

RUNNING HEAD: IMPACT GOAL FOCUS ON ATTENTIONAL BIAS

Winning or not losing?

The impact of non-pain goal focus on attentional bias to learned pain signals

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Abstract

Background and aims: Insights into the nature of cognitive bias, including attentional bias to threat signals, are considered pivotal to understanding (chronic) pain and related distress. It has been put forward that attention to pain-related threat is normally dynamic and relates to the motivational state of the individual. In this experiment we aimed (i) to replicate the finding that attentional bias for pain signals in healthy participants can be reduced when a non-pain goal is pursued, and (ii) to extend this finding by taking into account the outcome focus of the non-pain goal. We hypothesized that the reduction in attentional bias for pain signals by concurrent non-pain goal pursuit would be stronger with non-pain prevention goals than with promotion goals.

Methods: Healthy university students performed an attentional bias task (i.e., spatial cueing task) containing visual cues that signaled the possible occurrence of a painful stimulus (electrocutaneous stimulus at tolerance level) or its absence, in combination with a non-pain goal task (i.e., digit naming task). The non-pain goal was either related to acquiring a positive outcome (gaining money depending on digit-naming performance; *promotion goal group*, $N=31$) or related to avoiding a negative outcome (losing money; *prevention goal group*, $N=31$). A standard attentional bias task served as the control condition (*control group*, $N=31$).

Results: Spatial cueing effects were larger for pain cues than for no-pain cues, indicating attentional bias for pain signals. The pattern of results suggests that this effect was indeed reduced in the goal groups as compared to the control group, but there was no significant group difference.

Conclusions: We found no statistically-significant evidence for the impact of non-pain goal pursuit or outcome focus on pain-related attentional bias. At best, there were indications of a reduced attentional bias for pain signals with non-pain goal pursuit that was either promotion- or prevention focused.

Implications: These data add to the small but growing body of literature on the assumed relevance of motivational context in explaining variations in attentional bias. The results trigger new questions on the nature and assessment of pain-related attentional bias, and more specifically attentional bias for fear-conditioned pain signals (versus safety signals), from a motivational perspective.

Keywords: attention, experimental pain, fear, fear conditioning, motivation, goal pursuit

1. Introduction

Learning about pain outcomes that follow a stimulus influences the extent to which that stimulus is attended to. Indeed, a considerable body of experimental evidence indicates preferentially attending towards visual stimuli that predict pain, as compared to stimuli that are never followed by pain [1,2,3,4,5,6,7,8,9,10,11]. These findings are in line with research indicating prioritized attending to stimuli with high threat value [12,13,14,15]. Excessive attention to pain-related information has been thought to be dysfunctional and to relate to more intense pain and chronic disability [15,16,17,18].

In many previous studies, attentional bias to pain signals was assessed in a motivationally inert context. However, pain typically occurs in a dynamic context of motivations and goals [19,20,21,22]. Individuals in pain often pursue goals related to pain control and avoidance, but also goals not related to pain, such as achieving academic success or being a good partner. The motivational perspective suggests that attentional bias varies with the goals that people pursue [15,23]. Research has shown that when the goal of pain relief or avoidance is boosted, attentional bias to pain-related information is enhanced [4,24]. Moreover, and especially relevant for the current study, attentional bias to learned pain signals can be reduced when one is motivated to pursue a concurrent non-pain goal [5,25]. This latter finding implies that engaging in activities that promote the pursuit of valued non-pain goals may successfully reduce attention to pain-related threat, and therefore improve daily functioning [5,26]. Studies have been few, however, and further research and replication are needed.

It remains largely unknown what characteristics of non-pain goals are important to reduce attentional bias to pain signals. The present study investigates the role of one feature: the outcome focus of non-pain goals. A distinction can be made between *promotion goals* focusing on positive outcomes (gain vs. non-gain) and *prevention goals* focusing on negative

outcomes (loss vs. non-loss). Individuals with promotion focus differ from those with prevention focus in how they approach desired outcomes and avoid undesired ones [27,28]. Evidence suggests that individuals are more motivated to perform a task when incentive outcomes are negatively framed, focusing on avoiding losses, than when incentive outcomes are positively framed, focusing on obtaining gains [29]. Similarly, individuals may be more motivated to pursue non-pain prevention goals than non-pain promotion goals. If so, individuals may be more cognitively engaged to and allocate more attention to non-pain prevention goals than non-pain promotion goals. Consequently, the reduction in attentional bias to pain signals by concurrent non-pain goal pursuit would be stronger with prevention goals than with promotion goals.

The first aim of the present study was to replicate the finding that attentional bias to learned pain signals is reduced with non-pain goal pursuit. The second aim was to extend this work by examining the differential impact of outcome focus during non-pain goal pursuit. To this end, we applied the innovative approach introduced in [5] but crucially with different goal focus instructions. We predicted that (i) attentional bias to pain signals would be reduced in participants who are motivated to engage in a non-pain goal task (digit naming) during attentional bias assessment (spatial cueing task) than in participants who only perform the attentional bias task; (ii) this reduction would be stronger with prevention focus (risk of losing money) than with promotion focus (opportunity of gaining money) during non-pain goal pursuit.

2. Methods

2.1. Participants

One hundred eight students from Maastricht University (24 male), recruited through advertisements at campus, participated in this experiment, with 36 participants assigned to each of the three study groups (promotion goal group, prevention goal group, and control group; see Section 2.2.4.). For safety reasons, pregnant women and people with an electronic implant such as a cardiac pacemaker were excluded as they should not be exposed to the electrocutaneous stimulation. Additional exclusion criteria were self-report of current pain complaints (acute/chronic); recent accident or surgery; (history of) psychiatric problems; attention deficit disorder; current use of medication for anxiety or depression; (uncorrected) vision impairments interfering with computer task performance; alcohol use the same day prior to testing. All participants were fluent in Dutch, gave written informed consent and received 10€ compensation for their participation, paid in the form of vouchers. Characteristics of the final sample included for analysis are reported in the Results Section. The study was approved by the Ethics Committee of the Faculty of Psychology and Neuroscience at Maastricht University (Reg. nr. 74_5-10-2008-2).

2.2. Apparatus and task materials

2.2.1. Electrocutaneous stimuli

Electrocutaneous stimuli (300-millisecond duration; bipolar sinus waveform; 50 Hz) were delivered by an isolated bipolar constant current stimulator (DS5; Digitimer Ltd, Hertfordshire, United Kingdom). These stimuli were applied to the left ankle (external side) using two 8-mm stainless steel surface electrodes, vertically placed with 1-cm inter-electrode distance, secured to the participant's skin by adhesive collars, and filled with microlyte electrode gel.

Stimulus intensity was individually set at a level that the participant described as very unpleasant and demanding some effort to tolerate [5,6,9]. Each participant was exposed to two series of step-wise increasing intensities of electrocutaneous stimuli (1-mA steps). The onset of each stimulus was triggered by a key press by the experimenter, preceded by a verbal warning that the next stimulus was about to be delivered. The participant rated each stimulus on an 11-point numeric scale, with 0 indicating that they felt nothing, 1 indicating that they felt the stimulation but that stimulation was not unpleasant at all, 2 indicating that the stimulation started to become unpleasant, 9 indicating that the stimulation was very unpleasant but, with a certain effort, just tolerable, and 10 indicating that the stimulation was very unpleasant and intolerable. Stimulus intensity was increased until the participant rated the stimulus as a 9. Then, if the participant was willing to accept a higher intensity stimulus, a stimulus with a one-step higher intensity was delivered. If not so (tolerance level), or if a rating of 10 was given, the series was not continued. The interval between each rating and the next stimulus was about 8-12 seconds. The first series started with a 1-mA stimulus and the second series with a stimulus at detection threshold (i.e., lowest intensity associated with a rating of 1 during the first series). The stimulus with the highest intensity associated with a rating of 9 during the two series was presented during the computer task. Participants were not informed about these procedural details.

2.2.2. Spatial cueing task

Spatial cueing tasks have been successfully used as a methodology to assess attentional bias to pain signals [5,6,7,8,9].

In the current task design, a fixation cross (black; 7 mm x 7 mm) flanked by two rectangular frames (black; 6.5 cm high x 4.8 cm wide; 9.8 cm between screen centre and frame centre)

was displayed throughout the task on a light grey background at the centre of the computer screen. Participants were encouraged to maintain central fixation consistently.

The sequence of events in a typical trial was as follows. One thousand milliseconds (ms) after trial onset, a spatial cue (i.e., coloured rectangle) appeared for 200 ms within either the left or right frame, completely filling the frame. Thirty ms after cue offset, a small target (‘/’ or ‘\’; 4 mm) appeared at the centre of either the left or the right frame, either at the position previously occupied by the spatial cue (*valid trials*) or at the other position (*invalid trials*). Participants’ task was to press on each trial, as quickly and accurately as possible, the top key on a response box with the right index finger to ‘\’ and the bottom key with the left index finger to ‘/’. Faster responses on valid trials than on invalid trials (i.e., *cue validity effect*) were taken to reflect attending to spatial cues [30,31]. Targets remained on the screen until a response was made or for max. 2000 ms. Inter-trial interval randomly varied between 1000 and 1500 ms.

Spatial cues were either pink or green [5,6,7,8,9]. Each cue colour appeared equally often (at either position) and was equally often followed by each target identity. Within each combination of cue colour and target identity, there were an equal number of valid and invalid trials.

2.2.3. Differential conditioning

A differential conditioning procedure was used to create *pain cues* that were sometimes followed by painful stimulation and *no-pain cues* that were never followed by painful stimulation [5,6,7,8,9]. In the test phase (see Section 2.3.4.), one of the cue colours (pink or green; counterbalanced between participants) was immediately followed by the unpleasant electrocutaneous stimulus on one-third of the trials in which it appeared (*pain cue*). The other colour was never followed by electrocutaneous stimulation (*no-pain cue*).

Participants were informed that one of the colours would predict electrocutaneous stimulation, but not which colour. Larger cue validity effects for pain cues than for no-pain cues were taken to reflect biases in attention to pain signals [8,32].

2.2.4. *Non-pain goal task and goal focus instructions*

This study included two goal groups, who performed the same non-pain goal task but with a different goal focus. The non-pain goal task consisted of digit trials that were similar to the cueing task trials (see Section 2.2.2.), except that a random digit from 1 to 9 (black; 7 mm) replaced the fixation cross for 50 ms during the inter-trial interval or during the trial (but not simultaneously with targets or responses to targets, for technical reasons). Digit trials and cueing task trials were intermixed. Participants' task with regard to the targets (‘/’ and ‘\’) was the same on both trial types. The non-pain goal task was to read aloud each digit as quickly and accurately as possible. Because digit trials were similar to cueing task trials, digits were also expected on cueing task trials and so the non-pain goal task remained active throughout the assessment of attentional bias.

Participants in both goal groups received 10€ at the start of the session and were led to believe that the monetary compensation for their participation at the end of the session would depend on digit naming performance (i.e., end score on the non-pain goal task, at the end of the test phase; see Section 2.3.4.). More specifically, the non-pain goal task started with a score of 0 (at the start of the baseline phase; see Section 2.3.2.). It was explained that one would get one point for each fast and accurate response, but lose one point for each slow, inaccurate, or missed response. In order to categorize digit naming responses as fast or slow, a criterion was used that was adjusted after each response, resulting in an equivalent proportion of fast and slow responses throughout the non-pain goal task. Intermediate scores were provided during regular task breaks (see Section 2.3.). The *promotion goal group* was

told in advance that they would receive 15€ compensation with a positive end score and 10€ otherwise (i.e. focus on gaining 5€ on top of the 10€ already received versus no gain). The *prevention goal group* was told that they would receive 5€ compensation with a negative end score and 10€ otherwise (i.e. focus on losing 5€ from the 10€ already received versus no loss). An end score of 0 was presented to all participants. Similar monetary task incentives have been successfully used in previous research on the impact of promotion focus vs. prevention focus in student samples [33,34]. There was also a *control group* that was presented with the same trials as the goal groups but without instruction to respond to digits. Digits were also presented to the control group to control for differences in perceptual load between groups. The control group was informed that the digits were presented as an aid to focus on central fixation. They were told that they would receive 10€ compensation at the end of the test phase independent of task performance.

2.2.5. Apparatus

Electrocutaneous stimulus delivery, task presentation, and response registration (latency, accuracy) were controlled by a Dell Optiplex 755 (Dell, Round Rock, TX, USA) computer, running Presentation software (Neurobehavioral Systems, <http://www.neurobs.com>) and connected to a response box, a QWERTY keyboard, a computer mouse, and two 19-inch Samsung Syncmaster 931 BF LCD (Samsung, Ridgefield Park, NJ, USA) monitors (one for the participant and one for the experimenter). In the goal groups, verbal response latency was registered via a Sennheiser HMD/HME 25-1 (Sennheiser Electronic Corporation, Old Lyme, CT, USA) microphone/headphone combination connected to a voice key. At the end of each digit trial, the experimenter manually entered the participant's response to the digit through the keyboard (i.e., the corresponding digit or 0 in case of missing) so that it could be recorded whether the participant had responded accurately

or inaccurately to each digit. In order to establish comparable testing conditions for all groups, the control group also wore the microphone/headphone combination (allegedly as part of the intercom system and to attenuate distracting noise). Self-report questions and questionnaires were completed via a secure online survey system (EMIUM ; Research Institute Experimental Psychopathology, Maastricht University, the Netherlands).

2.3. Procedure

Participants were tested individually in a dimly lit, quiet testing room in the department of Clinical Psychological Science at Maastricht University. They were video-monitored and could communicate via an intercom with the experimenter who was located in a separate room. During the lab session, the participants did not drink or eat anything containing caffeine or other stimulants (e.g. coffee, tea and chocolate). They were led to believe that the study concerned the relationship between concentration and performance. Moreover, they were informed that noxious stimuli would be delivered to their ankle using surface electrodes; that these stimuli feel like pinpricks, stimulate pain nerves, and are perceived by the majority as unpleasant. They received debriefing about the actual purpose and procedures of the experiment after all participants had completed the study.

Upon arrival in the laboratory, participants were randomly assigned to either the promotion goal group, the prevention goal group, or the control group. Participants in all three groups were seated at a viewing distance of about 60 cm from the computer screen. They first completed demographics and rated their fatigue at that moment on an 11-point numeric rating scale (0 = *not at all tired*; 10 = *extremely tired*). Then they completed the 13-item Pain Catastrophizing Scale [35], the most commonly used questionnaire measure of pain catastrophizing [36]. Higher total scores are associated with more catastrophizing thoughts and feelings about pain experiences.

Then, following electrocutaneous stimulus selection, they performed the computer task consisting of a mixture of cueing task trials and digit trials. The goal groups were instructed to respond manually to targets ('/' or '\') on every trial and verbally to digits that appeared on 25% of the trials; the control group had only to respond to targets. The goal groups received two 5€-vouchers before computer task performance that remained visible throughout the session. All task instructions appeared on the computer screen. For all three groups, the computer task consisted of the following phases:

2.3.1. Practice phase

The goal groups practiced first the cueing task without the digit naming task (32 cueing task trials), then in combination with the digit naming task (16 cueing task trials intermixed with 16 digit trials). The control group practiced the cueing task only without the digit naming task (2 x [16 cueing task trials intermixed with 16 digit trials]). Participants received no electrocutaneous stimulation and were informed about this. Following practice, all participants assigned to the goal groups were able to repeat the rules for gaining/losing points and money.

2.3.2. Baseline phase

For all groups, the baseline phase consisted of 96 cueing task trials intermixed with 32 digit trials. The goal groups performed the cueing task in combination with the digit naming task, whereas the control group performed only the cueing task. Participants received no electrocutaneous stimulation and were informed about this.

2.3.3. Acquisition phase

The acquisition phase consisted of 8 cueing task trials and was immediately (no break) followed by the test phase. The goal groups performed the cueing task in combination with the digit naming task, whereas the control group performed only the cueing task. On 4 trials, the spatial cue was a pain cue, followed by electrocutaneous stimulation; on the other 4 trials, the spatial cue was a no-pain cue.

2.3.4. Test phase

The test phase consisted of 144 cueing task trials intermixed with 48 digit trials. The goal groups performed the cueing task in combination with the digit naming task, whereas the control group performed only the cueing task. On one-third of the trials in which a pain cue appeared (24 cueing task trials; 8 digit trials), participants received electrocutaneous stimulation. On the other trials, no electrocutaneous stimuli were delivered.

During all phases except the acquisition phase, cueing task trials and digit trials were presented in a random order, different for each participant. During all phases, incorrect and premature responses to targets ('/' or '\') were signalled by a short beep along with the display of an error message at screen centre for 500 ms (+ 1000 ms pause). Missed responses to these targets were also followed by a visual message lasting 500 ms (+ 1000 ms pause). Every 32 trials, feedback about target responses (i.e., mean reaction time; number incorrect) and digit-naming performance (i.e., intermediate score on goal task; goal groups only) was presented at screen centre during short breaks terminated by the participant.

2.3.5. End of session

Following computer task performance, electrodes were detached and participants were presented with two open questions to elicit participants' primary goals/motives during the computer task (i.e., responding to targets and for the goal groups also reading digits): (1) how

they performed the task and whether they pursued a strategy (and if so, what strategy); (2) whether they had a particular goal in mind during task performance (in other words, whether there was a particular reason why they performed the task the way they did).

Then, participants indicated the extent to which they expected green and pink cues to be followed by electrocutaneous stimulation, how fearful they were when green and pink cues were presented, and how painful, unpleasant, and threatening they perceived the electrocutaneous stimulation during task performance, the extent to which they focused on preventing intense perception of the electrocutaneous stimulation during the task, the extent to which they focused on achieving good task performance, and how motivated they were to perform the task well. The *promotion goal group* also indicated the extent to which they focused on achieving a gain of 5€, the extent to which they focused on not getting 10€, how important it was for them to gain 5€, and the extent to which they worried about not gaining 5€. The *prevention goal group* also indicated the extent to which they focused on preventing a loss of 5€, the extent to which they focused on getting 10€, how threatening they found the risk to lose 5€, and the extent to which they worried about losing 5€. All ratings were made on 11-point numeric rating scales with end points labelled 0 (*not at all*) and 10 (*to a very large extent* or *extremely*).

Finally, all participants completed a battery of self-report questionnaires including a scale developed to assess the extent to which individuals are in general promotion or prevention oriented [37, Study 3]. This Promotion/Prevention Scale consists of 9 items relevant to promotion goals (e.g., *I typically focus on the successes I hope to achieve in the future*) intermixed with 9 items relevant to prevention goals (e.g., *In general I am focused on preventing negative events in my life*). The participant indicates for each item the extent to which the statement is true of him or her, on a 9-point numeric rating scale with endpoints labelled 1 (*not at all true of me*) and 9 (*very true of me*). An index of *promotion goal strength*

is created by averaging all items relevant to promotion goals; an index of *prevention goal strength* is created by averaging all items relevant to prevention goals [37]. The participants also completed the Fear of Pain Questionnaire [38,39], the BIS/BAS Scales [40,41], and the Goal Pursuit Questionnaire [42]. These Questionnaires were included for exploratory reasons only and are not discussed further.

All questions and questionnaires appeared on the computer screen and participants answered by using a keyboard and computer mouse. The session concluded with the participant receiving 10€, for participants in the goal groups according to their end score of 0. The total duration of the session was about 1 hour.

2.4. Experimental design and data analysis

This experiment employed a 2 (valid cueing vs. invalid cueing) x 2 (pain cue vs. no-pain cue) x 3 (promotion goal group vs. prevention goal group vs. control group) factorial design with reaction time (RT) to targets as main dependent variable. This design was used to examine group differences in attentional bias for pain cues during the test phase and to check for attentional bias for one of the cues as a function of its distinctive visual features rather than its conditioned signal value during the baseline phase (prior to differential conditioning in the test phase). Attentional bias would be reflected in a significant 2x2 interaction and group differences in attentional bias in a significant 3-way interaction.

The reported RT analyses were based on *median* correct RTs to reduce the impact of outliers, but the same pattern of results was obtained with *mean* correct RTs (also when responses deviating more than 2.5 SDs from the mean latency per condition were discarded). Accuracy data (the log of percentage correct; [43]) were analyzed in the same way as was done for RTs. All reported *p* values are two-tailed. Data were analysed using SPSS (version 24). Partial eta squared (η_p^2) and dependent Cohen's *d* are provided as measures of effect

size. Dependent Cohen's d and associated 95% confidence intervals (CI) were calculated with ESCI software (www.thenewstatistics.com), with an averaged SD as the standardizer for d [44].

The sample size was informed by previous findings in this field. Post-hoc power analyses were conducted using G*Power software (version 3.1.9.2; [45]), assuming a significance level α of 0.05.

3. Results

3.1. Group characteristics

Six participants were excluded from the analyses: four because of incomplete (computer task) data; two because of meeting exclusion criteria (see Section 2.1.). Nine additional participants were excluded who were slow or inaccurate on cueing task trials with no electrocutaneous stimulation (2.5 SD or more above their group mean) during baseline and/or test phase. The final sample consisted of 93 participants, with 31 participants in each group. A total of 93 participants provides 93.8% statistical power to detect a large group difference ($\eta_p^2 = .14$) in attentional bias, as we observed before [5].

The final groups did not significantly differ in gender ratio, $\chi^2(2, N = 93) = 1.7, p = .4$, mean age, fatigue at the start of the lab session, pain catastrophizing, or electrocutaneous stimulus perception (Table 1).

Self-reported fear and expectancy of electrocutaneous stimulation indicated that differential conditioning had occurred. That is, and as can be seen in Table 1, electrocutaneous stimulation was more often expected after pain cues than after no-pain cues, and participants were more fearful when pain cues were presented than when no-pain cues were presented, with no differences between groups. This was confirmed by ANOVAs with

cue identity (2: pain cue vs. no-pain cue) and group (3: promotion vs. prevention vs. control) as factors, on fear ratings (cue identity: $F(1, 90) = 211.8, p < .001, \eta_p^2 = .70, d = 1.65$; group: $F(2, 90) = 2.1, p = .12, \eta_p^2 = .05$; cue identity x group: $F(2, 90) = 2.4, p = .10, \eta_p^2 = .05$) and expectancy ratings (cue identity: $F(1, 90) = 260.7, p < .001, \eta_p^2 = .74, d = 1.67$; group: $F < 1.0$; cue identity x group: $F(2, 90) = 1.2, p = .30, \eta_p^2 = .03$). Exclusion of participants who were not able to verbalize the contingency between cue identity (color) and electrocutaneous stimulation contingency (i.e., no report of higher expectation of stimulation following pain cue than following no-pain cue; ($n=3$) in control group, ($n=5$) in promotion goal group, ($n=2$) in prevention goal group) did not change the results. They are included in the reported analyses.

TABLE 1 ABOUT HERE

Our student sample was predominantly promotion focused in general, with no differences between groups (Table 2) as confirmed by an ANOVA on goal strength [37] with goal focus (2: promotion vs. prevention) and group (3) as factors (goal focus: $F(1, 89) = 205.0, p < .001, \eta_p^2 = .70, d = 1.5$; group: $F < 1.0$; goal focus x group; $F < 1.0$). In the lab situation, groups did not differ in self-reported focus or motivation (Table 2), except for motivation to perform the target classification task well. The control group reported slightly but significantly more motivation than the promotion goal group to perform the target classification task well, Bonferroni corrected $p < .05$. Post-hoc comparisons revealed no significant differences between either of these groups and the prevention goal group (Bonferroni corrected $ps > .5$). Self-report (Table 2) suggested that all groups were motivated to perform well and focused on good task performance, with average ratings of about 8 and higher on scales from 0 to 10. Self-report also suggested that during the goal task, the

promotion goal group was more focused on gain than on non-gain or prevention. The prevention goal group seemed equally focused on loss and non-loss or promotion.

TABLE 2 ABOUT HERE

3.2. Spatial cueing task: RTs

3.2.1. Baseline phase

Median correct RTs on cueing task trials (Table 3) were subjected to an ANOVA with cue validity, cue identity, and group as factors. Responses were faster following valid cues than following invalid cues, $F(1, 90) = 151.6, p < .001, \eta_p^2 = .63, d = .75$, 95% CI on d [.59, .91], with a mean difference of 32.5 ms (SD = 25.4; 95% CI [27.2, 37.7]). There were no other significant results from the ANOVA. Note that as expected cue validity effect did not depend on cue identity during the baseline phase (cue validity x cue identity: $F < 1.0$; cue validity x cue identity x group: $F(2, 90) = 1.6, p = .2, \eta_p^2 = .03$).

3.2.2. Test phase

Median correct RTs on cueing task trials (Table 3) were subjected to an ANOVA with cue validity, cue identity, and group as factors. Responses were faster following valid cues than following invalid cues, $F(1, 90) = 98.7, p < .001, \eta_p^2 = .52, d = .65$, 95% CI on d [.49, .81]. As expected, this cue validity effect was larger for pain cues than for no-pain cues (cue validity x cue identity: $F(1, 90) = 7.7, p < .01, \eta_p^2 = .08, d = .29$, 95% CI on d [.08, .50]), with a mean difference in cue validity effect of 7.8 ms (SD = 27.1; 95% CI [2.2, 13.4]), indicating attentional bias for pain signals. There were no other significant results from the ANOVA.

So, the ANOVA revealed no significant difference between groups in attentional bias (cue validity x cue identity x group: $F(2, 90) = 1.4, p = .3, \eta_p^2 = .03$), although the pattern of results suggests a bias reduction in the goal groups as compared to the control group. As Figure 1 shows, the average difference between pain cues and no-pain cues in cue validity effect was in the same direction for all three groups, but of a different magnitude. Our sample of 93 provided good statistical power to detect a large-sized difference between the three groups in attentional bias, but the study was underpowered to detect a small-to-medium-sized group difference (30.0% for $\eta_p^2 = .03$). So, smaller effects may exist that were not captured. Despite the lack of a significant three-way interaction, because of our *a-priori* hypothesis of bias reduction in the goal groups, we explored the attentional bias effects further.

The control group had a significant attentional bias to pain signals, as reflected in a significantly larger cue validity effect for pain cues than for no-pain cues, $t(30) = 2.97, p = .006, d = .42, 95\% \text{ CI on } d [.12, .72]$, with a mean difference of 13.8 ms (SD = 25.8; 95% CI [4.3, 23.3]). Attentional bias was however not significant in either the promotion goal group, $t(30) = .58, p = .6, d = 0.12, 95\% \text{ CI on } d [-.28, .52]$, or the prevention goal group, $t(30) = 1.3, p = .2, d = .29, 95\% \text{ CI on } d [-.16, .74]$. Mean difference between pain cues and no-pain cues in cue validity effect was for the promotion goal group 2.6 ms (SD = 24.7; 95% CI [-6.5, 11.7]) and for the prevention goal group 7.0 ms (SD = 30.2; 95% CI [-4.1, 18.1]).

TABLE 3 ABOUT HERE

FIGURE 1 ABOUT HERE

3.3. Spatial cueing task: accuracy

Accuracy was high (>93%) in both baseline phase and test phase, across task conditions and groups; variability in accuracy rates was low. It is therefore advisable to interpret the results from accuracy analyses with caution. ANOVAs of log percentage correct with cue validity, cue identity, and group as factors revealed a significant cue validity effect (i.e., more accurate on valid than invalid trials) for the baseline phase; $F(1,90) = 22.3, p < 0.001, \eta_p^2 = .20, d = .67, 95\% \text{ CI on } d [.38, .96]$, and for the test phase; $F(1,90) = 25.3, p < 0.001, \eta_p^2 = .20, d = .56, 95\% \text{ CI on } d [.32, .80]$. There were no other significant effects, except a small cue identity x group interaction in the test phase, $F(2,90) = 3.4, p < 0.05, \eta_p^2 = .07$, suggesting more accurate responses following pain cues than no-pain cues in the prevention group (and no difference in the control or promotion group).

4. Discussion

The current experiment was designed to test (i) whether attentional bias to learned pain signals is reduced with non-pain goal pursuit and (ii) whether this reduction is stronger with non-pain prevention focus than with non-pain promotion focus. Toward this end, we assessed attentional bias to learned pain signals with a modified spatial cueing task in healthy participants who were at the same time also engaged in a non-pain goal task. For participants in the *promotion goal group* the possible outcome of their performance on the goal task was positively framed (chance of gaining money) whereas it was negatively framed for participants in the *prevention goal group* (risk of losing money). Participants in the *control group* were not motivated to engage in non-pain goal pursuit.

This experiment is a close replication of our previous study on the influence of non-pain goal pursuit on pain-related attentional bias [5] which was the first of its kind. In the original study, the current innovative task design was introduced. Healthy participants performed the same attentional bias task, either combined with the same non-pain goal task (*goal group*) or without (*control group*). The critical difference with the current experiment was that the non-pain goal was related to both losing and gaining money. So, the impact of different goal orientations could not be disentangled. The original study revealed a significantly reduced (and even reversed) attentional bias for pain cues in the goal group compared to the control group.

Here, we were not able to reject the null hypothesis that the control group and goal groups differed in attentional bias for pain cues. Differences between groups were not statistically significant, and confidence intervals were rather wide and considerably overlapping. Future studies may seek to increase the sensitivity of the study and may benefit from a larger sample size.

Although group differences were not significant, the results point in the expected direction of a reduced attentional bias for pain cues with non-pain goal pursuit. On average, the control group, but not the goal groups, showed a significant attentional bias. As suggested by the confidence intervals, non-pain goal pursuit lowered the plausibility of large attentional bias and increased the plausibility of a reduced (and even reversed) attentional bias. What is novel about this is that this pattern of results was found with goal instructions that were either specifically promotion-focused or prevention-focused. This crucial difference in goal focus instructions with the original study [5] might explain differences in findings. A possible though speculative explanation is that the current participants might have been less encouraged to engage in the non-pain goal task than

participants in the original study who faced both the risk of losing money and the chance of gaining money.

We found no differences in attentional bias dependent on goal focus. An explanation might be found in the actual goal focus of the present sample. Participants' self-report suggests that our student sample was predominantly promotion focused [cf. 37], with no clear differences between groups. It could be argued that because the prevention goal group was, on average, more driven by promotion goals, they were less receptive to the induction of a prevention goal focus [27,37]. The main focus in our current investigation was on average differences between groups rather than on individual differences within groups. Further study in a broader and larger sample is warranted to elucidate individual differences in outcome focus and their role in the motivational control of attentional bias. Future research may include alternative manipulations of outcome focus (e.g., asking participants to describe goal-relevant experiences and strategies; [37]) in an attempt to find overall group differences between situationally induced promotion vs. prevention focus.

Our hypothesis was based on observed differences in task motivation between positively and negatively framed incentive outcomes [29]. Our self-report data do not support a difference in task motivation between the goal groups. However, self-report data do not necessarily provide a reliable estimation of motivation. Future studies should consider alternative (performance-based) measures of motivation and task commitment. We acknowledge that different mechanisms may be at play that could affect the current results. Additional possible effects of the outcome focus manipulation could have obscured group effects and future studies might therefore benefit from a focus on individual levels. *First*, negatively and positively framed outcomes may have important different affective consequences. Compared to positively framed outcomes focusing on

potential gain (or reward), negatively framed outcomes focusing on loss (or punishment) may reduce task enjoyment or enhance state anxiety. Theory suggests that anxiety-related processes are especially enabled in contexts involving potential punishment but not potential reward [46]. In a similar vein, it may be suggested that attentional bias to signals of (threatening) pain would be more evident (or less reduced) during prevention-focused non-pain goal pursuit than during promotion-focused non-pain goal pursuit. Research outside the pain domain found no support for a stronger attentional bias for threatening cues when potential outcomes were framed in terms of losses rather than gains [47]. Like in the present study, it could not be excluded that motivational effects related to outcome focus manipulation were obscured by participants' general interpretation and emotional state during the experimental session (e.g. state anxiety due to perceived task difficulty or uncertainty regarding performance and outcomes) [47]. It would be valuable for future studies on the impact of outcome focus on attentional bias to also assess affect throughout the experimental session.

Second, framing potential outcomes as positive (in terms of gains) or as negative (in terms of losses) may lead to counter-regulatory attention allocation to stimuli that are opposite in valence to the current frame [23]. The function of such a mechanism would be to facilitate flexible, adaptive responses to positive and negative stimuli, in order to down-regulate affective states. Following this principle, it may be suggested that attentional bias to pain signals would be more evident during promotion-focused than during prevention-focused non-pain goal pursuit. An interesting question for future research is whether this incongruence effect also applies to attentional allocation to valenced stimuli with a more specific content focus (e.g. pain signals and safety signals rather than more general negative and positive words) that differs from the focus of the current frame (e.g. loss or gain of money).

A number of other possible limitations warrant further comment. First, within the current paradigm, attention to goal-task-relevant digits is instrumental to goal achievement. Moreover, the brief presentation of digits at the screen centre may have enhanced attention to central fixation, especially when these digits were motivationally salient. Differences in central attentional focus may influence attentional bias effects for stimuli presented peripherally. This issue has been discussed in detail elsewhere [5]. Recent data show that attentional bias to pain signals is reduced in the presence of competing goal-information even when attention to goal-related information is not instrumental to goal achievement [25]. It might be valuable for future experiments on the impact of non-pain goal pursuit on pain-related attentional bias to avoid differences in attentional focus between goal conditions.

Second, despite clear conceptualizations and careful task design, several interdependent processes may be going on in parallel in the current paradigm, which ask for further systematic inquiry. We remain for instance uncertain about how non-pain goal pursuit influences attention to conditioned pain signals, independent of its possible influence on threat conditioning.

Third, a relatively high number of participants were excluded from the analyses. Exclusion was mostly due to technical problems in response registration and outlier performance. Importantly, all exclusion criteria were decided *a priori* and are in line with standard criteria in attentional bias research, including the work that the current study is built upon.

Fourth, trait attentional control might moderate the impact of non-pain goal pursuit on attentional bias [25] but was not assessed.

Fifth, findings with healthy participants cannot be readily generalized to other populations, including those with chronic pain problems. We anticipate for chronic pain

patients, within a context of multiple-goal pursuit, reduced inhibition of pain-related attentional bias [48,49,50]. More studies are needed, testing the predictive value of the observed attention effects, and their variation across context, for daily pain outcomes in chronic pain patients and healthy controls [11].

Finally, we used monetary incentives to motivate participants to engage in the non-pain goal task. Nevertheless, money is probably not the most important source of motivation in everyday life. Monetary gains and losses have been successfully used in experimental research to provide control over incentives [e.g., 33,34,51,52], but entail a possible trade-off with external validity [53]. Future experiments might want to examine pain-related attention under motivational conditions that are more similar to real life situations, including incentives that are considered more important (e.g., social comparison, educational credits).

In conclusion, the present project extends previous work on attentional bias for pain-related information, and in particular conditioned pain signals, and builds upon previous work on motivation and goal contexts. We found no statistically-significant evidence for the impact of non-pain goal pursuit and outcome focus on attentional bias. There were possible indications of a reduced attentional bias for pain cues with non-pain goal pursuit that was either promotion- or prevention-focussed, but the critical analysis did not reach statistical significance. Although caution is needed in interpretation, these data add to the small but growing literature on the assumed relevance of motivational context and concurrent goal pursuit in explaining variations in attentional bias. This study highlights the need for further investigation to define the essential aspects of the role of motivation and goal contexts in pain-related attention, in both acute and chronic pain conditions.

0. References

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Figure legends

Figure 1. Mean cue validity effects of the promotion goal group (n=31), the prevention goal group (n=31), and the control group (n=31) for pain cues and no-pain cues during the test phase. Magnitude of cue validity effects was calculated by subtracting mean reaction times (RTs) on valid trials from median RTs on invalid trials. Error bars indicate the SE of the group average of cue validity effects in each condition.

Tables

Table 1. Mean (SD) age, fatigue at the start of the lab session, pain catastrophizing (aggregate score across all 13 items of the Pain Catastrophizing Scale), and electrocutaneous stimulus (ES) perception per group. Ratings were made on 11-point numeric scales from 0 (*not at all*) to 10 (*to a very large extent or extremely*).

Table 2. Mean (SD) self-reported goal focus and motivation per group. Goal strength was assessed with the Promotion/Prevention Scale [49]. The other ratings were made on 11-point numeric scales from 0 (*not at all*) to 10 (*to a very large extent or extremely*).

Table 3. Median correct RTs (in ms; SD in brackets) on cueing task trials during which no electrocutaneous stimulus was delivered, as a function of cue validity, cue identity, and group (baseline phase and test phase).

RT, reaction time.

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Authors' Statements

The authors report how they determined their sample size, all data exclusions (if any), all manipulations, and all measures in the study.

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Informed Consent. All participants gave written informed consent before testing.

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