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Negative Emotional Responses Elicited by the Anticipation of Pain in Others: Psychophysiological Evidence

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Abstract: Limited evidence is available about factors influencing observers' anticipatory emotional responses to another's pain. We investigated fear and distress towards the threat of pain in others, and the moderating role of observers' psychopathic traits and catastrophizing about their own or others' pain. Thirty-six dyads of healthy participants were randomly assigned to either the role of observer or observed participant. Both participants were instructed that 1 colored slide (blue or yellow) signalled that a pain stimulus could possibly be delivered to the observed participant (=pain signal), whereas no pain stimulus would be delivered when a differently colored slide was presented (=safety signal). Observers' self-reported fear, fear-potentiated startle, and corrugator electromyography activity during pain and safety signals were measured. Furthermore, observers rated the presence of pain after each trial allowing assessment of observers' perceptual sensitivity to others' pain. Results indicated that self-reported fear, fear-potentiated startle, and corrugator electromyography activity were augmented during pain signals compared to safety signals. Moreover, these negative emotional responses were heightened in observers highly catastrophizing about others' pain, but reduced in observers with heightened psychopathic traits. Psychopathic traits were also related with a diminished perceptual sensitivity to others' pain. The results are discussed in light of affective-motivational perspectives on pain.

***Perspective:** This study investigated observers' negative emotional responses in anticipation of pain in another, and the moderating role of observers' psychopathic traits and pain catastrophizing. Knowledge about characteristics influencing observers' emotional response to others' pain may provide insight into why observers engage in particular behaviors when faced with another in pain.*

***Key words:** Observational learning, observers' sensitivity, psychophysiological responses, pain catastrophizing, psychopathy.*

Pain is an alarm signal of bodily harm, and elicits defensive or protective reactions.[1,12,29,66] Through first-hand experiences, we learn to predict pain, and these signals for pain may in themselves become a source of fear and action.[1,7,29,38,74] However, pain is rarely a private event as the sufferer's reactions to pain have the capacity to communicate pain to others.[40] According to the communications model of pain, pain may have a profound influence on both the observer and pain sufferer.[40] Specifically, learning about pain may also occur indirectly by observing when others experience pain.[14,37,43,60] This form of learning, also called vicarious conditioning, may change our behavior when we encounter a similar situation.[14-17] Furthermore, it provides us with information about when others will likely experience pain and suffering. It is no surprise that studies on vicarious conditioning reveal that signals of pain in others elicit fear and anxiety in observers.[40,42,59,77] Several , however, deserve further scrutiny.

There is large variability in the fear and distress responses of observers.[40] In 1 of the early studies, Lanzetta et al[49] showed that vicarious fear and distress were markedly lower when the other in pain was disliked. It may be expected that individual difference variables may also

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account for the variability.[40] One variable that increases fear and distress may well be catastrophizing about pain, defined as an exaggerated negative orientation towards actual or anticipated pain experiences.[67] It is well documented that pain catastrophizing is related to a more negative experience of pain in the sufferer as well as in the observer. Specifically, individuals catastrophizing about their pain report more pain and distress.[67,69] Likewise, observers catastrophizing about others' pain seem to experience another's painful situation as more distressing.[33,36,52] Other individual difference variables may reduce fear and distress. This may be the case for psychopathic characteristics, such as manipulativeness, insincerity, egocentricity, and lack of guilt. Research has revealed that high scores on psychopathic traits reduce empathy for others when experiencing negative consequences such as sadness, fear, or disgust.[5,56] No evidence is yet available about the impact of psychopathic traits in the interpersonal context of pain.

It is largely unknown how individual difference variables such as catastrophizing about one's own or others' pain and psychopathic traits affect observers' fear and distress responses. One hypothesis may be that these individual difference variables affect the early stages of information processing, leading to a higher or lesser detection of pain in others.[24,80] In line with this idea we would then expect that catastrophizing about one's own or others' pain would lead to hypervigilance, and a higher detection of pain in others,[40,68] whereas psychopathy would lead to a lower detection of and hyposensitivity for pain in others.[18,54]

In the present study, we used a vicarious conditioning paradigm, in which 1 participant (observer) watched a differential conditioning procedure in another participant. One visual cue preceded the possible occurrence of pain (pain signal). Another visual cue preceded the nonoccurence of pain (safety signal). We measured fear and distress during these signals in the observer using self-report and psychophysiological indicators (eg, fear-potentiated startle[20,39,41,47,48] and corrugator electromyography (EMG) activity[26,27]). Observers were also requested to rate the presence of pain after each trial. We expected that signals of pain in others would evoke fear and distress in observers. We further expected that catastrophizing about one's own or others' pain would increase these responses, whereas psychopathic traits would decrease these responses. Finally, using signal detection methods, we investigated whether catastrophizing about one's own or other's pain is related to an increased perceptual sensitivity to detect pain in others, whereas the reverse pattern was expected for psychopathic traits.

Methods

Participants

Seventy-two female Caucasian undergraduate students from Ghent University participated. Each student volunteered independently for the experiment in an attempt to maximize the rate of unfamiliarity between participants. Only female students were recruited in order to avoid possible sex differences.[19] Participants were tested in pairs: 1 participant experienced the pain procedure, (N = 36; M = 18.89 years; SD = 2.13) while being observed by the other participant (N = 36; M = 18.81 years; SD = 1.65). Participants received course credits for participation. This study was approved by the ethical committee of the Faculty of Psychology and Educational Sciences.

Electrocutaneous Stimuli

Electrocutaneous stimuli consisted of trains of 2-ms pulses with an internal frequency of 65 Hz delivered by means of a constant current stimulator (Digitimer DS7A, Hertfordshire, UK). Two lubricated Fukuda standard Ag/AgCl electrodes, with a diameter of 1 cm, were used to administer the electrocutaneous stimuli at the external side of the right wrist. Before placement of the electrodes, the skin at the electrode sites was abraded with a peeling cream (Nihon Kohden) in order to reduce skin resistance. The electrocutanous stimuli had an instantaneous rise and fall time and a duration of 300 ms. Tolerance level was established with 1 calibration cycle starting at an intensity of .50 mA and increasing in intensity in steps of .25 mA. Participants were instructed to stop at the intensity that was just tolerable. The stimulus at tolerance level (M = 2.00 mA, SD = 1.91; range, .50–10.50) was the intensity used in the pain task. Before the start of the pain task, both participants were asked if they had previously experienced an electrocutaneous pain stimulus.

Psychophysiological Measures in Observing Participants

The fear-potentiated startle was measured as the magnitude of the eye blink modulation to a sudden probe. Ag/AgCl electrodes with a diameter of .40 cm were filled with highly conductive gel and placed over the orbicularis occuli muscle of the left eye. After cleaning the skin with alcohol, 1 electrode was placed just below the left pupil, a second was placed 1 cm laterally. A ground electrode was placed on the forehead.[6] The acoustic startle probe was a 50-ms burst of white noise (90–100 dB) with instantaneous rise time, which was presented binaurally over headphones.

The EMG response over the corrugator muscle, responsible for frowning the eyebrow, was registered with Ag/AgCl electrodes with a diameter of .40 cm. After filling the electrodes with highly conductive gel and cleaning the skin with alcohol, 2 electrodes were placed at the corrugator muscle above the left eye.[31] The same ground electrode as for the startle reflex was used. The raw EMG signals of both psychophysiological measures were recorded using an EMG100C Electromyogram Amplifier (BIOPAC Systems MP150, Biopac Systems, Inc., Goleta, CA) with the high pass filter set at 90 Hz and the low pass filter at 500 Hz. EMG responses were sampled at 1,000 Hz. Conforming with the guidelines specified by Blumenthal et al,[6] the psychophysiological data were integrated and analyzed offline, using a semiautomated program for parameter extraction (Psychophysiological Analysis, PSPHA).[23]

Self-Report Measures in Observing Participants

Psychopathic Characteristics

Psychopathic characteristics were measured with the Hare Self-Report Psychopathy Scale-III (SRP-III) (Paulhus DL et al, unpublished data, 2012). The SRP-III assesses core features of psychopathy on 4 different domains: 1) interpersonal, manipulative behavior; 2) callous affect; 3) erratic lifestyle; and 4) criminal tendencies in psychopathy.[79] The SRP-III contains 64 items that are scored on a 5-point scale ranging from 1 (disagree strongly) to 5 (agree strongly). The SRP-III exhibits good reliability and validity in nonforensic samples.[79] The authorized Dutch translation, established by following FACIT translation guidelines (2006), was used in the present study (Uzieblo, De Ruiter, Crombez, Paulhus & Hare, 2007). The SRP-III showed a good internal reliability in the current study (Cronbach's α = .86).

Catastrophic Thoughts About Own Pain

Catastrophic thinking about own pain was assessed with the Dutch version of the Pain Catastrophizing Scale (PCS).[67] This scale contains 13 items describing thoughts and feelings that participants may experience during past painful experiences (eg, "I become afraid that the pain may get worse"). Three subscales can be distinguished: rumination, magnification, and helplessness. Participants indicate how frequently they experience each thought or feeling when in pain using a 5-point scale, ranging from 0 (not at all) to 4 (always). The Dutch version of the PCS has good reliability and validity in both clinical and nonclinical samples.[72] In our sample, Cronbach's α of the total score was .88.

Catastrophic Thoughts About Other's Pain

Observers also rated their catastrophic thoughts about the observed participant's pain during the pain task. For this purpose, the Significant Other version of the PCS (PCS-S)[11] was adapted. The PCS-S measures catastrophic thoughts about the pain of a significant other and has a similar factor structure as the PCS (see above). The PCS-S has shown to be a reliable and valid instrument in undergraduate students and couples with chronic pain (PCS-S).[11] In line with previous research,[8,34] a state version was developed in order to assess observers' catastrophic thoughts about the pain the observed participant could experience during the pain task. For each subscale, 1 item was selected and adapted to the experimental situation. Participants responded on an 11-point numeric rating scale (NRS) with the endpoints 0 (not at all) and 10 (a lot). This new instrument, the PCS-Other-state (PCS-O-state), consisted of the following 3 items (Rumination: "At this moment, to what extent do you keep thinking about how much pain the other student will experience during the task?" Magnification: "At this moment, to what extent do you think that, because of the pain, something serious might happen to the other student?" Helplessness: "At this moment, to what extent do you think, because of the pain of the other student, you will not be able to endure the task?"). In this study, we used the mean score, ranging from 0 to 10. Cronbach's α for the PCS-O-state was good (α = .71).

Self-Reported Fear

After the pain task, observers rated to what extent they experienced fear during the pain signals and safety signals, using an 11-point numeric rating scale ranging from 0 (not at all) to 10 (a lot). The items rated by the observers were: 1) how anxious/fearful were you during the presentation of the pain signal; and 2) how anxious/fearful were you during the presentation of the safety signal. These items reflect observers' general fear when anticipating others' pain.

Self-Report Measures in Participants Being Observed

Pain Experience

After the pain task, the observed participant rated how much pain she had experienced when receiving electrocutaneous stimuli. Specifically, the observed participant rated: 1) how much pain she had experienced on average; and 2) how painful was the worst pain she had experienced. Both ratings were obtained by using an 11-point NRS from 0 (no pain) to 10 (a lot of pain).

Impact of Being Observed Upon Pain Expression

To assess the potential impact of being observed, the observed participant rated, after the pain task, the following questions by means of an 11-point rating scale ranging from 0 (not at all) to 10 (a lot): 1) "Did you respond spontaneously to the electrocutaneous stimuli, even when you knew the other student was observing you?" and 2) "Has knowledge of being observed by another student influenced your reactions to the electrocutaneous stimuli?"

Self-Report Measures in Both Participants

How familiar participants were with each other was assessed by asking both participants the following question: "Have you met the other student before?" If they indicated yes to this question, they were requested to rate the question: "How well do you know the other student?" by means of an 11-point NRS, ranging from 0 (not at all) to 10 (very well).

Procedure

Preparation Phase

First, participants were informed about the aim and procedure of the study (ie, how observers cope with pain in others) and signed an informed consent. Participants were randomly assigned to 1 of the 2 roles by tossing a coin. The observer was asked to complete the SRP-III and the PCS. Subsequently, she was placed in an adjacent room, where electrodes were attached. By means of a television screen, the observer was able to observe

how pain tolerance level of the observed participant was determined. Before the start of the pain task, the observer completed the PCS-O-state.

Pain Task

The pain task consisted of several trials of blue and yellow colored screens. These screens signalled that an electrocutaneous stimulus could possibly be delivered to the observed participant when the colored screen disappeared (ie, pain signal) or that no electrocutaneous stimulus would follow (ie, safety signal). The colored screens were controlled and presented by Inquisit (Millisecond Software)[45] on a Dell Dimension 5000 computer connected to a 17" flat panel monitor. Before the start of the pain task, both participants were informed which color (ie, blue or yellow) was the pain signal. The other color represented the safety signal. The colors were counterbalanced across participants. The pain task consisted of 48 trials, with 50% safe trials, divided in 2 blocks. Each trial started with the presentation of a fixation cross for 5,000 ms followed by a pain or safety signal for 8,000 ms. The latter was followed by a white screen for 5,000 ms. After 25% (N = 6) of the pain signals, an electrocutaneous stimulus (300 ms) was delivered to the observed participant as soon as the pain signal disappeared. In order to prevent habituation, the administration of the pain stimulation was randomized and well spread so that several pain and safety signals were presented between the pain stimuli. Each trial ended with an orange screen that indicated a rating period of 10,000 ms. During this rating period, observers were instructed to indicate whether the observed participant had received a pain stimulus or not. These ratings were used to calculate observers' perceptual sensitivity for the others' pain.

Throughout the entire pain task, the observer was instructed to watch the facial expressions of the observed participant on a television screen. The observer was only provided with video display showing the face of the observed participant; no auditory information was provided. Within the visual field of the observer, a computer screen was additionally placed on which pain and safety signals were presented. These signals were simultaneously presented to the observed participant and the observer. The observed participant could not see or hear the observer during the pain task.

We used the eye blink modulation and corrugator EMG response as an indication of a negative emotion elicited in the observer.[26,27,39,41] To prevent the development of expectancy of the startle probe, startle probes were administered on different time points. Startle probes occurred: 1) during pain and safety signals at 3,000 or 6,000 ms after signal onset; 2) after pain and safety signals at 1,000 ms after the signal offset; or 3) halfway between the period of offset of the orange colored screen and signal onset, which varied between 5,000 and 7,000 ms. After the pain task, all sensors were removed. The observer was then requested to rate her experienced fear during pain and safety signals. The observed participant was asked to rate her experienced pain. The entire experiment took approximately 2 hours.

Data Reduction and Analysis

PSPHA[23] was used to analyze the psychophysiological data offline. Eye blink modulation was defined as a baseline-to-peak difference. We calculated the magnitude of the eye blink modulation by subtracting the mean rectified baseline value (0–20 ms after probe onset) from the rectified peak value in the 21- to 200-ms interval after probe onset. Trials with a baseline EMG activity of at least 2.5 SDs above the mean baseline were signalled by PSPHA as a potential artefact. These potential artefacts were visually inspected and were rejected when it regarded: 1) a bad signal-to-noise ratio; or 2) a too early eye blink onset. The absolute magnitude and variability of their eye blink responses may differ considerably between individuals. Therefore, in accordance with previous research,[3,53,61] the eye blink magnitudes were z-transformed across trials within individuals. Thereby, a common metric system is created before performing the statistical analyses concerning the eye blink modulation.[3,53,61] The impact of outliers was reduced by substituting z-scores smaller than -3 or greater than 3, by -3 or 3, respectively.[61] As we were primarily interested in the anticipatory reactions of observers, we only used the reaction to startle probes presented during the signals (ie, at 3,000 and 6,000 ms after signal onset) in our analyses. The results using the average eye blink modulation after signal onset (ie, a Pain versus Safety Signal repeated measure analysis of variance [ANOVA]) were comparable with analyses using a 2 (Signal: Pain versus Safety Signal) $\times$ 2 (Time: 3,000 versus 6,000 ms) repeated measure design. Therefore, we decided to use the average eye blink modulation in the analyses.

To control for interference of the eye blink modulation, only trials in which no startle probe was present during the signal were used in analyses of the corrugator EMG activity. For each observer, a baseline value was established by calculating the mean corrugator EMG response 1,000 ms before the onset of the signal. In a second step, the baseline-corrected activity was calculated for every second of the 8,000 ms during signals. The first second of the signal was not included in the analyses in order to avoid interference from orientating reactions.[26,28,55] Finally, we averaged this baseline-corrected activity for safety and pain signals separately.

To investigate observers' reaction to signals of pain in others, a repeated measure ANOVA (Pain versus Safety Signals) was performed with eye blink modulation or corrugator EMG response as dependent variable. We calculated the effect-size Cohen's d for these analyses to quantify the difference between pain and safety signals. To examine the moderating role of catastrophizing about own or others' pain and psychopathic traits, the scores on the self-report measures were included as covariates. For these analyses, partial eta squared (η_p^2) was calculated. This gives us an estimation of the proportion of total variability attributable to a specific variable.[58] Statistically significant interactions were investigated by plotting and testing the significance of the regression lines of the continuous moderator variables for responses during pain signals and safety signals.[44,57]

Furthermore, signal detection analyses were performed to investigate observers' perceptual sensitivity. Perceptual sensitivity was defined as the ability to detect pain in the observed participant. Three observers made errors in rating the 48 trials, making it impossible to retrieve the specific trials they had rated. Therefore, these analyses were performed on a subsample of 33 observers. Hit rates, defined as correctly indentifying a pain stimulus, and false alarm rates, defined as identifying a no pain trial as a pain trial, were calculated for each observer. These scores were used to construct the Receiver-Operating-Characteristic. Sensitivity for others' pain was assessed by calculating A',[65] which represents the area under the operating characteristic. A' values vary from 0 to 1.0. A value of .5 indicates a chance performance or lack of ability to discriminate pain trials from nonpain trials. In order to investigate the influence of catastrophizing about own or others' pain and psychopathic characteristics upon perceptual sensitivity to the expressed pain, correlations were calculated between A' and the scores on the PCS, PCS-O state, and SRP-III. All analyses were conducted with SPSS v.15.0 (SPSS Inc., Chicago, IL).

Results

Sample Criteria

Several possible interfering factors (ie, previous experiences with the pain stimulation, whether participants were familiar with each other, and whether the observed participant's pain expression was influenced be being observed) were investigated before conducting the analyses. First, 1 observer and 2 observed participants indicated that they had experienced painful electrocutaneous stimulation before. However, analyses with and without these participants indicated that this previous experience with the electrocutaneous pain stimulation did not impact the results. Second, only 5 couples indicated they had met each other before. The mean score for how well they knew each other was 2.33 (SD = 3.39, range = 0–8) for the observed participants and 1.71 (SD = 2.75, range = 0–7) for the observers. As the mean scores were rather low, we could conclude that in general participants were unfamiliar with each other. Moreover, results stayed the same when excluding couples that have met each other before. Lastly, overall the observed participants indicated that they reacted spontaneously to the electrocutaneous stimuli (M = 7.67, SD = 2.08, range: 3–10) and that their response to the pain stimulus was little influenced by being observed (M = 2.58, SD = 2.21, range: 0–7). Moreover, excluding the 4 observed participants who indicated on both questions that they were highly influenced by being observed by the other revealed similar results compared with the results with those participants included. Therefore, based upon the examination of these 3 criteria, we decided to retain all participants within the final sample (N = 36).

Self-Report Data

The mean level of average and worst pain reported by the observed participants was 5.31 (SD = 1.89; range = 0–9) and 6.17 (SD = 1.99, range = 0–10), respectively. Observers' level of catastrophizing about own pain (PCS: M = 17.57, SD = 7.29, range = 3–31) was comparable with catastrophizing scores of a previous study in a Dutch student population (M = 16.56, SD = 7.78; t(584) = .80, ns).[72] Observers' mean score for catastrophic thoughts about the pain of the other participant (PCS-O state) was 3.79 (SD = 1.69, range = .67–7.67). A positive, but nonsignificant correlation (r = .21, ns) was found between PCS and PCS-O state. Scores for psychopathic characteristics ranged from 110 to 188, with a mean score of 141.56 (SD = 21.09). These scores are comparable with the mean scores for female undergraduates (M = 139.6, SD = 25.4; t(128) = .05, ns) observed by Pauhlus et al (Paulhus DL et al, unpublished data, 2012). Paired samples t-test indicated that observers reported more fear during pain signals (M = 5.11, SD = 2.46) than during safety signals (M = 2.14, SD = 2.09, t(35) = 5.91, $P < .01$).

Pearson correlations revealed that higher levels of observers' psychopathic characteristics (SRP-III) were significantly negatively correlated with catastrophic thoughts about the other's pain (PCS-O-state; r = −.40, $P < .05$). No significant correlation was found between psychopathic characteristics and catastrophizing about own pain (PCS; r = .08, ns). Furthermore, observers' catastrophic thoughts about the others' pain (PCS-O-state) was significantly positively correlated with observers' fear during pain signals (r = .39; $P < .05$). There was no significant correlation between catastrophizing about own pain or psychopathic characteristics and fear of pain during pain signals (PCS: r = .27, ns; SRP-III: r = −.23, ns). In addition, no significant correlation was found between the individual difference variables (ie, catastrophizing about own pain, catastrophizing about others' pain and psychopathic traits) and observers' self-reported fear during safety signals (all r < .23).

Observers' Eye Blink Modulation and Corrugator EMG Response During Pain and Safety Signals

A repeated measures ANOVA (Pain versus Safety signal) revealed a main effect of Signal on eye blink modulation (F(1,35) = 10.32, $P < .01$). As expected, the eye blink modulation was augmented during pain signals (M = .11, SD = .26) compared with safety signals (M = −.07; SD = .16, t(35) = 3.21, $P < .01$, d = .84). Furthermore, repeated measures ANOVA revealed that corrugator EMG response during pain signals (M = .83, SD = 1.82) was more pronounced than during safety signals (M = −.05; SD = .53, F(1, 35) = 8.75, $P < .01$, d = .62).

The Moderating Role of Observer Characteristics

Eye Blink Modulation

Observers' catastrophic thoughts about own or other's pain (PCS: F(1,33) = .92, ns; PCS-O-state: F(1,34) = .19, ns) nor psychopathic characteristics (F(1,34) = 3.47, ns) had a main effect on observers' eye blink modulation. In addition, observers' catastrophic thoughts about own or

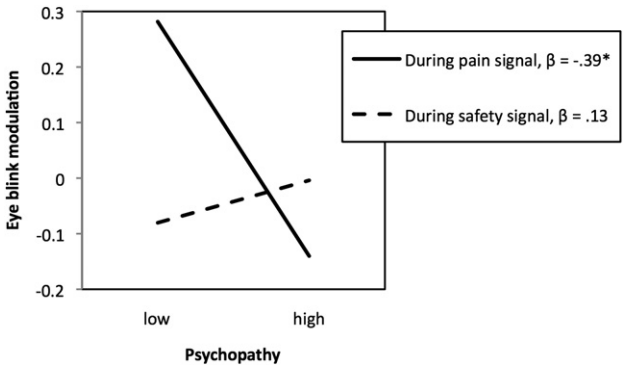

Figure 1. The influence of observers' psychopathic characteristics on eye blink modulation during pain and safety signals. Standardized betas are presented. *P < .05; **P < .01.

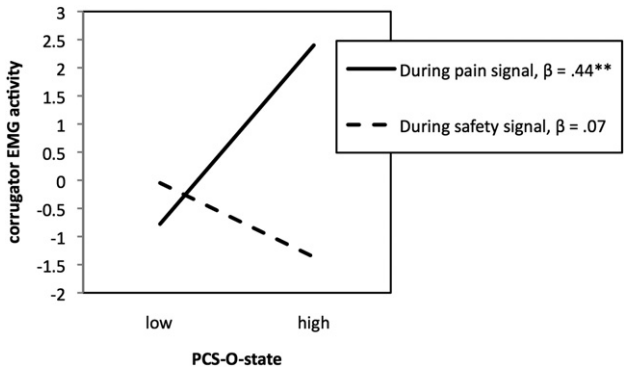

Figure 2. The influence of observers' catastrophic thoughts about the others' pain (PCS-O-state) on corrugator activity during pain and safety signals. Standardized betas are presented. *P < .05; **P < .01.

other's pain did not moderate the effect of Signal on eye blink modulation (PCS: F(1,33) = .02, ns; PCS-O state: F(1,34) = 1.91, ns). However, psychopathic characteristics significantly moderated the effect of Signal upon eye blink modulation (F(1,34) = 4.59, P < .05, η_p^2 = .13). To illustrate the pattern reflected in this statistically significant interaction term, we plotted regression lines of psychopathic characteristics on eye blink modulation during pain and safety signals (see Fig 1). In line with our expectations, higher scores for psychopathic characteristics were related to a smaller eye blink modulation during pain signals, $\beta = -.39$, P < .05. The level of psychopathic traits was, however, not related to eye blink modulation during safety signals, β = .13, ns.

Corrugator EMG Response

Psychopathic characteristics and observers' catastrophic thoughts about own pain (PCS) did not moderate the effects of Signal on corrugator EMG (SRP-III: F(1, 34) = 2.08, ns; PCS: F(1, 33) = .78, ns), nor did they show a main effect on the corrugator EMG response (SRP-III: F(1, 34) = .42, ns; PCS: F(1, 33) = 1.30, ns). Observers' catastrophizing about the others' pain (PCS-O-state), however, showed a significant main effect on corrugator EMG (F(1, 34) = 7.23, P < .05), indicating that observers with a high level of catastrophic thoughts about the pain of the other generally showed a stronger corrugator EMG response. Furthermore, observers' catastrophizing about the others' pain (PCS-O-state) moderated the effects of Signal on corrugator EMG (F(1,34) = 7.69, P < .01, η_p^2 = .18). Regression lines were plotted of observers' catastrophizing about the others' pain for corrugator EMG activity during pain and safety signals (see Fig 2). The results indicated that observers who catastrophized more about the other participants' pain exhibited a stronger corrugator EMG response during pain signals (PCS-O-state: β = .44, P < .05).

Observers' Perceptual Sensitivity for Others' Pain

The mean sensitivity score A' was .83 (SD = .13), indicating that observers were good at discriminating trials in which the observed participant received an electrocutaneous stimulus (ie, pain trials) from nonpain trials (ie, pain signals not followed by a pain stimulus). Furthermore, participants with more psychopathic characteristics showed less perceptual sensitivity to pain expressed by the observed participants (r = −.38; P < .05). No significant correlation between observers' perceptual sensitivity and catastrophic thoughts about own or others' pain were found (PCS: r = −.20, ns; PCS-O-state: r = −.04, ns).

Discussion

This study investigated: 1) observers' negatively valenced emotional responses to impending pain in others; 2) observers' ability to detect others' pain; and 3) the moderating influence of catastrophizing about own or others pain and psychopathic traits. Overall, findings were partially in line with our expectations. First, findings suggest that anticipating another's pain elicits aversive responses in observers. Specifically, observers reported more fear, demonstrated augmented fear-potentiated startle, and increased corrugator EMG activity during signals of pain in others compared with safety signals. Second, individual difference variables moderated emotional responses to impending pain in another. Specifically, observers with more psychopathic characteristics demonstrated a lower fear-potentiated startle during pain signals. Observers highly catastrophizing about others' pain showed more pronounced corrugator EMG activity and reported more fear during pain signals. No significant influences were found for observers' catastrophic thinking about own pain. Third, although observers were overall able to accurately detect when the other experienced pain, this ability was reduced with increasing levels of psychopathic traits.

The present findings corroborate previous findings on vicarious fear conditioning in humans[15-17,42,59,71,77] and suggest that seeing others in pain has a profound influence on observers.[40] Specifically, findings indicate that others' pain can serve as a sign of threat, resulting into fearful responses towards previously neutral stimuli. The present study extends previous research by investigating observers' reactions in a more salient interpersonal context. Specifically, instead of using pictures, videotaped

models/confederates, or avatars,[13,15,16,71,77,80] observers watched a real-life participant undergoing painful stimulation. Additionally, individual difference variables and related processes were taken into account, allowing more precise conclusions about moderators of observers' response.

Our results indicate that impending pain in another triggers fear and distress in observers. The heightened corrugator EMG response and fear-potentiated startle suggest the activation of a self-oriented, aversive system.[26,28,39,47,48] Supporting this idea, the amygdala, a key structure implied in fear responses, plays a critical role in the evocation of the fear-potentiated startle reflex.[21,39,46,59,60] Furthermore, research on personal pain experience has consistently shown that participants display a fear-potentiated startle when experiencing or anticipating pain,[25,38,41,47] particularly when pain is perceived as highly threatening.[7] The present findings suggest that similar processes are likely involved when observing another in pain. Moreover, results demonstrated that situation-specific catastrophic thinking about *others'* pain plays a more important role in explaining observers' emotional responses than general tendencies to catastrophize about *own* pain. This attests to the importance of measurement compatibility.[9] Further, this is in line with the growing evidence that situational measures of pain catastrophizing have, in comparison with dispositional measures, more predictive value in explaining responses to pain.[10] Yet, findings indicate that the moderation by catastrophizing about others' pain only holds for observers' corrugator EMG response and self-reported fear, not for the fear-potentiated startle. Although it is unclear why this is the case, it is plausible that increased corrugator EMG response in high catastrophizing individuals reflects increased empathizing with another in pain. Such an account is in line with earlier findings indicating that catastrophizing about others' pain is associated with increased attention to and more accurate estimations of others' pain[34,68] and with recent evidence indicating that the ability to empathize with another is strengthened by one's tendency to react in accordance with the emotional expression of the other.[27]

Observers' distress towards pain signals in others likely serves a protective function of preparing observers for dealing with impending threat.[40] Specifically, observers' distress responses may instigate avoid/escape tendencies.[71,80] Such defensive tendencies seem to be in conflict with the often-observed emergence of other-oriented emotions (eg, sympathy) and associated approach tendencies when viewing others in pain.[35] To date, it is unclear how other-oriented feelings and related approach tendencies overcome initial self-oriented emotions and related avoidance. A potential key process might be the ability to regulate this self-oriented distress elicited by viewing another's pain.[8,34,36] In the present study, observers' distress is likely an automatic response to another's pain, which in later stages may be regulated by contextual and individual difference variables,[32,35] enabling other-oriented emotions to prevail.[22,30,35,71,76] Distress regulation may become difficult with increasing levels of threat, for example in high catastrophizers. Specifically, the present and previous studies[8,36,51] indicated that individuals with high levels of catastrophic thoughts about others' pain experience more distress when faced with another in pain. These increased levels of distress may have important implications for caregiving behavior. Preliminary evidence suggests that distress mediates the association between catastrophizing and tendencies to restrict the pain sufferer's activity.[8] Although further research is needed, it is plausible that feeling distressed may motivate behavior aimed at reducing own distress (eg, by escaping or reducing others' pain), instead of engagement in behavior attuned to the needs of the pain sufferer.[2]

Future research concerning this approach/avoidance conflict may also benefit from investigating attentional processing of another's pain. Our results indicate that signals predicting others' pain can attract observers' attention, allowing them to indicate when the other experienced pain. Attentional processes are mostly investigated to own pain, showing that heightened attention to pain is related to more fear and escape/avoidance tendencies.[29,50,75] Preliminary evidence also emphasized the importance of attention within the interpersonal pain context. In particular, findings suggest that, for individuals highly catastrophizing about others' pain, automatic orienting to pain faces may instigate escape/avoidance tendencies,[78] but this may only be successful for low pain expression. With increasing facial pain display, catastrophizers' avoidance tendencies may conflict with an increased difficulty of disengaging from pain.[73] As this avoidance tendency might reflect a strategy to alleviate distress, it may not prevail in persons perceiving another's pain as only slightly threatening, possibly because they can maintain or swiftly alleviate their self-oriented emotional reactions within a tolerable range.[30,71] As we did not find an association between catastrophizing about own or others' pain and observers' perceptual sensitivity, further research is needed to disentangle the role of attention in observers' responses to others' pain.

Of further interest, findings indicated that observers with higher levels of psychopathic traits were less perceptually sensitive for another's pain and showed a diminished fear-potentiated startle when anticipating others' pain. This is in line with previous research in criminal and non-criminal samples showing deviant fear conditioning[5] and reduced fear-potentiated startle towards threatening pictures in individuals with psychopathic characteristics.[4,53,61,62] Moreover, this reduced emotional response seems unrelated to their overt emotional expression, as no moderation of corrugator activity was found.[53] But, due to reduced perceptual sensitivity to others' pain, diminished distress may not entail higher levels of other-oriented feelings such as sympathy.[24,54,56,70] Although most research has focused on criminal samples, varying levels of psychopathic characteristics may be found among all community groups,[3] even in females[63] and high achievers.[64] Therefore, our findings are important to fully understand various, possibly maladaptive, responses to others' pain

manifesting in daily life and professional pain treatment.[40] As people with more psychopathic traits are less able to detect others' pain, they may be less capable in providing adequate care. Future research is warranted investigating how reduced aversive emotional responses and diminished perceptual sensitivity translates in behavioral responses.

The current study is not without limitations. First, due to our small sample size, we might have been unable to detect small effects (ie, d's > .62; η_p^2 > .13). Additionally, male participants were not included. The research was conducted in female pain-free undergraduate students using experimental pain stimuli. Replication of the results in larger, other nonclinical and clinical samples also including males, is needed. Second, mean levels of psychopathic characteristics and catastrophizing about own/others' pain were low, but comparable to other student populations. Further research is needed to investigate whether our findings generalize to clinical levels of these individual difference variables. Third, most participants were unfamiliar to each other. As previous research has shown that the level of familiarity with another influences empathic responses,[51] it would be interesting to replicate the findings in participants with a close relationship, eg, couples or parent-child dyads. Fourth, our measure of perceptual sensitivity may not specifically reflect detection of pain, but detection of a negative event experienced by the other. We cannot rule out that observers also relied on other negative emotional expression than pain expressions to judge the presence of pain. Fifth, we did not control for possible influences of attention and arousal on the psychophysiological responses. Further research may incorporate a control condition involving a nonaversive event, such as a tactile stimulus, as an unconditioned stimulus. However, it is unlikely that the observed startle facilitation is owing to attention because attention is known to result in startle inhibition instead of startle facilitation.[47] Lastly, fear and pain were only measured after and not during the pain task. Accordingly, we do not know whether experience of pain changed over time and whether habituation occurred.

In spite of these limitations, this study demonstrated that anticipating pain in another is an aversive experience, particularly when observers catastrophize about others' pain. In contrast, observers' aversive responses and perceptual sensitivity for another's pain are diminished in persons with higher levels of psychopathic characteristics.

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