Hide your pain

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The Journal of Pain, Vol 00, No 00 (), 2019: pp 1–13
Available online at www.jpain.org and www.sciencedirect.com

Original Reports

Hide Your Pain: Social Threat Increases Pain Reports and Aggression, but Reduces Facial Pain Expression and Empathy

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Abstract: **Earlier research studying the effects of social threat on the experience and expression of pain led to mixed results. In this study, female participants (N = 32) came to the lab with 2 confederates. Both confederates administered a total of 10 painful electrocutaneous stimuli to the participant. The framing of the administration was manipulated in a within-subjects design: In the low social threat condition the participant was told that the confederate could choose between 10 and 20 pain stimuli, thus they believed that this confederate chose to administer the minimum allowed number of pain stimuli. In the high social threat condition the confederate had a choice between 1 and 10 stimuli, thus they believed that this confederate chose to administer the maximum allowed number of stimuli. Participants reported on the intensity, unpleasantness, and threat value of the painful stimuli, and their facial expression was recorded. Moreover, aggression and empathy toward the confederates were assessed. As hypothesized, participants reported increased pain intensity, unpleasantness, and threat in the high social threat condition compared to the low social threat condition, but showed less facial pain expression. Finally, participants exhibited increased aggression and reduced empathy toward the confederate in the high social threat condition.**

Perspective: ***Social threat reduces painful facial expression, but simultaneously increases pain reports, leading to a double burden of the person in pain. Additionally, social threat affected social relationships by increasing aggression and reducing empathy for the other.***

Key words: *Social threat, pain expression, self-report, aggression, communication, retribution, empathy.*

Received April 9, 2019; Revised June 18, 2019; Accepted June 26, 2019.

Disclosures: Johan W.S. Vlaeyen is supported by the ''Asthenes'' long-term structural funding—Methusalem grant (# METH/15/011) by the Flemish Government, Belgium. Ann Meulders is a postdoctoral researcher of the Research Foundation Flanders (FWO-Vlaanderen), Belgium (grant ID 12E3717N), and is supported by a Vidi grant from the Netherlands Organization for Scientific Research (NWO), the Netherlands (grant ID 452- 17-002). Kai Karos is a post-doctoral researcher supported by the Research Foundation, Flanders, Belgium (grant ID = 1111015N) and a postdoctoral mandate from the KU Leuven (grant ID = PDM/18/089). The authors report no conflict of interest.

Author contribution statement: K.K. conceived of the experimental study, carried out the data collection and analysis of the data. K.K. also wrote the manuscript and A.M., L.G., and J.W.S.V. provided feedback on the written manuscript and provided supervision during the conception of the study and during data collection.

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1526-5900/$36.00

https://doi.org/10.1016/j.jpain.2019.06.014

Social context can profoundly alter the experience and communication of pain[9,21,32] and it has been proposed to explicitly acknowledge the social dimension in the very definition of pain.[73] Social context can be harnessed to alleviate pain and facilitate coping with pain, for instance via social support[5,27] but much less is known about the effects of social contexts that are perceived as threatening,[28] even though people with chronic pain frequently feel excluded,[48] stigmatized,[49,74] treated unfairly,[38,51,56] and invalidated.[30,31,71] Experimental research investigating the effects of social threat on the experience and communication of pain is lacking. In the broadest sense, we conceptualize social threat here as a threat to the self that is posed by one or several other social agents.[28]

Pain is commonly communicated to others through facial expressions,[43] which in turn are modulated by

social context.[9,66,68] According to evolutionary theory, emotions in general and pain in particular are expressed when it is advantageous for survival to do so.[72] However, in a threatening (social) context expressing pain might not be so advantageous as it signals vulnerability, which could be exploited by adversaries. Consequently, pain expression might be suppressed in the presence of a threatening other.[74] While adaptive in a threatening situation, suppression of pain expression might also have side effects such as underestimation of pain by others, a bias that is common in both lay observers[20,46] and health-care professionals.[25,50] Moreover, a threatening social context may worsen the experience of pain itself. Pain that is inflicted intentionally leads to higher pain reports than pain that is inflicted nonintentionally,[19] possibly because intentional pain is perceived as more threatening[32] or as unjust.[60] In sum, a threatening social context may suppress facial pain expression but simultaneously increase the experienced intensity of pain. Additionally, social threat might also have interpersonal consequences. An individual in a threatening social interaction might react with aggression and reduced empathy toward threatening others, which can negatively impact social relationships and increase the risk for further social isolation.[17,70] For instance, it has been shown that the experience of social exclusion can reduce empathy toward others' suffering,[11] increase aggression,[63] and decrease prosocial behavior.[62]

Evidence for the above-mentioned effects of social threat is mixed. A study by Peeters and Vlaeyen[42] found that social threat led to decreased facial pain expression, but simultaneous increases in reported pain intensity for participants high in pain catastrophizing. In contrast, a recent study by our group was not able to replicate these results but showed that social threat was associated with increased aggression, reduced empathy and increased threat value of pain.[26] In these studies social threat was operationalized as the intentional, malicious administration of painful electrocutaneous stimuli. However, these studies had a couple of limitations that might account for the mixed results: The low social control condition was still rated as rather threatening and there was considerable variability between participants because a between-subject design was used.

Here we aimed to replicate and extend earlier studies in this area.[26,42] We compared a high social threat condition with a low social threat condition.[42] We adapted the paradigm by Peeters and Vlaeyen[42] to maximize the difference between the high and low social threat condition, thereby trying to correct one of the limitations of the earlier studies. We also employed a within-subject design to minimize interindividual variation. We hypothesized that a high social threat context 1) increases self-reported pain intensity, unpleasantness, perceived threat, 2) decreases facial expression of pain, 3) increases aggression, and 4) reduces self-reported sympathy and empathetic distress toward a confederate in a threatening compared to a less threatening social context. Moreover, we also evaluated the possible moderating influence of pain catastrophizing on self-reported pain and facial expression of pain.

Materials and Methods

Participants

Thirty-two female participants between the age of 18 and 38 ($M_{age} = 21.97$ years, $SD_{age} = 3.50$) were recruited by spreading flyers at the Faculty of Psychology and Educational Sciences of the KU Leuven as well as through the departmental Experiment Management System (EMS, Sona Systems) for a study investigating the effect of personality traits on the administration and the receiving of painful stimuli. Sample size calculations were run using G*power[14] based on an α of .05, a medium effect size (dz = .5), and a power of .80, resulting in a required total sample of 34 participants. Because of practical limitations (eg, the availability of the confederates) we were only able to recruit 32 participants. In line with our earlier study,[26] we decided to only recruit female participants in order to reduce interindividual variability, since males and females differ in the encoding and decoding of pain.[29] Of the 32 participants, 29 (90.63%) were students. The exclusion criteria for this study were the presence/diagnosis of (acute or chronic) pain; the use of anxiolytics or antidepressants; medical advice to avoid stressful situations; a neurological or psychiatric disorder; electronic implants (eg, pacemakers); pregnancy; impaired, uncorrected vision; heart disease or other severe medical conditions and nonfluency in Dutch. Participants were recruited and compensated in 2 ways: First-year psychology students participated in return for course credit (n = 7; 21.9%); volunteers recruited by means of flyers were paid €8 for their participation (n = 25; 78.1%).

Ethical Approval

The experimental protocol was approved by the Social and Societal Ethics Committee (SMEC) of the KU Leuven (Belgium) (registration number: G- 2016 04 553). All participants provided written informed consent prior to participation. It was emphasized that participation was completely voluntary and that participants were allowed to stop the experiment at any time without any negative consequences.

Experimental Design and Social Threat Manipulation

In contrast to earlier studies,[26,42] a within-subject design was employed with all participants running through both the high social threat and the low social threat condition. The advantage of this design is the reduction of inter-individual variability, which is especially important with regard to large variations in facial expression between individuals and was one of the limitations of earlier studies.[26,42] The presentation order of the conditions was randomized across participants using a randomization list (created at http://www.random.org) for 40 participants, with 20 participants being allocated one order and 20 participants the other. Because of practical reasons we were only able to recruit 32 participants, which resulted in 14 participants first receiving the low social threat and then the high social threat condition,

and the remaining 18 participants receiving them in reverse order. The manipulation of social threat was similar to earlier studies in this area[26,42]: Participants came to the lab with 2 female confederates (2 Caucasian females, aged 23) whom they believed to be 2 other participants. Based on a bogus randomization procedure, the participant was allocated to receive painful electrocutaneous stimuli, whereas the confederates were allocated to administer them to the participant. The confederates were then asked to choose how many electrocutaneous stimuli they wanted to administer to the participant. In the *high social threat condition*, the confederate could choose between 1 and 10 stimuli and chose to administer the maximum of 10 painful stimuli. In the *low social threat condition*, the confederate could choose between 10 and 20 painful stimuli and chose to administer the minimum of 10 painful stimuli. This is in contrast to the earlier study by Karos et al,[26] where the confederate did not have a choice in the low social threat condition and administered 10 stimuli. We thought that this control condition would increase perceptions of safety and trust, because the confederate seemingly actively chooses the minimum amount of stimuli, rather than being told to do so by the experimenter. We aimed to further maximize the difference between the low social threat condition and the high social threat condition, thereby correcting for one of the limitations of our earlier study.[26] So while the number of painful stimuli in both conditions was identical (10 stimuli), the participant was led to believe that the confederates intentionally chose to deliver the maximum of painful stimuli in the *high social threat condition*. In addition, while the confederate in the *low social threat condition* expressed some concern for the wellbeing of the participant, the confederate in the *high social threat condition* acted distant and uninterested toward the participant to further increase the difference in perceived social threat between the 2 conditions. Note that one confederate consistently took on the role of the high social threat confederate and the other the role of the low social threat confederate throughout the experiment and they were both trained using a relatively standardized protocol on how to act during the interaction.

Apparatus and Experimental Stimuli

Pain Stimuli and Calibration

Electrocutaneous squarewave stimuli of 3 seconds were administered by a commercial stimulator (DS5, Digitimer, Welwyn Garden City, England) through 2 electrodes (1 cm diameter) filled with K-Y gel (Johnson & Johnson, New Brunswick, NJ) and attached approximately 2 cm from each other to the right ankle of the participants. At the beginning of the experiment the intensity of the electrocutaneous stimulus was individually calibrated. During this calibration procedure, the intensity of the stimulus was gradually increased while participants were asked to verbally rate the pain intensity of each stimulus on an 11-point Likert scale. This Likert scale ranged from 0 (feeling nothing) to 10 (worst pain imaginable). The participants were instructed to select a stimulus which was ''moderately painful and demanding some effort to tolerate'' (mean self-reported stimulus intensity was 8.15, $SD = 0.87$, range = 5–10). After selecting the painful stimulus, the participant was informed that she would receive a stimulus of maximally this amplitude during the remainder of the experiment. In fact, all stimuli administered during the remainder of the experiment were of the intensity selected during the calibration procedure. Participants were also given the possibility to increase or decrease the selected stimulus intensity at this point (mean physical stimulus intensity was 7.26 mA, $SD = 4.59$, range = 1.5–20.25 mA).

Software and Computer

The experiment was run on a Windows XP computer (Dell Optiplex 755) with 2GB RAM and an IntelCore 2 Duo processor at 2.33 GHz and an ATI Radeon 2400 graphics card with 256 MB of video RAM. Programming of the experiment was done in Affect (version 4.0).[54] As mentioned previously, the experiment started with a bogus randomization procedure in which the participant and the 2 confederates were allegedly allocated one of 2 roles: administrator or receiver of electrocutaneous stimuli (see Procedure). For this allocation we used the same computer program reported by Peeters and Vlaeyen.[42] This program depicted a coin toss after the participant chose a side (head or tails) by clicking on a button. Note that the participant was always selected as the receiver of the electrocutaneous stimuli and the 2 confederates as the 2 administrators.

Apparatus

A webcam (HD Webcam C525, Logitech, Newark, CA) was installed on top of the computer screen and was used to record participants' facial expressions and the self-report ratings throughout the experiment. The instructions throughout the experiment were delivered by an audiotape, which was prerecorded. The instructions were spoken by a male native Belgian Dutch speaker and indicated when the electrocutaneous stimuli were to be administered and prompted for the self-report ratings of the participant (see Outcome Measures). Lastly, the confederates used a 2-button response box to administer the electrocutaneous stimuli following the audiotape instructions, which was placed on the table.

Experimental Setting

The experiment took place in a sound-attenuated experimental room, equipped with a table, a computer screen and 2 chairs facing each other. Communication between the experimental and the experimenter's room was possible through an intercom system and the experimenter could observe the participant throughout the entire experiment.

Outcome Measures

Pain Expression

Painful facial expressions of each participant were rated using the Childhood Facial Action Coding System (CFCS).[4] This system is based on the Facial Action Coding System (FACS)[13], a fine-grained anatomically based system that is considered the gold standard when decoding the facial expression of pain.[43,47] Six facial action units which have been demonstrated to be the most reliable indicators of pain are brow lower, eye squeeze, eye squint, nose wrinkle, check raiser, and upper lip raise.[34,35,42,43,45] Even though the CFCS was originally developed for children, it has been successfully used in previous studies investigating the effects of social threat on pain in (young) adults, so in the interest of comparability between studies we used the same action codes here.[26,42]

There were a total of 20 video fragments per participant (10 per condition), one for each painful electrocutaneous stimulus. Each video fragment was 4 seconds long, capturing 1 second prior and 3 seconds after administration of the electrocutaneous stimulus. Each second of the 4-second interval was coded using a software program enabling the rater to view and review each second at normal rate and at a rate of one-tenth of a second. All facial action codes were coded for intensity (no action [0], slight action [1], distinct/maximal action [2]). For each time interval, a mean score per second for each of the 6 facial actions was calculated. A total score was calculated by summing these mean scores per participant and per condition resulting in one total facial pain expression score per condition.[6] All action codes were coded by one of the confederates (L.D.) who was trained by the first author, who is a certified CFCS coder. These ratings were used for all the analyses of pain expression. The first author independently also rated a random subset of 20% of all video fragments. Interrater reliability between the 2 coders was satisfactory for overall frequency (> .79) and intensity (> .73).

Verbal Ratings

Participants were asked to verbally rate the intensity, unpleasantness and threat value of the painful stimulus after each electrocutaneous stimulus. They were asked how painful they found the painful stimulus (*pain intensity*) on a scale from 0 (feeling nothing) to 10 (worst pain imaginable), how unpleasant they perceived the painful stimulus (*pain unpleasantness*) on a scale from 0 (not unpleasant at all) to 10 (extremely unpleasant) and how threatening they perceived the painful stimulus (*threat value of pain*) on a scale from 0 (not threatening at all) to 10 (extremely threatening).

Aggression

Aggression has been defined as any behavior that is directed at another individual with the intent to cause harm, frequently in response to provocation or threat.[1] In line with the earlier study by Karos et al (2018),[26] aggression was operationalized by asking the participant to choose the number of painful electrocutaneous stimuli that would be administered back to the confederates. They could choose between 1 and 20 stimuli for each confederate. At this moment the participants were unaware that these electrocutaneous stimuli were never actually administered to the confederates.

Empathy

The assessment of empathy toward the confederate was based on the work of Batson et al.[2] Participants rated how strongly *they* would feel a number of emotions when the confederate would receive painful electrocutaneous stimuli. The scale included a total of 4 self-oriented (worried, upset, anxious, sad) adjectives assessing *empathic distress* and 3 other-oriented (understanding, compassionate, sympathizing) adjectives assessing *compassion/sympathy*. Each adjective was rated on an 11-point Likert scale (ranging from 0 = ''not at all'' to 10 = ''very much''). Scores could range from 0 to 40 for empathic distress, and 0 to 30 for compassion/sympathy with higher scores indicating higher levels empathic distress and compassion/sympathy, respectively.

Social Threat

The Social Threat Questionnaire (STQ)[42] consists of 14 statements concerning the relation between the confederate and the participant. Participants were asked to rate the degree to which they agreed with each of the statements, using an 11-point Likert-scale ranging from 0 = ''completely disagree'' to 10 = ''completely agree''. Social threat was conceptualized through 3 dimensions, namely: specific social threat (eg, "*I had the feeling the other participant enjoyed hurting me*"), social proximity (eg, "*I feel close to the other participant*"), and social likeability (eg, "*the other participant is honest*"). The score ranges from 0 to 140, with higher scores reflecting increased perceptions of social threat. Internal consistency was good, both in the high ($\alpha = .89$) and low social threat condition ($\alpha = .88$).

Pain Catastrophizing

The Pain Catastrophizing Scale (PCS)[55] was used as a measure of catastrophic thinking associated with pain. Participants were asked to reflect on past painful experiences and indicate on a 5-point scale (0 = ''not at all'' to 4= ''all the time'') to which degree they experienced each of 13 thoughts or feelings. The PCS yields a total score and 3 subscales assessing rumination, magnification, and helplessness with a total score ranging from 0 to 52, with higher scores reflecting higher levels of pain catastrophizing. The Dutch version of the PCS has been demonstrated to have good temporal stability, internal consistency in healthy and clinical samples, and good convergent validity with similar measures.[53] Internal consistency of the PCS in the present sample was excellent ($\alpha = .92$).

Procedure

The participants arrived at the laboratory together with the 2 confederates and were seated at a table, facing each other (see Fig 1). Note that the webcam was angled toward the participant so the entire face was visible in the recording. Subsequently, they provided informed consent and the 2 different roles (*administrator/receiver*) were explained. Then the bogus randomization program was run, always allocating the role of receiver to the participant. The confederates were led to an adjacent room and the calibration procedure was performed with the participant (see Electrocutaneous pain stimuli and calibration). Afterward, depending on the order of conditions, one of the 2 confederates was called back into the room. The experimenter placed a button box on the table and instructed the confederate to administer electrocutaneous stimuli by pressing the left button when prompted. Depending on the condition, the confederate could choose to administer between 1 and 10 stimuli (*high social threat condition*) or between 10 and 20 stimuli (*low social threat condition*). Both confederates always chose to administer 10 stimuli. The confederate was asked to verbally express her choice when prompted by the audio instructions. The participant was then instructed to orally respond to the questions posed by the audio instructions. Subsequently, the experimenter would leave the room and start the audio instructions. The instructions prompted the confederate to administer the electrocutaneous stimuli following a 3 second countdown. Nine seconds after each electrocutaneous stimulus, the participant was cued to provide the verbal ratings in the presence of the confederate (see Outcome Measures). During this procedure, the participant's facial expression was recorded.

After completion of the final verbal rating by the participant, the experimenter returned to the experimental room and asked the confederate to leave the experimental room and the participant to fill in the STQ. Then the same procedure was repeated with the other confederate. Afterward, the experimenter explained that the roles of administrators and receiver would be reversed for the final phase of the experiment, and the aggression and empathy measures were taken. Afterward, the participant was asked to fill in the PCS and a demographic questionnaire on the computer while the experimenter was allegedly performing the calibration procedure and administration of the electrocutaneous stimuli with the participant in another experimental room. After the participant filled in all questionnaires, both the confederates and the experimenter reentered the room and fully debriefed the participant.

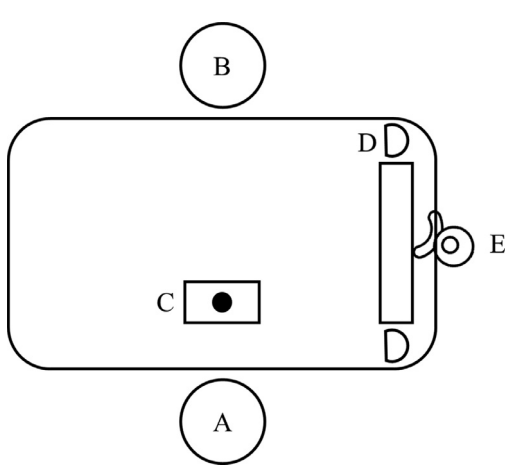

Figure 1. Schematic representation of the experimental setting with the confederate **(A)** and the participant **(B)** sitting at a table across from each other, a button box used to administer the electrocutaneous stimuli **(C)**, speakers to present the audio instructions **(D)**, and a webcam to record the facial expressions of the participant **(E)**. Note that the face of the participant **(B)** was fully visible for the recording.

Statistical Analyses

First, a one-way ANOVA was run as a manipulation check to compare the scores on the STQ between the high and low social threat conditions. Second, to test whether social threat affects self-reported pain intensity, unpleasantness or threat value of pain (*hypothesis 1*), 3 separate 2 [Condition (high/low social threat)] x 10 [Trial (1-10)] repeated measures analyses of variance (RM ANOVAs) were carried out to examine differences for self-reported pain intensity, unpleasantness and threat value of pain between the conditions. PCS was included as a covariate to investigate whether effects of social threat on self-reported pain levels depend on pain catastrophizing as found by Peeters and Vlaeyen (2011).[42] Planned comparisons were carried out to test our a priori hypotheses. Third, to investigate whether social threat reduces pain expression (*hypothesis 2*), a RM ANOVA with condition (high/low social threat) as independent variable, nonverbal pain expression as dependent variable, and pain catastrophizing as covariate was run. Fourth, to investigate whether social threat increases aggression (*hypothesis 3*) and reduces empathy (*hypothesis 4*), separate paired samples t-tests were run to compare the high with the low social threat condition. To account for possible order effects, order 2 [Order (high−low/low−high) was included as a between-subject factor in all analyses. An alpha level of .05 was used for all statistical tests. Greenhouse-Geisser corrections are reported when appropriate. Uncorrected degrees of freedom and corrected *P* values are reported together with ε and the effect size indication η_p^2. Planned comparisons were carried out to test our a priori hypotheses and are reported with effect size indication for Cohen's d. Holm-Bonferroni correction was used to correct for multiple testing per hypothesis and to keep the experiment-wise α at .05.[22] All statistical analyses were run using SPSS 20 (Armonk, NY: IBM Corp.).

Results

Manipulation Check

As intended, perceived social threat was significantly greater in the high social threat condition, $M = 87.19$, $SD = 3.83$, compared to the low social threat condition, $M = 31.75$, $SD = 3.37$, $F(1, 30) = 11.04$, $P = .002$, $\eta_p^2 = .27$, indicating that the manipulation of social threat was successful. There was no main or interaction effect with

order ($F < .62$). Pain catastrophizing was not a significant covariate in any of the following analyses and was therefore excluded from all the analyses reported here.

Hypothesis 1: Does Social Threat Increase Pain Intensity, Unpleasantness and Perceived Threat Value of Pain?

There was randomly missing data due to technical difficulties, which was imputed using expectation maximization (0.94% for pain intensity, pain unpleasantness, and threat value of pain).

Pain Intensity

As expected, pain intensity ratings were higher in the high social threat condition, $M = 6.18$, $SE = .30$, compared to the low social threat condition, $M = 5.71$, $SE = .28$, $F(1, 270) = 5.87$, $P = .02$, $\eta_p^2 = .16$ (see Fig 2). There was no main effect of trial, $F(9, 270) = 2.72$, $P = .09$, $\varepsilon = .18$, $\eta_p^2 = .08$, and no interaction between condition and trial, $F(9, 270) = .97$, $P = .46$, $\varepsilon = .64$, $\eta_p^2 = .03$. There were no main or interaction effects with order on pain intensity ratings (all $F < .83$).

Pain Unpleasantness

In line with the pain intensity ratings, pain unpleasantness ratings were higher in the high social threat condition, $M = 5.46$, $SE = .29$, compared to the low social threat condition, $M = 4.81$, $SE = .31$, $F(1, 270) = 16.85$, $P < .001$, $\eta_p^2 = .36$ (see Fig 2). Moreover, pain unpleasantness ratings increased across trials in both conditions, $F(9, 270) = 4.68$, $P = .02$, $\varepsilon = .21$, $\eta_p^2 = .14$. However, this sensitization did not differ between the 2 conditions, $F(9, 270) = 1.01$, $P = .37$, $\varepsilon = .53$, $\eta_p^2 = .03$. Again, there were no effects of order on pain unpleasantness (all $F < 1.01$).

Perceived Threat Value of Pain

The effect of condition and trial did depend on the order of conditions, Condition x Trial x Order, $F(9, 270) = 3.22$, $P = .02$, $\eta_p^2 = .10$. We then ran 2 separate analyses based on order including Trial and Condition as factors. We found that the perceived threat value of pain was higher in the high social threat group, $M = 3.94$, $SE = .49$, compared to the low social threat group, $M = 2.21$, $SE = .38$, but only in participants who were first exposed to the high social threat condition, Condition, $F(1, 153) = 16.09$, $P = .001$, $\eta_p^2 = .49$. The interaction between Condition and Trial was not significant ($F = 1.49$) and neither was the main effect of Trial ($F = 1.65$). In contrast, the effect of condition was not significant in those participants who received the low social threat condition first, $M = 2.16$, $SE = .39$, followed by the high social threat condition, $M = 2.85$, $SE = .45$, was the second, Condition, $F(1, 117) = 3.81$, $P = .07$, $\eta_p^2 = .23$ (see Fig 2). Again, the interaction between Condition and Trial was not significant ($F = 1.88$) and neither was the main effect of Trial ($F = 2.71$).

Hypothesis 2: Does Social Threat Reduce Facial Pain Expression?

Two participants had to be excluded from this analysis because of technical difficulties during the recording of the facial expression. As expected, facial expressions in the high social threat condition, $M = 3.01$, $SE = .91$, were lower than in the low social threat condition, $M = 6.97$,

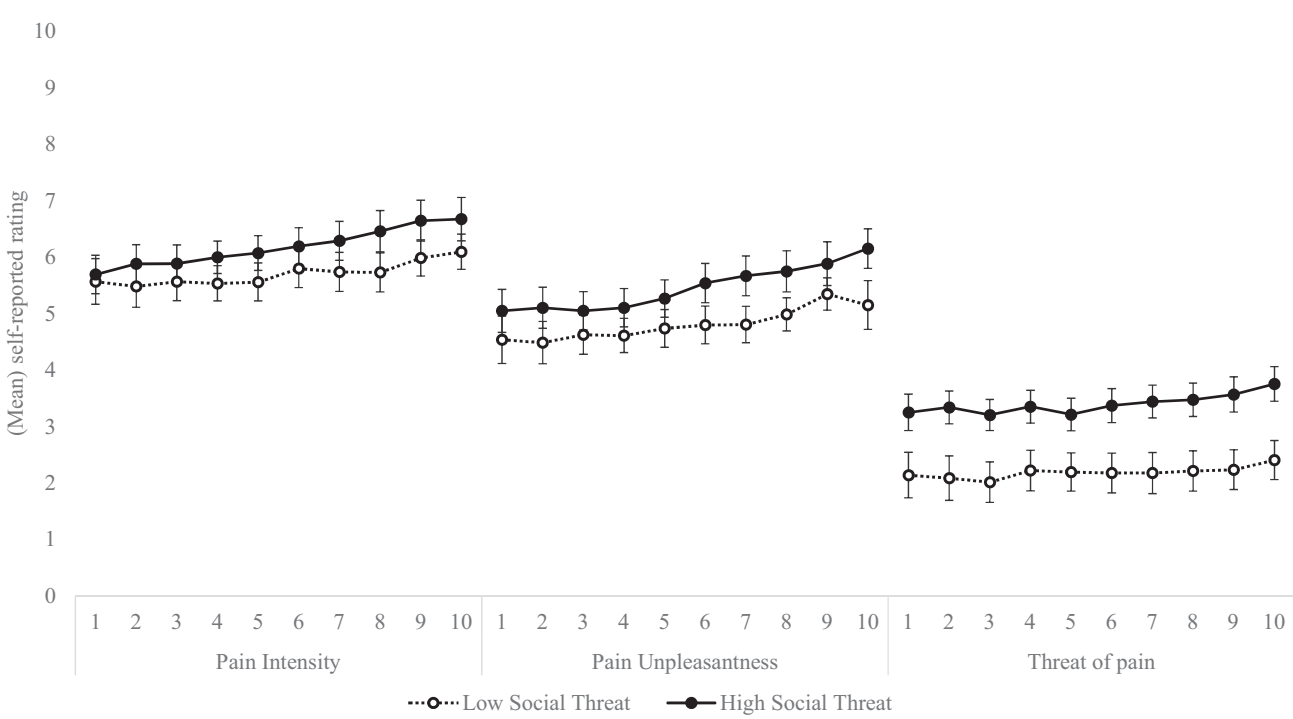

Figure 2. Self-reported mean (+SE) pain intensity, pain unpleasantness and threat of pain ratings in the low and high social threat condition for each of the 10 electrocutaneous stimuli. Note: SE, standard error term based on mixed analyses estimates.

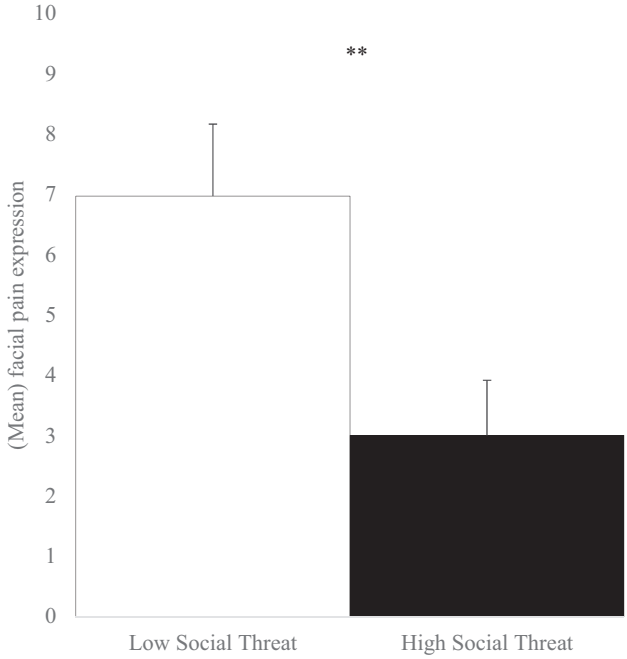

Figure 3. Mean (+ SE) facial pain expression in the low and high social threat condition, as well as in the baseline (during calibration) phase. Note: SE, standard error term based on mixed analyses estimates, $^{**}P < .001$.

$SE = 1.19$, $F(1,28) = 16.52$, $P < .001$, $\eta_p^2 = .37$ (see Fig 3). There was no main or interaction effect with the order of conditions (all $F < 2.42$).

Hypothesis 3: Does Social Threat Increase Aggression?

One participant's response was not recorded due to a technical error and was therefore excluded from the analysis. Participants were willing to administer more electrocutaneous stimuli to the confederate in the high threatening condition, $M = 8.45$, $SE = 1.06$, compared to the low social threat confederate, $M = 3.84$, $SE = .64$, $F(1,29) = 17.47$, $P < .001$, $\eta_p^2 = .38$ (see Fig 4, Panel A). Interestingly, only participants in the high social threat condition were willing to exceed the 10 electrocutaneous stimuli that they were given (n = 9, 29.03%) (see Fig 4, Panel B). Again, this effect did not depend on the order of conditions (all $F < 2.14$).

Hypothesis 4: Does Social Threat Reduce Sympathy and Empathy?

As hypothesized, participants had less empathic distress, $F(1,30) = 6.09$, $P = .02$, $\eta_p^2 = .17$, and less compassion/sympathy, $F(1,30) = 10.31$, $P = .003$, $\eta_p^2 = .26$, for the confederate in the high social threat condition ($M_{distress} = 14.99$, $SE_{distress} = 1.57$, $M_{compassion} = 19.84$, $SE_{compassion} = 1.27$) compared to the low social threat condition, ($M_{distress} = 18.16$, $SE_{distress} = 2.05$, $M_{compassion} = 25.40$, $SE_{compassion} = 1.27$) (see Fig 5). In both cases, this effect was independent of the order of conditions (all $F < 2.18$).

Discussion

This study investigated the effects of a threatening social context on self-reported pain, facial pain expression, aggression and empathy. First, the manipulation of social threat was successful. The low social threat condition was experienced as less threatening compared to the high social threat condition. Moreover, the low social threat condition was also rated as less threatening compared to the earlier study by Karos et al.[26] This was likely a result of the implemented methodological changes in the present study: The confederate in the low social threat condition behaved more compassionately and

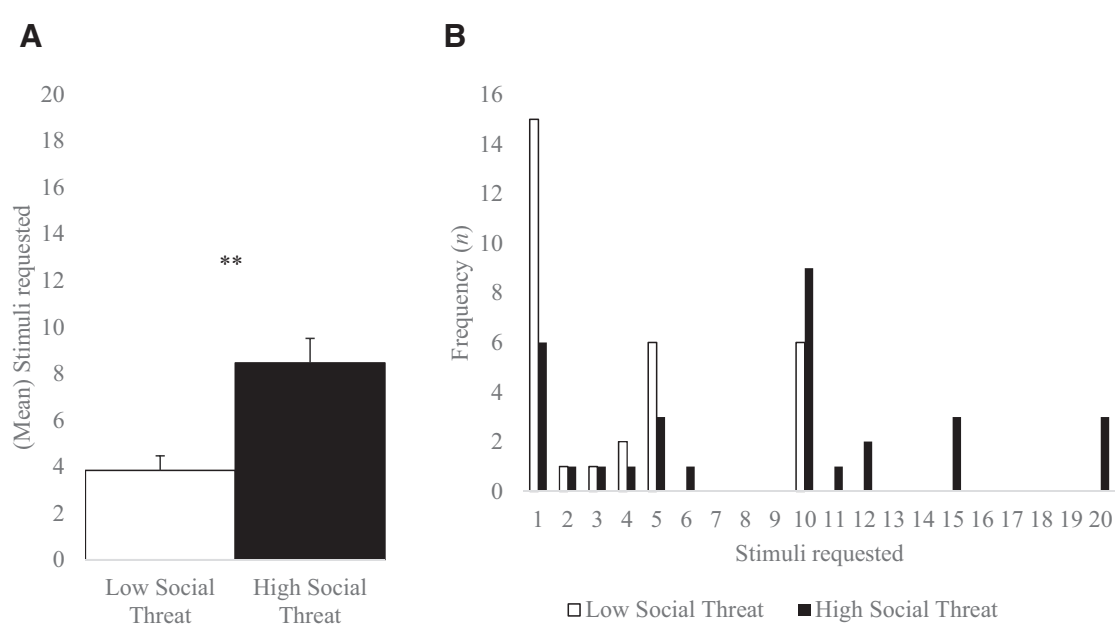

Figure 4. **(A)** Mean (+ SE) electrocutaneous stimuli requested to be administered to the confederates in the low and high social threat condition. Note: SE, standard error term based on mixed analyses estimates, $^{**}P < .001$. **(B)** Number of participants (n) who selected each number of stimuli.

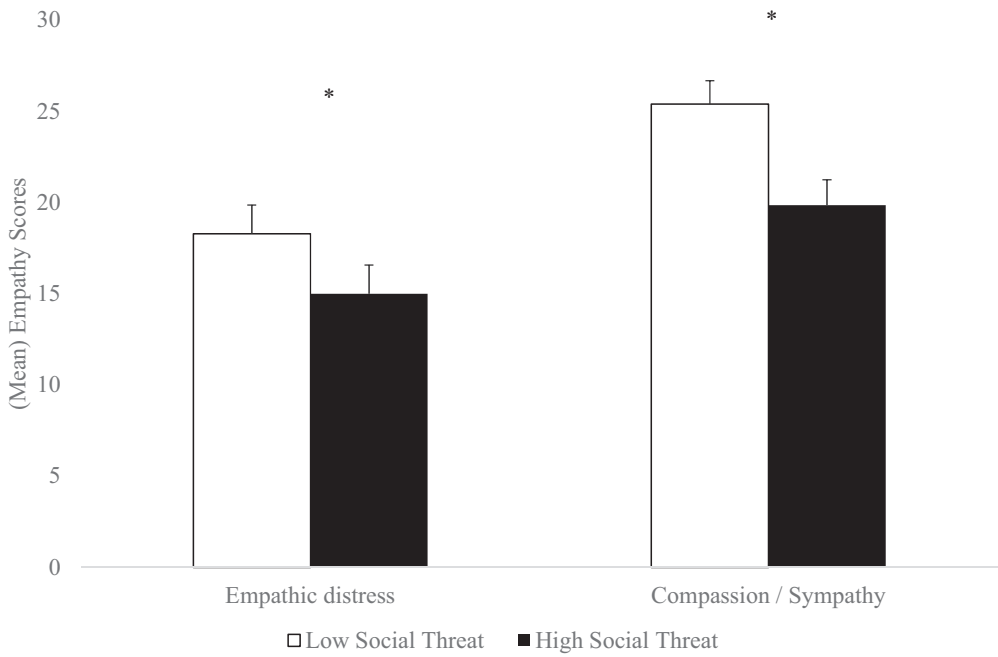

Figure 5. Mean (+ SE) scores for empathic distress and compassion/sympathy for the confederates in the low and high social threat condition. Note: SE, standard error term based on mixed analyses estimates, *$P < .05$.

chose the minimum number of stimuli (10 out of 20), rather than being requested to simply administer 10 stimuli. Consequently, the low social threat condition in the present study was experienced as less threatening compared to the earlier studies.[26,42]

We found support for all 4 hypotheses. Participants reported that the pain in the high social threat condition felt more intense, more unpleasant, and more threatening compared to the low social threat condition (hypothesis 1). These findings are in line with the original study by Peeters and Vlaeyen[42] and the study by Gray and Wegner,[19] but unfortunately these studies only investigated the effect of intentional pain on self-reported pain intensity without differentiating between the sensory and affective dimension of pain. In contrast, Karos et al[26] found that perceived social threat was associated with the threat value of pain, but not pain intensity or pain unpleasantness. Here we found that social threat indeed increased the threat, unpleasantness, and the experienced intensity of painful electrocutaneous stimuli themselves. This is the first study to demonstrate that social context can affect both the sensory *and* affective dimension of pain.

The effect of social threat on the threat value of pain was dependent on the order of the conditions, and was only present when the high social threat condition was the first condition. This could possibly be a novelty effect. The high social threat context did not increase the threat value of stimuli that were already rendered relatively safe beforehand (in the low social threat condition within the relative safety of a laboratory environment). In contrast, the low social threat context might have acted as a safety signal that could reduce increased threat of pain,[32,68] possibly driven by a feeling of relief, when following the high social threat condition. In conclusion, a threatening social context might be especially detrimental in determining the threat value of painful stimuli that are novel and unknown.

Application to clinical and real-world situations is premature at this stage, but the current study might shed light on several clinically relevant phenomena. First, social threat in this study was operationalized as intentionally administered, unnecessary pain by a stranger. This might resemble a situation of physical bullying, which has been identified as a risk factor for the development of psychological and physical problems, including chronic pain.[15,69] This study adds to the mounting evidence that pain which is inflicted intentionally by someone else, is experienced as more aversive,[19,26,42] which could explain the link between bullying and somatic symptoms. Second, even though not assessed in this study, our manipulation of social threat likely led to strong perceptions of injustice. Injustice perceptions also have been linked to problematic pain outcomes and poor recovery.[39,51,58] This study raises the question whether injustice can also worsen the experience of pain itself, an hypothesis which has only received scant scientific attention.[60]

The elevated pain reports but lower facial pain expressions in the high social threat condition compared to the low social threat condition indicate a remarkable dissociation between pain reports and facial pain expression (hypothesis 2). This finding is similar to the original study by Peeters and Vlaeyen[42] and in line with predictions from evolutionary theory,[72,74] which proposes that it is disadvantageous to express vulnerability (ie, pain) in a threatening social environment. It is also worth noting that we again did not find any effect of pain catastrophizing on pain reports or the facial expression of pain, contradicting predictions of the communal coping model of

pain that people high in pain catastrophizing express more pain in the presence of others in order to elicit help.[57] Interestingly, the communal coping model does not make specific predictions about the role of social context itself. For instance, it is likely that high pain catastrophizers are sensitive to social context as well and only show increased expression of pain behavior in a context where it is likely that others will actually provide help (ie, in a nonthreatening social context). The present study indeed provides evidence that social context might override the effect of pain catastrophizing itself in determining pain expression.

We did not find this dissociation in an earlier study.[26] There are 2 likely reasons for this discrepancy: First, this study employed a within-subject design, and thereby eliminated interindividual variability in pain expressiveness, leading to increased power when focusing on context effects within individuals. Second, the low social threat condition in the current study was perceived as less threatening compared to the study by Karos et al.[26] This raises questions about the boundary conditions of this effect: Is painful facial expression only reduced in actively hostile and threatening environments, or does even an ambiguous social environment lead to reduced facial expression?

Earlier studies have shown that even social interactions that were intended as *neutral*, can lead to decreased facial pain expression.[23,32] Similarly, emotional contagion in rats and humans has been shown to be inhibited in the presence of an unfamiliar conspecific.[37] In other words, the suppression of facial expression might be much more widespread than originally thought, and this suppression might only be released in a context where another is perceived to be actively helpful/cooperative, rather than in the presence of a stranger who is somewhat ambiguous as was the case in the earlier study by Karos et al.[26] This conclusion has important clinical implications, as it suggests that a threatening social environment can lead to reductions in facial expression of pain and might therefore be related to the underestimation of pain by others, which is commonly seen in clinical practice.[24,25,46] To counteract this, it could be crucial to create an actively supportive, safe and validating environment to facilitate the communication of pain.[49,72,74] In the current study, the control condition involved a stranger who at least expressed some empathy toward the participant and could therefore be seen at least as somewhat validating. Future studies might want to actively investigate the effect of a validating versus a threatening social environment. Validation might be an especially useful social tool in clinical practice to reduce threat and fear of painful procedures and increase satisfaction with care.[10,65]

We demonstrated again that social context can have dissociating effects on verbal pain reports and facial pain expression, suggesting that they might serve different functions[21,42] and/or are governed by separate processes. While facial pain expression can be deliberately controlled,[44] it has been hypothesized that it is often the result of unconscious processes, whereas verbal pain reports might be more controlled.[7,41,72] In any case, the current findings are in line with operant models and evolutionary theory, which propose that the facial expression of pain is not a direct, automatic, and reliable device for communication but rather an "unconditioned behavior controlled by display rules" (Williams, 2002, p. 463).[72]

Aside from detrimental effects on pain reports and pain expression, social threat also increased reactive aggression (hypothesis 4),[1] in line with earlier research showing that especially perceived injustice or provocation can be a strong motivator for aggression.[16,40,59] Strikingly, some participants were willing to administer twice as many painful stimuli to the threatening confederate as they experienced themselves, demonstrating that the motivation to inflict pain on the confederate most likely reflected a sort of punishment rather than simply a "tit-for-tat" response.[33] Moreover, this finding is relevant in the context of other studies showing that perceived injustice in the context of pain is associated with anger and aggressive behavior.[52,61] While we operationalized aggression as the direct infliction of physical pain on someone else, punishing responses in reaction to perceived injustice might also take other forms that are clinically relevant, such as intentionally staying away from work.

In line with the aggression findings, empathy for the confederate was reduced in the high social threat condition (hypothesis 5). This reduction in empathy affected both the empathic distress experienced when thinking of the confederate's pain, as well as feelings of compassion and sympathy for the confederate. This finding supports our earlier study, where increased perceptions of social threat were correlated with reduced empathy.[26] Similarly, social exclusion has also been shown to reduce empathy for physical and emotional pain in others.[11] Moreover, a wealth of research demonstrates that empathy and emotional contagion is facilitated with intimate others (eg, family and friends) but is reduced toward strangers, and even further toward outgroups, adversaries and competitors.[8,18,36] A possible implication which deserves further scientific scrutiny is that being the victim of social threat in the context of pain might make it more likely that a person engages in retributive behavior toward others. This has also been shown in the case of bullying, where victims of bullying frequently become perpetrators of bullying themselves.[64] Reduced empathy for others and retributive motivations might be a possible mechanism underlying this finding.

The present study demonstrates that the social environment can powerfully impact pain-related processes and interpersonal relationships but there are also some limitations to the present study. First, as in earlier studies,[26,42] the present study relied exclusively on female participants and female confederates. There are substantial sex and gender differences in the experience and communication of pain.[3,12,29,67] Critically, gender is a socio-cultural construct and gender expectations and norms might powerfully affect display rules for pain as well.[12] For instance, there is research demonstrating that women generate more facial expressions and emotional utterances (eg, crying) than men do, and at the

same time women seem to be better at recognizing emotions in others' faces than men.[29] Evolutionary theory also suggests that it might be more relevant for males to inhibit the expression of vulnerabilities which could be exploited.[72] For instance, in a recent study by Edwards et al,[12] the presence of a male friend in particular increased pain tolerance in male participants, more so than in other dyadic relationships.

Second, the current research is applicable to experiences where pain is intentionally administered by a stranger (eg, physical bullying), but there are other forms of social threat which are more subtle but also very relevant for patients with chronic pain[28] such as stigmatization, invalidation, or ostracism.[48,49] In addition, in the current study the person administering the pain was a stranger to the participant but in real life examples, especially in a clinical context, prior experiences with others (eg, healthcare professionals) could powerfully shape how social interactions are interpreted. Numerous chronic pain patients are dissatisfied with the care that they receive, and this might affect trust during subsequent interactions with healthcare professionals.[21] It is hard to generalize the current results to other forms of social threat, especially to a clinical context, but the current study can be understood as a strong argument for further scientific interrogation of the effects of social environments on the experience and communication of pain, especially in a clinical context where the accurate communication and assessment of pain is critical and underestimation is widespread.[46] Especially in this context, the current study is relevant, as a threatening social context might lead to a double burden for the person in pain: Pain is experienced as worse but pain expression is reduced, which could further increase the likelihood that pain is underestimated by others. However, this was beyond the scope of the current study. Future research should extend the current research by investigating the effects of social threat on observers as well as the person in pain.

Taken together, this study found that a threatening social context led to a dissociation between verbal pain reports and the facial expression of pain: Pain reports were increased but facial expression was decreased. In addition, social threat may facilitate interpersonal aggression and reductions in empathy. Consequently, the effects of the social environment on persons with pain should be a primary concern in understanding how pain is experienced and expressed to others.

Acknowledgments

The authors thank Louise Desmit and Elien Maeriën for their contribution to this study, and Jeroen Clarysse and Mathijs Franssen for their technical support.

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