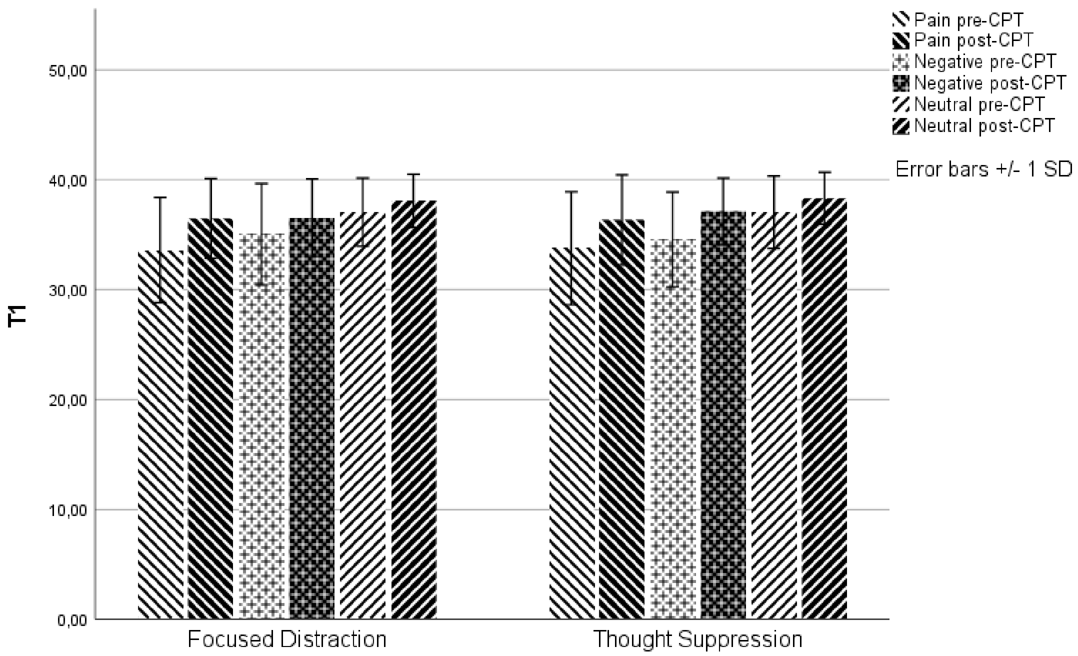

Figure 5. Attentional blink T2 lag 2 pre- and post-CPT. Error bars represent +/- 1SD.

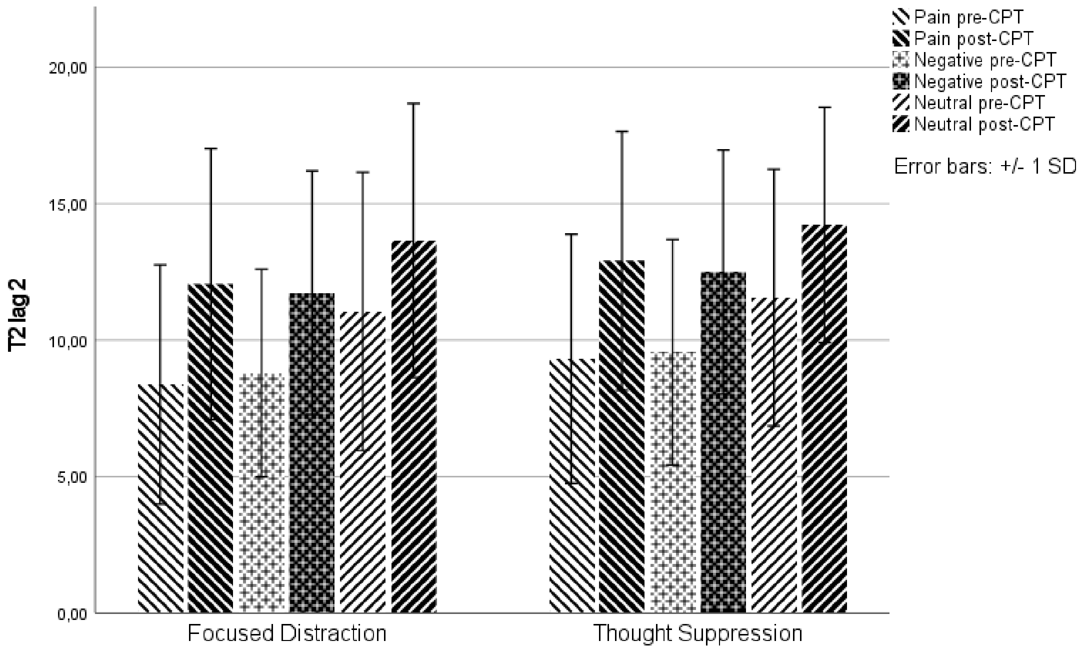

Figure 6. Attentional blink T2 lag 8 pre- and post-CPT. Error bars represent +/- 1SD.

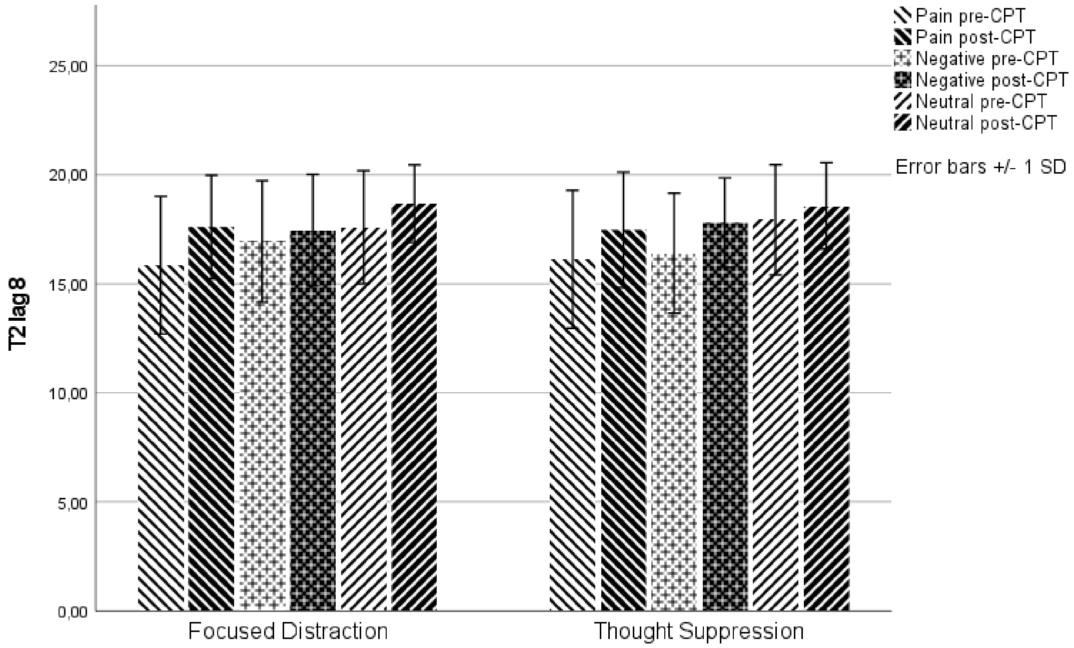

Table 1. Sample characteristics, means (SD).

	Focused Distraction		Thought Suppression	
	Female (43)	Male (26)	Female (43)	Male (27)
Age	25.02 (8.80)	24.08 (5.86)	23.98 (5.16)	26.04 (11.42)
Native English speaker	Yes= 30, No= 13	Yes= 20, No= 6	Yes= 28, No= 15	Yes= 16, No= 11
Questionnaires and pre-CPT questions				
Trait thought suppression (AEQ-TSS) (0-24)	14.10 (5.09)	12.33 (5.21)	13.39 (4.16)	13.08 (5.39)
Cognitive intrusion (ECIP) (0-60)	24.09 (11.55)	20.08 (9.88)	26.76 (11.45)	24.04 (11.41)
DASS (0-63)	12.60 (9.43)	13.73 (8.51)	15.86 (10.46)	14.33 (10.94)
Pain anxiety (PASS-20) (0-100)	39.07 (17.29)	34.72 (11.88)	45.14 (13.49)	40.81 (18.01)
Current anxiety	2.15 (1.84)	1.32 (1.03)	1.68 (1.50)	1.75 (1.84)
Worry about cold water task	1.82 (1.41)	1.54 (1.23)	1.62 (1.17)	1.29 (1.34)
Current Pain	0.33 (0.50)	0.45 (0.62)	0.37 (0.60)	0.45 (0.70)

Table 2. Sample characteristics regarding post-CPT questions, means (SD).

	Focused Distraction		Thought Suppression	
	Female (43)	Male (26)	Female (43)	Male (27)
Post-CPT questions				
Lasting through the cold pressor	Yes= 42, No= 1	Yes=26, No= 0	Yes= 41, No= 2	Yes= 26, No= 1
Current anxiety	1.79 (1.98)	1.50 (1.64)	1.62 (1.76)	1.59 (1.89)
Current pain	1.14 (1.25)	1.08 (1.04)	1.13 (1.21)	1.09 (1.18)
Maximum pain during cold pressor	4.31 (1.94)	4.06 (1.84)	3.65 (1.96)	3.49 (2.01)
Average pain during cold pressor	3.07 (1.73)	2.70 (1.40)	2.63 (1.88)	2.39 (1.63)
Threat of cold pressor pain	1.73 (1.94)	1.61 (2.27)	1.27 (1.75)	0.95 (1.30)
Pain thoughts frequency	3.62 (2.22)	3.46 (1.95)	2.97 (2.48)	3.33 (2.57)
Cold thoughts frequency	4.04 (2.68)	3.87 (2.32)	4.45 (2.33)	4.19 (2.71)
Manipulation check questions				
Difficulty following instructions	3.29 (2.03)	2.88 (1.98)	3.03 (2.01)	2.87 (2.47)
Success following instructions	6.50 (2.03)	6.51 (2.00)	6.31 (2.23)	6.20 (2.58)
Thought intrusiveness	3.80 (2.47)	3.95 (2.18)	3.84 (2.53)	3.75 (2.63)
External distraction	2.65 (2.28)	2.41 (1.79)	2.30 (2.07)	1.62 (1.77)

Table 3. Dot-probe bias indices, means (SD). Positive values reflect attention, negative values reflect avoidance of the respective dot-probes.

Bias Indices

	Focused Distraction		**Thought Suppression**	
	Female	Male	Female	Male
Pre-CPT				
Pain	1.43 (26.79)	-6.08 (23.61)	-10.43 (37.72)	-18.61 (40.58)
Negative	-1.44 (15.41)	4.54 (23.16)	-5.69 (32.93)	1.80 (34.71)
Post-CPT				
Pain	-4.37 (25.78)	7.50 (28.94)	2.37 (32.78)	-5.81 (40.58)
Negative	0.94 (23.56)	-6.25 (27.61)	-4.29 (36.72)	-3.75 (20.02)

Table 4. Percentages of correct target identification of targets in the attentional blink. All valences displayed for T2 represent the valence of the T1 preceding the (always neutral) T2.

	Focused Distraction						**Thought Suppression**					
	Female			Male			Female			Male		
	Pain	Neg	Neu	Pain	Neg	Neu	Pain	Neg	Neu	Pain	Neg	Neu
Pre												
T1	84.0	87.3	92.8	84.0	88.3	92.5	84.8	86.5	92.5	84.0	86.3	93.0
T2 lag 2	41.5	43.0	54.5	42.5	46.0	56.5	48.0	46.5	55.8	44.5	49.5	57.5
T2 lag 8	80.5	84.0	88.5	77.0	86.0	87.0	82.0	83.0	89.5	78.5	80.5	90.0
Post												
T1	92.0	92.0	96.8	89.8	90.5	92.8	91.3	92.8	96.3	90.5	92.8	95.3
T2 lag 2	61.5	58.5	71.5	58.5	59.5	63.0	63.5	63.0	74.0	66.0	61.5	67.0
T2 lag 8	89.5	88.0	95.5	85.5	86.5	90.0	88.0	90.0	93.5	86.5	88.0	92.0

Supplementary Material 1 – Word list

Cold/Pain	Neutral
sting	keys
aching	toilet
beating	mirror
biting	furnish
bleak	dining
burn	bath
choking	dresser
crushing	basement
dull	sofa
harm	bowl
hurting	flannel
inflamed	ornament
numb	soap
tightness	newspaper
pain	room
pounding	cupboard
shooting	polished
spasm	plate
stabbing	banister
throbbing	wallpaper

Negativity	Neutral
alone	glass
annoyed	laundry
avoid	frame
awkward	curtain
blamed	aerial
blushed	ironing
critical	lavatory
defeat	pillow
dislike	heating
embarrass	armchairs
foolish	candles
idiotic	shampoo
idle	jug
reject	boiler
revolted	resident
selfish	drawers
shy	rug
teased	blinds
unkind	socket
wrong	radio

Neutral	Neutral
cleaner	surface
bleach	rented
bricks	lamp
brushing	decorate
chair	floor
clean	tidy
comb	rent
container	staircase
cook	dust
doorknob	bathroom
furniture	corkscrew
grater	mopped
hook	steps
lighting	speakers
nail	plants
painted	bathing
pipe	sill
rail	plug
saucepan	landing
stair	table

Supplementary Material 1. Word list. All words from the list were used in the dot-probe task. Words marked in yellow were used in the attentional blink task.

Supplementary Material 2 – Questions

Pre-CPT

1. How anxious are you currently feeling?
2. How worried are you about the upcoming pain task?
3. How much pain are you currently experiencing?

Post-CPT

1. How anxious are you currently feeling?
2. How much pain are you currently experiencing?
3. What was the *maximum* pain intensity you experienced during the cold water task?
4. What was the *average* pain intensity you experienced during the cold water task?
5. How much did you see the pain as threatening?
6. How difficult did you find it to follow the thought instructions? (place a mark on the line below)
7. How successful were you at following the thought instructions?
8. How frequently did you find yourself thinking about *pain* during the task?
9. How frequently did you find yourself thinking about *cold* during the task?
10. How intrusive were your thoughts and feelings about pain during the task?
11. How distracted by external factors were you during the thought task?

Participants were asked to indicate these on blank VAS that were exactly 10cm in length, starting at the left side with low values and ending on the right side with high values. For example, “not anxious” on the left, and “highly anxious” on the right.

Supplementary Material 3 – Instructions

<table>
<tr><td colspan="2">Common instruction for both groups:

Please put your non-dominant hand in the blue water bucket and listen to the instructions. For the following cold water task, I would like you to place your non-dominant hand and wrist into the cold water. Keep your hand still and open when it is in the water, and do not make a fist. Please try and keep your hand in the water until I ask you to stop.

Whilst you are completing the cold water task, a range of different thoughts, feelings and sensations, some of them related to pain, may come to mind</td></tr>
<tr><td>Thought Suppression only:

Your task is to not think about these thoughts, feelings and sensations about pain. You should not think about the cold water or pain experiences, and not experience any emotions associated with the task. Try not to think or feel anything about pain and the whole procedure as best as you can. Even if you start thinking about coldness or pain, put these thoughts out of your mind and stop thinking about them. Not thinking about cold water or pain is your primary task. It is important that you do not think about the task, or anything to do with cold or pain. Please continue this way until I ask you to stop.</td><td>Focused Distraction only:

Your task is to distract yourself from these thoughts, feelings and sensations about pain. You should do this by thinking about the rooms in your home. Try to imagine your home, room by room, as best as you can. Picture the wall colours, the furniture, the pictures on the walls, in each room, as vivid as you can. Imagine yourself being there, filling your mind with as many images, scenes, sounds and activities as possible. Be as vivid and detailed as you can. Even if you drift to other thoughts, return straight to the thoughts about your home. Forming a mental image of your home is your primary task. It is important that you continue imagining your home in vivid detail. Please continue this way until I ask you to stop.</td></tr>
<tr><td colspan="2">Common instruction for both groups:

In a moment, I will ask you to put your non-dominant hand and wrist into the water, and use these instructions I have just given you. Please close your eyes while completing your thought task. Continue not thinking about pain or cold and keep your hand in the water, until I ask you remove your hand from the water by saying “now”. When you do remove it, I would like you to put your hand on the towel in your lap, and continue with not thinking about pain or cold a little longer, until I ask you to stop. Remember to try as hard as you can to continue this way until I ask you to stop.

Now please place your hand in the water, and start using the instructions I have given you.</td></tr>
<tr><td colspan="2">Upon reaching the cold pressor time limit:

“Now.”</td></tr>
</table>

Supplementary Material 4 – Word list ratings

Word	Cold Rating	Negative Rating	Pain Rating
aching	2.20	5.40	7.20
aerial	0.00	0.00	0.00
alone	0.00	5.60	1.00
annoyed	0.00	6.20	1.20
armchairs	0.00	0.00	0.00
avoid	0.00	4.80	0.20
awkward	0.00	4.60	1.00
banister	0.00	0.00	0.00
basement	0.00	0.00	0.00
bath	0.80	0.00	0.00
bathing	0.80	0.00	0.00
bathroom	0.80	0.00	0.00
beating	0.80	4.80	4.80
biting	4.80	4.40	7.00
blamed	0.00	6.20	0.20
bleach	0.00	0.40	1.80
bleak	1.80	5.80	1.20
blinds	0.00	0.00	0.00
blushed	0.00	3.80	0.60
boiler	0.00	0.00	0.00
bowl	0.00	0.00	0.00
bricks	0.00	0.00	0.00
brushing	0.00	0.00	0.00
burn	2.40	4.40	8.00
candles	0.00	0.00	0.00
chair	0.00	0.00	0.00
choking	1.00	6.80	6.20

clean	0.00	0.00	0.00
cleaner	0.20	0.20	0.20
comb	0.00	0.00	0.00
container	0.00	0.00	0.00
cook	0.00	0.00	0.00
corkscrew	0.00	0.00	0.40
critical	0.00	5.40	0.20
crushing	1.20	5.80	7.00
cupboard	0.00	0.00	0.00
curtain	0.20	0.20	0.20
decorate	0.00	0.00	0.00
defeat	0.00	5.00	2.20
dining	0.20	0.20	0.20
dislike	0.60	6.20	1.00
doorknob	0.00	0.00	0.00
drawers	0.00	0.00	0.00
dresser	0.20	0.20	0.20
dull	1.20	4.60	1.60
dust	0.00	0.00	0.00
embarrass	0.40	5.80	1.60
flannel	0.00	0.80	0.80
floor	0.20	0.20	0.20
foolish	0.00	6.40	0.80
frame	0.00	0.00	0.00
furnish	0.20	0.20	0.20
furniture	0.00	0.00	0.00
glass	1.80	0.40	1.00
grater	1.00	1.40	2.40
harm	1.20	6.20	4.20
heating	0.00	0.20	0.40

hook	0.00	0.80	0.80
hurting	1.60	6.60	8.20
idiotic	0.00	6.80	0.60
idle	0.00	2.60	0.00
inflamed	1.20	4.40	7.40
ironing	0.00	0.00	1.80
jug	0.20	0.20	0.20
keys	0.00	0.00	0.00
lamp	0.00	0.00	0.00
landing	0.00	0.00	0.00
laundry	0.00	0.00	0.00
lavatory	0.20	0.60	0.00
lighting	0.00	0.00	0.00
mirror	1.40	0.00	1.80
mopped	0.20	1.00	0.60
nail	0.00	0.00	2.60
newspaper	0.00	0.00	0.00
numb	7.40	4.75	5.00
ornament	0.00	0.00	0.00
pain	2.00	6.00	9.60
painted	0.00	0.00	0.00
pillow	0.00	0.00	0.00
pipe	0.40	0.00	0.00
plants	0.00	0.00	0.00
plate	0.00	0.00	0.00
plug	0.00	0.00	0.00
polished	0.00	0.00	0.00
pounding	1.60	5.20	6.40
radio	0.00	0.00	0.00
rail	0.00	0.00	0.00

reject	0.00	6.20	0.80
rent	0.00	0.00	0.00
rented	0.20	0.20	0.20
resident	0.00	0.00	0.00
revolted	0.00	5.60	1.20
room	0.00	0.00	0.00
rug	0.00	0.00	1.00
saucepan	0.00	0.00	0.00
selfish	0.00	6.75	0.60
shampoo	0.60	0.00	0.00
shooting	1.60	6.00	4.40
shy	0.00	4.00	0.20
sill	0.00	0.00	0.00
soap	0.00	0.00	0.00
socket	0.00	0.00	0.00
sofa	0.00	0.00	0.00
spasm	1.00	5.20	6.40
speakers	0.00	0.00	0.00
stabbing	2.00	6.20	8.20
stair	0.00	0.00	0.00
staircase	0.00	0.00	0.00
steps	0.00	0.00	0.00
sting	1.20	4.00	6.40
surface	0.00	0.00	0.00
table	0.20	0.20	0.20
teased	0.00	5.40	0.80
throbbing	2.60	4.60	7.60
tidy	0.00	0.60	0.00
tightness	1.60	4.20	4.20
toilet	0.00	0.80	0.00

unkind	0.00	6.20	1.20
wallpaper	0.00	0.00	0.00
wrong	0.00	5.80	0.40

Supplementary Material 4. Results from the word list rating task. 232 words were rated for their cold, pain, and negative ratings. This list includes the words that were included in the tasks, based on this rating. The chosen neutral words on the list were rated as low in negativity, cold, and pain; the chosen pain words had relevant ratings in all three; and the chosen negative words had low ratings in cold and pain, but relevant ratings in negativity. Words that did not fulfil these criteria were excluded. See Supplementary Material 1 for word pairs and usage in the tasks.

Supplementary Material 5 – All tables not split by sex

Table 1. Demographic sample characteristics.

	Focused Distraction	**Thought Suppression**
N	69	70
Sex	Female: 43, Male: 26	Female: 43, Male: 27
Age	24.67 (7.79)	24.77 (8.13)
Native English speaker	Yes: 50, No: 19	Yes: 44, No: 26
Questionnaires and pre-CPT questions		
Trait thought suppression (AEQ-TSS) (0-24)	13.44 (5.16)	13.27 (4.63)
Cognitive intrusion (ECIP) (0-60)	22.58 (11.05)	25.70 (11.43)
DASS (0-63)	13.03 (9.04)	15.26 (10.60)
Pain anxiety (PASS-20) (0-100)	37.47 (15.57)	43.47 (15.41)
Current anxiety	1.84 (1.63)	1.71 (1.63)
Worry about cold water task	1.71 (1.34)	1.49 (1.24)
Current Pain	0.37 (0.54)	0.40 (0.64)

Table 2. Sample characteristics regarding post-test questions.

	Focused Distraction	**Thought Suppression**
Post-CPT questions		
Lasting through the cold pressor	Yes= 68, no= 1	Yes= 67, no= 3
Current anxiety	1.68 (1.86)	1.61 (1.80)
Current pain	1.11 (1.16)	1.12 (1.19)
Maximum pain during cold pressor	4.21 (1.89)	3.59 (1.97)
Average pain during cold pressor	2.93 (1.61)	2.54 (1.78)
Threat of cold pressor pain	1.68 (2.05)	1.15 (1.59)
Pain thoughts frequency	3.56 (2.11)	3.11 (2.50)
Cold thoughts frequency	3.98 (2.53)	4.35 (2.47)
Manipulation check questions		
Difficulty following instructions	3.13 (2.00)	2.97 (2.18)
Success following instructions	6.50 (2.00)	6.27 (2.35)
Thought intrusiveness	3.86 (2.35)	3.80 (2.55)
External distraction	2.56 (2.10)	2.03 (1.97)

Table 3. Bias indices.

Bias Indices	Focused Distraction	Thought Suppression
Pre		
Pain	M=-1.26 (SD=25.8)	M=-13.51 (SD=38.7)
Negative	M=.70 (SD=18.6)	M=-2.87 (SD=33.6)
Post		
Pain	M=-.12 (SD=27.3)	M=-.71 (SD=35.8)
Negative	M=-1.64 (SD=25.1)	M=-.4.09 (SD=31.3)

*Table 4. Percentage of correct target identification. *All valences displayed for T2 represent the valence of the T1 preceding the (always neutral) T2.*

Correct %	Focused Distraction			Thought Suppression		
	Pain	Neg.	Neu.	Pain	Neg.	Neu.
Pre						
T1	84.0	87.6	92.7	84.4	86.4	92.6
T2 lag 2*	41.9	44.0	55.3	46.6	47.8	57.8
T2 lag 8*	79.3	84.7	88.0	80.6	82.1	89.7
Post						
T1	91.2	91.4	95.2	90.9	92.8	95.8
T2 lag 2*	60.3	58.7	68.3	64.5	62.5	71.2
T2 lag 8*	88.5	87.3	93.4	87.4	89.0	92.9