Received: 23 July 2021 | Revised: 22 April 2022 | Accepted: 4 May 2022

DOI: 10.1002/ejp.1970

ORIGINAL ARTICLE

Crying does not alleviate acute pain perception: Evidence from an experimental study

Asmir Gračanin[1] | **Michelle C. P. Hendriks**[2] | **Ad J. J. M. Vingerhoets**[2]

[1]Department of Psychology, University of Rijeka, Faculty of Humanities and Social Sciences, Rijeka, Croatia

[2]Department of Medical and Clinical Psychology, Tilburg University, Tilburg, the Netherlands

Correspondence
Asmir Gračanin, Department of Psychology, University of Rijeka, Faculty of Humanities and Social Sciences, Sveučilišna avenija 4, 51 000 Rijeka, Croatia.
Email: agracanin@ffri.uniri.hr

Abstract

Background: Whereas previous studies revealed positive effects of emotional expressions such as swearing and laughing on acute pain, systematic research on the effects of crying on pain is missing. The rationale for the current study is that either a mere emotional distraction or changes in oxytocin and opioid levels represent a mechanism through which crying modulates pain, with the timing of mood changes as crucial information for distinguishing between potential mechanisms.

Methods: In two studies, we exposed participants (Study 1: $n = 57$; Study 2: $n = 70$) to a sad movie and measured their mood, and exposed them to pain induction procedures (electric shock and cold-pressor test, respectively) before and after the film. Dependent variables were pain threshold, tolerance, and intensity. In addition to baseline and one immediate post-crying mood and pain response measurement in both studies, in Study 2, we repeated these procedures 20 and 50 min later to discern between the potential role of neurobiological substances and distraction.

Results: Crying was elicited in 28 participants in Study 1 (49.1%) and 49 (70%) in Study 2. We found no systematic differences in pain and mood changes between criers and non-criers and no systematic dose-response relationship between crying and pain responses and mood. The only significant effects ran contrary to our hypotheses, showing detrimental effects of the occurrence (Study 1) and frequency of crying (both studies) on pain threshold.

Conclusions: Results do not support the idea that crying has pain-alleviating effects, either via distraction or direct biological mechanisms.

Significance: Despite previous findings on pain alleviating effects of emotional expression and the widespread idea about the generally beneficial consequences of emotional crying, research on the possible pain alleviating effects of crying is largely missing. Two quasi-experimental studies demonstrated that crying induced in laboratory conditions does not alleviate acute pain responses, suggesting that role of crying in pain interventions is doubtful. Less directly, results cast light on the role of emotional distraction from acute pain and possible crying-related neurochemical changes.

1 | INTRODUCTION

Emotional expressions such as swearing (Stephens & Umland, 2011) and laughter (Dunbar et al., 2012) appear to modulate acute pain. Surprisingly, comparable effects of tearful crying, a typical response to acute pain, remain mostly unexplored, although pain-alleviating effects of crying were already suggested by Darwin (1872/1965). The current study examines if crying affects pain responses and mood. The effects of crying on mood may provide important information about the mechanisms underlying the effects of crying on pain.

Crying and pain may be linked in two ways. First, crying (or accompanying emotional reactions) might distract from the acute physical pain, which represents one of the most effective pain coping mechanisms (Kohl et al., 2013). In general, distraction can decrease pain perception, with both stressful events (Quiton & Greenspan, 2007; Timmers et al., 2018; but see also Jennings et al., 2014) and positive emotional events (Mitchell et al., 2006; Weaver & Zillmann, 1994) acting as distractors. In this view, the immediate effects of crying are comparable to the impact of stress induction and any other positive or negative emotional response. Alternatively, crying might alleviate pain by increasing the levels of pain-relieving substances (see Pérez-Aranda et al., 2019 for a review), with endogenous opioids and oxytocin being the most likely responsible factors (Panksepp, 1998; Vingerhoets, 2013). Specifically, these substances have a crucial role in social bonding (e.g., Burgdorf et al., 2016), which was theorized to represent the primary function of tears (Vingerhoets, 2013), but they also have pain-reducing effects (Benarroch, 2012; Herpertz et al., 2019). While the current research will not directly assess fluctuations in these substances in the brain, it is important to note that their potential impact may be delayed and/or prolonged, due to the extended time course of their release and activity (e.g., Heinrichs et al., 2003). Thus, if opioids and oxytocin mediate the effects of tears on pain, then these effects could last longer than in the case of mere emotion-driven distraction.

Possible mood consequences of crying are potentially important for understanding the links between crying and pain. Notably, almost all earlier quasi-experimental studies revealed an immediate mood deterioration following crying (see Cornelius, 1997, 2001). However, in retrospective assessments of mental and physical benefits of crying in daily life, most criers claim to feel better following a tearful episode (Rottenberg et al., 2008; see also Gračanin et al., 2014, 2015; Vingerhoets, 2013). Nevertheless, mood assessments over more extended time periods (up to 90 min) after exposure to a sad movie revealed that crying was followed by improved mood (Gračanin et al., 2015). While there are notable differences between quasi-experimental laboratory studies and natural conditions that might affect the mood effects of crying (e.g. comforting responses are typically missing in the laboratory), the latter findings show that initial mood deterioration might be followed by mood improvements in laboratory conditions as well. Crucially, immediate mood deterioration following crying can be a valid indicator of stress that caused crying (Gračanin et al., 2015) and might reflect crying-related stress, which distracts from pain. However, delayed mood improvements might suggest neurobiological changes that might also affect pain. Specifically, because of the well-documented links between fluctuations in the substances mentioned above and mood changes (Benarroch, 2012; Burgdorf et al., 2016; Grewen & Light, 2011; Heinrichs et al., 2003; Inagaki et al., 2020; Meier et al., 2016), an improved mood might reflect higher (brain) levels of oxytocin and opioids, which in turn might influence pain.

Until now, only Sharman et al. (2020) directly explored the links between tears and acute pain and found no effects of crying on pain using a cold pressor test. The study focused primarily on measuring stress rather than pain responses, and it did not control for baseline pain tolerance. Thus, it could not investigate changes in these responses. In addition, it could not assess potential more delayed effects. The current research is the first to focus exclusively on the links between crying and pain. In two studies, we exposed female participants (because of their greater propensity to cry; Vingerhoets & Scheirs, 2000) to emotional films and measured mood and pain responses repeatedly. To induce pain, instead of electrical stimulation (Study 1), in the second study, we used a cold pressor test since it is less threatening and potentially more sensitive to prolonged mood and related physiological changes (Zelman et al., 1991). We anticipated beneficial effects of crying on the sensory and pain threshold, tolerance and intensity. If the pain-alleviating effect of crying occurs rather immediately, we expected this to be caused by negative emotional reactions acting as distractors. In contrast, prolonged effects of crying on pain would be accompanied by mood improvements.

2 | STUDY 1

2.1 | Methods

2.1.1 | Participants

Since Sharman et al. (2020) did not focus on changes in pain responses but rather on absolute pain tolerance levels, while we were specifically interested in within-subjects changes, we could not determine our sample size based

on that study. Instead, we based the sample size calculation on the effect observed in a comparable study (Dunbar et al., 2012) that demonstrated the impact of laughter on changes in pain tolerance. The effect size for the observed impact of laughter on pain tolerance in a between-subjects design was medium to large (Cohen's d of 0.65). Based on earlier studies that also used films (Gračanin et al., 2015; Van der Veen et al., 2012), we expected at least 50% of the participants to cry. This implied a minimal sample size of 40 subjects for each study.

Sixty female psychology students took part in Study 1. Forty of them were first-year university students, who received course credit for participation, and the remaining 20 students were second- or third-year students who received financial compensation (30 euro). Exclusion criteria in both Study 1 and Study 2 were the presence of any severe chronic physical or psychiatric illness, the use of medication other than hormonal contraceptives, and being pregnant. Data of three participants from Study 1 were excluded due to equipment failure. The age of the final group (57 participants) varied from 18 to 32 years ($M = 20.7$, $SD = 2.9$). More information about participants and other details of this project are available in supplementary materials and at https://osf.io/4s63t/?view_only=7a4a7dccf7574c23b76762094f11feea.

The Psychological Research Ethics Committee of the Tilburg School of Social and Behavioural Sciences approved both studies, and all participants provided written informed consent.

2.1.2 | Materials and measurements

Crying eliciting and neutral stimuli

A 15-minute-long National-Geographic documentary 'Natural Balance' (Nixon, 1994) was used as a neutral stimulus to familiarize the participants with the experimental setting and procedures. We applied the film 'Once Were Warriors' (OWW; Scholes & Tamahori, 1994) as the emotional stimulus. Previous research revealed that female students displayed strong emotional reactions to this film (Van Tilburg & Vingerhoets, 2002; Vingerhoets, 2013; p. 86). We used a shortened (70 min) version containing all dramatic scenes (see Vingerhoets, 2013; p. 86). Both films were displayed on a 27.6-inch television monitor placed approximately 3.30 m away from the participant, with a Dolby surround-system.

Crying behaviour during the film OWW

Participants were asked to press a button every time they cried while watching OWW. In the instructions, crying was defined as anything from just moist eyes to running tears and sobbing.

Mood ratings

Eighteen mood indicators were rated on a Likert scale varying from 1 (not at all) to 10 (very much). This instrument was previously used and validated in an experimental study on the effects of crying on psychophysiological responses (Hendriks et al., 2007). Average scores were calculated for positive (Cronbach alphas: 0.71 and 0.81) and negative mood (Cronbach alphas: 0.78 and 0.89, for the first and the second mood measurements of interest respectively). The positive mood scale included the mood items relaxed, happy, relieved, under control and cheerful. The negative mood scale contained the items powerless, pitiful, disgusted, sad, astonished, angry, guilty, tense, fearful, restless, bad-tempered, touched and nervous.

Pain induction and responses

For the induction and measurement of pain responses, we employed the procedure described by Nyklícek et al. (1999). Using a Tursky concentric electrode (Tursky, 1974), a constant electric current was delivered to the participants' ventral side of the left forearm. We only administered the slow automatic intensity-regulation from Nyklícek et al. (1999). Therefore, the current was raised automatically linearly from 0 mA to a maximum of 6 mA in 40 s unless the participant terminated the stimulus earlier. Participants were instructed to indicate, by pushing a button, (a) when the stimulus was perceived for the first time (*sensory threshold*); (b) when it was experienced as painful (*pain threshold*) and (c) when it reached the point to be 'unpleasant to the degree that one wanted to terminate the current (*pain tolerance*), at which point the stimulation stopped immediately. We used the average of three consecutive measurements taken at each time point in our analysis.

2.1.3 | Data collection

Pain responses were measured at the following three time points: (1) before the neutral film, (2) in between the neutral and the emotionally arousing film, and (3) immediately after the emotionally arousing film. In addition, participants reported their mood preceding and following each pain-responses measurement. However, since we were interested in the effects of the film OWW and the accompanying crying behaviour on mood and pain, our statistical analyses focused solely on the measurements taken immediately before and after participants had watched the film OWW. Since mood was measured before and after each pain induction, and since these mood measurements occurred closely in time (each pain induction lasted 5 min), we analysed only the mood responses measured after the second and before the third

pain induction (see Figure S1 in the supplementary materials for the complete timeline of the experimental procedure of Study 1). Studies 1 and 2 were both parts of a larger project with several additional psychophysiological recordings not relevant to the current research questions.

2.1.4 | Procedure

Participants signed informed consent when they made appointments for their study participation. After having welcomed the participants in the laboratory, the experimenter explained the general procedure, and then the electrodes for recording the psychophysiological variables were attached. Next, participants were seated in a comfortable chair and completed their first mood measure. Then, the current-delivery apparatus was connected, and the participants received instructions about the pain-induction procedure and the pain-responses assessment. Subsequently, the pain responses were determined for the first time, after which the participant completed the mood scale for the second time. This was followed by the neutral film, during which the researcher left the room and after which he returned to invite the participants to provide their mood ratings for the third time. The participant then underwent the pain induction procedure (T1 pain responses measurement in our analysis, T1), and completed the subsequent mood questionnaire (T1 mood measurement in our analysis). Before their exposure to the emotionally arousing film, the experimenter instructed the participants to press a button every time they cried (i.e. when they felt their eyes becoming moist) during the film. Then, the emotional film (OWW) was started, and the researcher left the room again and returned immediately after the film. Subsequently, after being decoupled from the apparatus measuring the psychophysiological variables, the participants rated their mood again (T2) and answered some questions about their reactions to the film. Next, the last pain measures were taken (T2), and participants rated their mood for the last time. The session ended with the removal of the shock apparatus and the debriefing of the participants.

2.1.5 | Data analysis

The average of the values of the three measurements for each pain parameter served as input for the statistical analyses. To test our main hypotheses that crying decreases pain responses and the secondary hypothesis, that crying results in immediate mood deterioration, we performed separate repeated-measures analyses of variance (ANOVAs) on the positive and negative mood scores and the three pain variables with *time* (before (T1) and after (T2) the film) as a within-subjects factor and *group* (non-crying and crying) as a between-subjects factor. In the case of a significant *time* x *group* interaction, changes within the groups were analysed with a two-way ANOVA for each group. Additionally, the variants of both hypotheses claiming a possible dose–response relationship between crying with mood and pain-responses changes, based on the crying frequency data from the button presses, were evaluated by computing a series of five Pearson's correlation coefficients (two for mood and three for pain measures) calculated for the difference between T2 and T1. Finally, to test the secondary hypothesis that the effects of crying on pain occurred due to the distraction by negative emotional reactions, we repeated all the analyses of the links between crying and pain responses by controlling for mood changes. This implied five and three (when controlling for the two mood parameters) dependent variables or correlations, and thus probability value was set to 0.01 and 0.015 respectively.

2.2 | Results and discussion

Twenty-eight (49.1%) of the 57 participants indicated that they had cried during the film OWW by pressing the button at least once. The number of crying episodes ranged between one and four times (median = 2).

2.2.1 | Crying, Mood and Pain Responses

Mood

The positive-mood score did not change significantly from before (T1) to after (T2) watching the film OWW, and there was also no significant *time* x *group* interaction (see Table 1 for the means, standard errors of mood and pain responses, and the effect sizes for the main effects and the interaction between *time* and *group*). Besides, criers and non-criers did not differ in an overall positive mood. In contrast, participants did report a higher negative mood score after the film OWW than before. However, there was no significant difference between non-criers and criers regarding changes (i.e. no interaction effect) or overall negative mood levels. The correlations between the frequency of crying and mood changes were not significant (*p*s 0.42 and 0.48).

Pain responses

Overall, none of the three pain-response measures changed from before (T1) to after (T2) watching the film OWW (see Table 1). Similarly, criers and non-criers had comparable overall pain responses. We also observed

TABLE 1 Means (±SEM) of positive and negative mood and three pain indices before and after watching the emotional film, in groups of non-criers and criers in study 1, with the corresponding effects sizes; P2 and M4 as pre-film baseline measures and P3 and M5 as post-film measures of pain and mood responses respectively

Measure	Group	Before the film(M4 & P2)	After the film(M5 & P3)	*Time*		*Group*		*Interaction*	
				F	η^2_p	*F*	η^2_p	*F*	η^2_p
Positive mood	Non-criers	5.40 (0.28)	5.27 (0.30)	3.2	0.06	1.23	0.02	1.08	0.02
	Criers	5.16 (0.29)	4.67 (0.30)						
Negative mood	Non-criers	2.10 (0.19)	3.75 (0.25)	241***	0.81	3.71	0.06	0.92	0.02
	Criers	2.56 (0.19)	4.43 (0.26)						
Sensory threshold	Non-criers	0.57 (0.05)	0.59 (0.05)	0.73	0.01	0.47	0.01	3.82	0.06
	Criers	0.65 (0.05)	0.60 (0.05)						
Pain threshold	Non-criers	1.55 (0.17)	1.72 (0.17)	0.47	0.00	0.55	0.01	7.18**	0.12
	Criers	1.88 (0.18)	1.74 (0.17)						
Pain tolerance	Non-criers	2.80 (0.26)	2.78 (0.24)	0.00	0.00	0.23	0.00	0.06	0.00
	Criers	2.95 (0.27)	2.97 (0.25)						

**$p < 0.01$; ***$p < 0.001$.

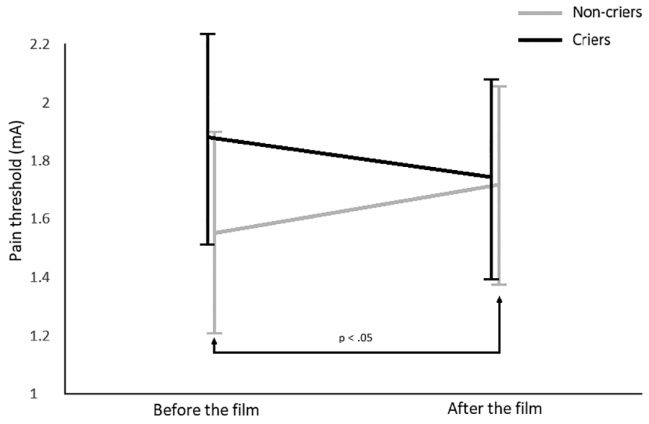

FIGURE 1 Mean values of pain threshold in non-criers and criers before (P2) and after (P3) the (potentially crying-inducing) film OWW in study 1. Error bars represent 95% confidence intervals.

no differences between criers and non-criers in sensory threshold and pain tolerance changes from before (T1) to after (T2) the film OWW. Analyses, however, revealed that the changes in the pain threshold of criers and non-criers differed (but the interaction effect was marginally significant; $p = 0.01$). Specifically, and contrary to expectations, the pain threshold increased in non-crying participants, [$F(1, 28) = 4.90$; $p = 0.035$; $\eta^2_p = 0.15$], but not in crying participants, [$F(1, 27) = 2.63$; $p = 0.120$; $\eta^2_p = 0.09$] (see Figure 1). Finally, correlations between the frequency of crying and changes in pain responses were not significant except for the pain threshold change from T1 to T2 ($r = -0.40$; $p < 0.001$). Thus, the decrease in the pain threshold was greater (or the increase was smaller) in those who cried more, which is in line with the interaction described above. When controlling for the mood changes, the results of ANOVAs and correlations between crying frequency and pain responses remained the same.

The findings of Study 1 failed to support our hypothesis about the pain-reducing effects of crying. The only significant effect ran contrary to our expectation: non-crying rather than crying participants showed a significant change in one out of three pain measures, specifically, an increase in the pain threshold. The dose–response relationship followed a similar pattern. Notably, the immediate pain threshold decrease observed in criers and its relation with crying frequency was independent of mood changes. Correspondingly, the emotionally distressing film affected criers and non-criers equally: both experienced an increase in a negative mood. This partly corroborates previous laboratory findings (Cornelius, 1997, 2001; Gračanin et al., 2015), and it also demonstrates that mood deterioration did not represent (or reflect) a distraction that alleviates pain. On the contrary, crying seems to decrease an individual's pain threshold, at least over a short run, and this seems to be unrelated to mood changes that follow tears.

Since we were interested in the emotional effects of film as potential mechanisms through which crying might affect pain, it is essential to consider that different pain induction procedures might affect participants' emotional states differently. Participants may perceive electrical pain stimulation used in Study 1 as more threatening than the cold pressor task (CPT), which is more similar to the more familiar experience of putting one's hands in cold water (Birnie et al., 2014). This difference in threat-perception, in its turn, could have created a different pattern of expectancy-related negative emotion (Staub &

Kellett, 1972), possibly modulating the effects of crying on pain.

A further major limitation of the present study was that criers and non-criers in the current quasi-experiment might have differed in certain stable features (such as personality). For example neurotic individuals cry more easily (Peter et al., 2001), and different levels of this trait may also affect the consequences of (non)crying in different ways, thus making it harder to detect any systematic effects of tears on changes in mood and pain responses. Relatedly, Study 1, like all previous laboratory studies on the intra-individual effects of crying (see Cornelius, 1997, 2001, for an overview), understandably applied a quasi-experimental design, which did not allow for optimal control of the individual differences. We tried to deal with this issue in Study 2 by adding a follow-up to the quasi-experimental study.

Another shortcoming of Study 1 was that we relied on the participants' button presses (in essence, also a kind of self-report) to determine when they had cried and how frequent their crying was. This failure to apply an objective assessment of the crying behaviour may compromise the validity of the results. Relatedly, this additional cognitive task to monitor one's own (crying) behaviour could have influenced both the occurrence of crying and its potential effects. Finally, the mood and pain evaluations were limited to immediately after the film, while Gračanin et al. (2015) found that the beneficial mood effects of crying might need some time to develop. Similarly, Weisenberg et al. (1998) observed the effects of a humorous film on increases in pain tolerance first with a delay of 30 min after the exposure to funny material. Therefore, the impact of crying on pain responses could perhaps follow a similar pattern. Importantly, prolonged, rather than immediate effects of crying could indicate the involvement of a neurobiological mechanism rather than mere distraction (Weisenberg et al., 1998).

3 | STUDY 2

In Study 2, we again tried to establish if crying might benefit pain responses. However, this time we tried to resolve some of the above-mentioned main shortcomings of Study 1. First, we used a different pain-inducing procedure (CPT instead of electrical stimulation). In addition to its advantages mentioned above, it is also noteworthy that the CPT is a widely used pain induction technique (Birnie et al., 2014) that was also used in previous experiments on the prolonged effects of emotional content on pain, comparable to ours (Weisenberg et al., 1998). Crucially, in contrast to the electrical pain stimulation procedure employed in Study 1, which can be regarded as phasic, CPT is closer to tonic pain stimulation, which can be more sensitive to prolonged mood improvements and related physiological changes (see, e.g. Zelman et al., 1991). This time, we did not limit the measurements to immediately before and after the film, but we also included more distant measurements at 20 and 50 min. After the emotion elicitation, when we expected the first beneficial effects of crying on pain and mood to appear (rather than immediately after the film). Next, to determine if a participant cried, instead of relying on self-reports (i.e. button presses), we recorded participants' facial expressions, which were coded by two trained observers. In addition to creating a more natural situation in which the participants did not have to monitor their crying, this was especially important for having a reliable estimation of the crying frequency.

Finally, and most importantly, in Study 2, we also addressed the critical limitation of quasi-experimental designs by conducting an additional follow-up study. Several months after their first participation, we invited only the participants who had cried during the main study and exposed them to a similar procedure. The crucial difference was that the stimulus was now a neutral rather than an emotional film. By inviting crying participants only, we could compare the mood and pain responses during exposure to a comparable experimental situation with a different, neutral stimulus in a subgroup of participants who generally seem prone to cry. This allowed us to, at least partly, eliminate the possibility that potential differences in the mood and pain responses between crying and non-crying participants in the main study could be attributed to some stable individual differences rather than to the effects of crying.

In sum, Study 2 attempts to replicate the finding from Study 1, specifically, the absence of the beneficial effects of crying on mood and pain indices immediately after a crying episode, implying that distraction is not a likely mechanism responsible for the potential links between crying and pain responses. We also evaluated the hypothesis that beneficial mood and pain response effects of tears may appear only later, rather than immediately following an emotional film, which would replicate the more recent findings on the effects of crying on mood (Gračanin et al., 2015) and also lend support to the neurobiological explanation of the links between crying and responses to acute pain. We anticipated that criers, compared to non-criers, would show increases in pain tolerance and decreases in pain threshold, subjective pain intensity, and negative mood later in time, especially when their pain or mood reactions to a comparable but neutral stimulus were taken into account. We further hypothesized that changes in pain responses are independent of mood changes immediately after the emotional and potentially crying eliciting

event. We finally anticipated the long-term effects of crying on pain to be accompanied by mood improvements.

3.1 | Methods

3.1.1 | Participants

The initial sample consisted of 89 female students (age range 18–26; $M = 20.06$; $SD = 1.94$) who received course credits for participation. In some cases, participants were excluded from the analyses due to equipment failure, constantly having wet eyes, not following the procedure, or because the CPT water temperature varied outside the 4 +/− 1.5°C limit (see below & the supplementary materials). Thus, the final sample consisted of 70 participants with numbers ranging from 66 participants for pain perception analysis to 68 participants for mood dynamics analysis. All 49 spontaneously crying participants were invited to participate in the follow-up, and 21 of them agreed to take part (note that non-returning also depended on whether a participant finished their university studies and moved to another city and/or stopped using the initial e-mail address). Having full data in both the main and the follow-up study allowed us to also take into account the follow-up study responses. This was the case in 17 (one of the pain threshold measurements was missing) to 19 (missing pain intensity measurements) participants.

3.1.2 | Materials and measurements

Crying eliciting and neutral stimuli

We used an edited version of the film 'Hachi: A Dog's Tale' (Hallström, 2009; 44′ 33″ long) as the crying eliciting stimulus. This edited version included all the most dramatic scenes that had the potential to trigger crying (see supplementary materials). The film depicts the dramatic story of a dog who waited endlessly at a railway station for his deceased owner to return. Earlier, this film elicited crying in 57% of a mixed-gender sample (Gračanin et al., 2015). The film was presented on a 19-inch monitor with two speakers, placed approximately 60 cm before the participant, with sound presented via headphones.

Mood assessment

Mood was assessed by the following 18 items from Gračanin et al. (2015) study, in which delayed effects of crying on mood were observed: nervous, bad-tempered, anxious, weepy, tense, guilty, helpless, sad, angry, miserable, rejected, fearful, cheerful, generous, relaxed, calm, active and merry. For the sake of simplicity of the analysis (due to multiple measurements), and to make our study comparable to Gračanin et al. (2015), we created a mood composite (with the last six items reversed) representing a measure of negative mood. Responses were given on a five-point Likert scale ranging from 1 (I do not feel this way at all) to 5 (I feel this way completely). The average negative mood score showed adequate internal consistency, with Cronbach alphas over the four measurements ranging from 0.82 (time 4) to 0.87 (time 2).

Detection of crying episodes

During the film presentation, an unobtrusive side light source pointed at the participant's face made changes in the moistening of the eyes better visible. Video recordings of the participants' eyes were analysed by two trained coders who first independently rated the presence of participants' eye moistening during the film presentation. Their task was to establish how often and when precisely, the participants' eyes started filling with tears. After the initial ratings, with a high agreement between the two coders for both the crying frequency, [ICC(2,2) = 0.923; 95% CI 0.88–0.95], and the overall presence of tears, [ICC(2,2) = 0.886; 95% CI 0.83–0.92], the coders together analysed all the scenes and agreed about the (non)presence of crying during each initially determined crying episode.

Pain induction and responses

We applied a standard CPT procedure to induce pain (e.g. Edens & Gil, 1995). Participants were seated in a comfortable chair next to a bucket containing circulating water (von Baeyer et al., 2005) with a constant 4 (+/− 1.5)°C temperature and were invited to put their dominant hand into the water with their first closed, without moving. Next, they were instructed (a) to raise their non-dominant hand index finger when they experience pain (*pain threshold*) and (b) to take their hand out of the water when they could not stand the pain (*pain tolerance*). If the participant reached the maximum of 3 min, the experimenter stopped the test. *Subjective pain intensity* was assessed by asking participants to indicate the level of experienced pain on a visual analog scale (VAS) immediately after taking the hand out of the water.

3.1.3 | Procedure

While in the waiting room, participants first signed the informed consent and subsequently completed the first mood questionnaire (T1). After entering the laboratory, electrodes were attached to measure psychophysiological responses, and a brief explanation about the measurement equipment was provided. After the participants had received instructions about the experiment, the first CPT (T1) started. Next, participants were seated in a comfortable

chair in front of the monitor and video camera, followed by the presentation of the film. After the film, the researcher re-entered the room, and the participant underwent the second mood measurement (T2) and CPT (T2). Next, the electrodes for the psychophysiological measurement were uncoupled, and the participant underwent a simple cognitive task unrelated to the study. Twenty minutes following the second mood measurement, participants reported their mood again (T3), followed by a CPT (T3). Subsequently, the participants completed a set of questionnaires, of which the first part represented systematic data collection not in the scope of the current study, while the last questionnaire was intended as a filler task. Participants were instructed to wait for the experimenter and relax if they completed the questionnaires within the available time. Most participants finished this task 1–3 min before the next task. If a participant was still filling in the last questionnaire after 25 min, they were interrupted by the experimenter saying, 'please stop; the questionnaire that was left unfinished is not important', and they received the fourth mood questionnaire (T4; 30 min following T3), and CPT (T4), followed by a debriefing. The mood (and pain responses) measurement timeline is comparable to the only earlier study with multiple mood assessments following crying (Gračanin et al., 2015) except that, in the current study, the period between T3 and T4 was 40 min shorter. The timeline of the experiment is presented in Figure S2 in supplementary materials.

3.1.4 | Follow-up study

Only those participants who had cried during the main study were invited to the follow-up study between 3 and 7 months after their first participation (median 5 months). The follow-up consisted of the same experimental procedure. The main difference was the exposure to a neutral instead of an emotional film of comparable length. This concerned the scientific documentary 'Natural World: Canine Conspiracy' (Flowers et al., 2002), which explains the evolution of dog behaviour. The nature of the filler task (completing a different set of personality questionnaires not relevant for the present research question) between the movie and the more delayed measurements was also very similar. Participants were treated in the same way as in the main study, though, this time, they received the invitation via e-mail rather than via the university participant-pool system.

3.1.5 | Data analysis

To evaluate the differences in changes in negative mood (secondary hypothesis) and in the three pain parameters (primary hypothesis) across the four measurements between criers and no-criers, four 4×2 mixed ANOVAs (one for mood and one for each of the three pain indices) were performed with *time* as a within-subjects factor (measurements at T1, T2, T3 and T4) and *group* (non-crying and crying) as a between-subjects factor (probability value set to 0.0125). Greenhouse–Geisser corrections were employed to correct for violations of the sphericity assumption. When a significant main effect of time was observed, changes between specific measurements were additionally analysed by conducting five one-way ANOVAs (one for each pair of time points of interest: T1 – T2, T1 – T3, T1 – T4, T2 – T3 and T2 – T4; probability value set to 0.01). Possible dose–response relationships of crying with mood (a variant of the secondary hypothesis) and pain-response (a variant of the primary hypothesis) changes were evaluated by computing a series of Pearson's correlation coefficients, with four of them computed (one for mood and each of the three pain measures) for the difference within each of the five pairs of time points listed above (probability value set to 0.0025). Finally, to test the secondary hypothesis that the effects of crying on pain occurred due to the distraction by negative emotional reactions (changes from T1 to T2) or due to the change in the levels of relevant neurochemical substances, as potentially evident from mood improvements (changes T1 – T3, T1 – T4, T2 – T3 and T2 – T4), we repeated all the analyses while controlling for mood changes.

The analyses based on the follow-up data included a repetition of the above-presented dose–response relationship computations in participants who cried during the main study, this time with statistically controlling for the mood changes (a variant of the secondary hypothesis) and pain responses (a variant of the primary hypothesis) within comparable periods during the follow-up (i.e. during the non-crying situation). Next, to eliminate the possibility that mood (secondary hypothesis) and pain (primary hypothesis) responses of criers in the main study reflected specific features of these individuals rather than the crying itself, we compared their mood and pain-response changes during the emotional film with the pattern of changes during the neutral film. Thus, the effects of emotional (tears present) and non-emotional (tears not present) films on mood and pain responses in participants who had cried during the main study were compared by four (mood and three pain indices) 4 x 2 repeated measures ANOVAs with *time* (T1 to T4) and *film* (emotional/crying - non-emotional/non-crying) as the independent variables. When a significant *time* by *film* interaction was observed, changes between specific measurements within each of the two conditions were analysed by conducting a separate one-way ANOVA for each film and/or, if appropriate, five one-way ANOVAs (one for each out of 5 pairs of time points

of interest as the above; probability value set to 0.01). Again, all the analyses were repeated by controlling for the mood changes.

3.2 | Results and discussion

The video analysis revealed that 49 (70%) of the 70 participants had cried at least once while watching the film. The number of observed crying episodes during the film varied between 1 and 6 times (median = 2).

3.2.1 | Mood Dynamics

We found a significant main effect of *time* on mood [$F(3, 169) = 40.41$; $p < 0.001$; $\eta^2_p = 0.38$]. However, no main effect of the *group* [$F(1, 66) = 0.20$; $p = 0.652$; $\eta^2_p = 0.00$] and also no *time* x *group* interaction [$F(3, 169) = 1.25$; $p = 0.291$; $\eta^2_p = 0.02$] was observed. When the main effect of *time* was decomposed (see Table 2), negative mood increased from T1 to T2 ($p < 0.001$) and decreased from T2 to T3 and from T2 to T4 ($p < 0.001$). Regarding a possible dose–response relationship between crying and mood, no significant correlations between the frequency of crying and the mood changes were observed (*p*s from 0.38 to 1). Similarly, when we took changes in negative mood during comparable periods in the follow-up study into account, none of the correlations reached significance (*p*s from 0.21 to 0.93).

3.2.2 | Pain Responses

There was no significant effect of either *crying* or the *crying* and *time* interaction on any pain measures. However, two out of the three pain measures changed significantly across T1 to T4 (Table 2). Pain tolerance decreased, and subjective pain intensity increased from T1 to T2 ($p < 0.001$) (Figure 2a and b). Regarding a possible dose–response relationship, 14 of 15 correlations between the frequency of crying and changes in three pain response indices were not significant (*p*s from 0.05 to 0.97; when controlling for the values in the Follow-up: *p*'s from 0.04 to 0.93). The only significant, negative, correlation between crying frequency and increases in pain responses was observed for the change in pain threshold from T2 to T4 when we controlled for the values obtained in the follow-up: $r = -0.73$; $p = 0.002$ (without controlling for the follow-up: $r = -0.23$; $p = 0.065$), implying that the more often the participants cried during the film, the more their pain threshold decreased from T2 to T4. Finally, when controlling for the mood

TABLE 2 Means (±SEM) of mood and three pain tolerance indices before and at three time points after watching the film, in groups of non-criers and criers in study 2, with the corresponding effects sizes

					Time		*Group*		*Interaction*	
Measure	**Group**	**Before the film**	**Immediately after the film**	**20 min after the film**	**50 min after the film**	***F***	η^2_p	***F***	η^2_p	***F***	η^2_p
Negative mood	Non-criers	1.84 (0.08)	2.54 (0.10)	1.89 (0.08)	1.91 (0.08)	41.18***	0.38	0.14	0.00	1.43	0.02
	Criers	1.88 (0.06)	2.40 (0.07)	1.88 (0.05)	1.88 (0.06)						
Pain threshold	Non-criers	47.90 (8.19)	44.52 (9.08)	45.52 (9.03)	45.95 (9.06)	0.12	0.00	1.62	0.03	0.21	0.00
	Criers	32.11 (5.53)	32.56 (6.14)	32.22 (6.10)	33.41 (6.12)						
Pain tolerance	Non-criers	102.52 (12.61)	84.33 (11.14)	85.05 (12.09)	80.90 (12.84)	5.77**	0.08	0.20	0.02	2.06	0.03
	Criers	75.10 (8.34)	64.33 (7.37)	67.75 (8.00)	73.19 (8.49)						
Pain intensity	Non-criers	6.82 (0.57)	7.58 (0.57)	7.29 (0.55)	7.44 (0.52)	6.39***	0.10	0.00	0.00	1.04	0.02
	Criers	6.92 (0.38)	7.68 (0.38)	7.55 (0.36)	7.08 (0.34)						

**$p < 0.01$; ***$p < 0.001$.

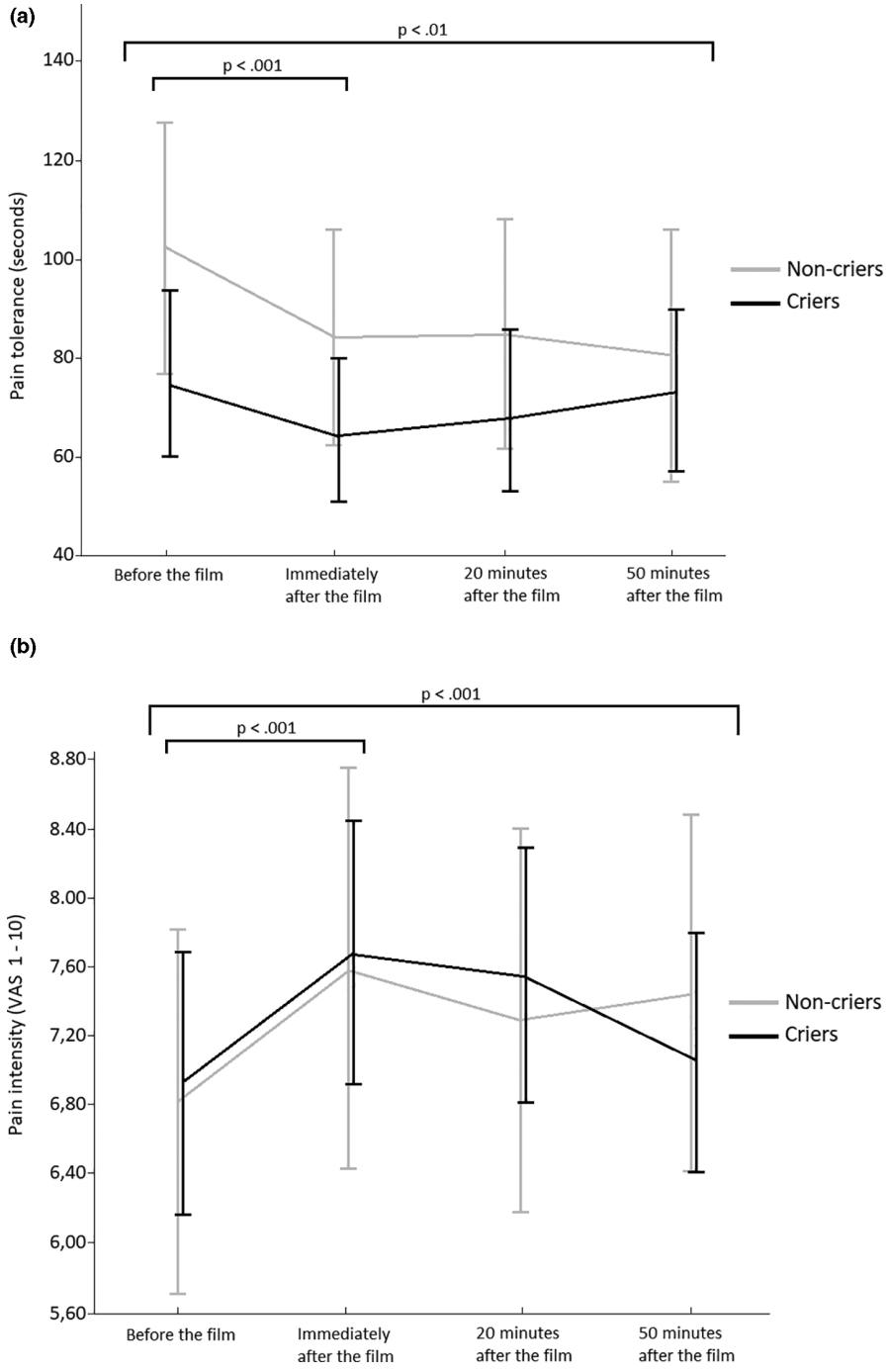

FIGURE 2 Mean values of pain tolerance (2a) and pain intensity (2b) in non-criers and criers across four measurements in study 2. Error bars represent 95% confidence intervals. P values pertain to the significance of the main effect of time and the effects from post hoc ANOVAs that compared values at different time points across the groups (non-criers/criers).

changes, the results remained the same, except that now the correlation between crying frequency and change (increase) in pain tolerance from T1 to T4 correlated positively when we took into account the follow-up values: $r = 0.68$; $p = 0.002$ (without controlling for the follow-up: $r = 0.22$; $p = 0.084$). However, the change in the strength of the correlation was minor compared to the marginally significant correlation obtained when mood was not controlled for ($r = 0.64$; $p = 0.003$). When all other analyses involving pain responses were repeated while controlling for mood changes, the results remained comparable.

3.2.3 | Interaction between film type (Main study / Follow-up) and time

The two-way interaction between *film* (emotional, crying/non-emotional, non-crying) and *time* (T1 to T4) was significant for mood [$F(3, 14) = 13.35$; $p < 0.001$; $\eta^2_p = 0.74$]. This interaction was based solely on the large increase in negative mood after the emotional, crying film (Main study), from T1 to T2, and the quick return to baseline levels from T2 to T3 ($p < 0.001$), while, as expected, no changes between measurements were observed during the non-crying (Follow-up) film

($p = 0.58$). Therefore, when changes in mood during the follow-up were considered, tears did not result in mood improvements over the longer run (i.e. the mood of crying participants was not significantly less negative at T3 or T4 than at T1). The interactions between *film* and *time* on pain threshold [$F(3,12) = 1.08$; $p = 0.39$; $\eta^2_p = 0.21$], tolerance [$F(2, 35) = 2.21$; $p = 0.12$; $\eta^2_p = 0.12$] and intensity [$F(3, 15) = 1.38$; $p = 0.29$; $\eta^2_p = 0.22$] were not significant. Controlling for mood changes yielded similar results.

Study 2 disconfirmed our hypothesis about different patterns of mood changes in criers and non-criers. Instead, the film presentation produced a consistent, strong increase in negative mood followed by a substantial return to the baseline in both criers and non-criers, which partly corresponds to earlier research findings (Gračanin et al., 2015).

Much like most of the results of Study 1, no effects of crying or no-crying on pain indices were observed. However, in the current study, there was a general increase in two out of three pain responses (decreased tolerance and increased subjective intensity) across the four measurements, irrespective of the crying. Similarly, the overall pattern of dose–response links largely disconfirms the hypothesis about a negative relationship between crying frequency and pain responses, which is in line with the other results of Study 2. An exception is the pain threshold, where the findings partly correspond to the unexpected effect of crying on pain threshold observed in Study 1. However, dose–response analysis provided a weak hint that the crying frequency might be positively related to pain tolerance over the longer run, irrespective of mood changes. Finally, the interaction between the type of the film (emotional/crying in the main study—non-emotional/non-crying in follow-up) and time (measurements 1–4) corroborated these quasi-experimental results.

4 | GENERAL DISCUSSION

The present two studies' main objective was to explore the effects of crying on acute pain. We expected that crying or associated mood deterioration might act as a distraction, which alleviates the pain immediately following a crying episode. Alternatively, if crying would stimulate the release of pain-reducing substances like oxytocin and/or endogenous opioids, it would predominantly reduce the pain responses over more extended time periods. This effect would more likely be connected with mood improvements than with mood deterioration.

As in previous laboratory studies (see Cornelius, 1997, 2001 for a review), the present findings revealed that participants who cried during emotionally arousing films felt worse after than before the film, as did participants who did not cry. Note that in some previous studies (e.g. Gračanin et al., 2015; Martin & Labott, 1991), participants who cried felt even worse than non-criers immediately after the emotional film, which was not the case in either of the current two quasi-experiments. Concerning the influence of crying on the pain measures, which included the sensory threshold (only in Study 1), the pain threshold (both studies), tolerance (both studies) and subjective pain intensity (only in Study 2), crying induced by a sad film failed to exert positive effects. This is comparable to the only previous study that assessed pain tolerance following crying (Sharman et al., 2020), although, as stated above, that study did not focus on changes but on the absolute level of pain tolerance, which precluded a more straightforward interpretation of findings. Using an additional, alternative pain-inducing method (electrical stimulation) and longer crying eliciting films (70 and 44 as compared to 17 min in that previous study), that allowed us to evoke more crying episodes, we still did not observe any pain-alleviating effects of crying. In study 1, the pain threshold instead increased for the participants who did not cry during the film. Furthermore, perhaps the observed decreases in pain tolerance and increases in pain intensity in both crying and non-crying participants in Study 2 resulted from the exposure to a highly emotionally arousing film. Unfortunately, these findings reveal little about the specific role of crying. However, they certainly speak against the possibility that emotional distraction plays a beneficial role. Finally, contrary to expectations, we observed negative correlations between the frequency of crying and increases in pain threshold (both studies), corresponding to the increased pain threshold in non-criers mentioned above.

To summarize, the present data failed to reveal any beneficial effects of crying behaviour on subsequent mood and pain responses. They even suggest that opposite effects are more likely, at least regarding pain threshold. Notably, the observed effects were relatively inconsistent and small, showing a pattern in which both crying and non-crying participants felt worse and experienced *more* pain after the emotional film. In several cases, these effects were even more pronounced in participants who cried. The most parsimonious explanation of the latter effect is that the negative emotional effects of films were stronger in criers. The idea that negative emotions evoked by films subsequently co-determine pain sensitivity is in line with the results of previous studies showing that the experimental induction of positive emotional states increased and negative emotional states decreased pain tolerance (Willoughby et al., 2002; Zelman et al., 1991). The latter effect can probably be best explained by the fact that negative mood states facilitate a more negative evaluation

of the events, including painful stimuli (Fields, 1991; Willoughby et al., 2002). However, this explanation can be ruled out in the current two studies because, when we repeated the analyses while controlling for the mood changes, the effects remained unchanged.

It is important to stress that both studies were similar to previous laboratory research on crying in that they necessarily applied a quasi-experimental design. Specifically, participants were 'assigned' to the two groups based on their responses to the films, making it impossible to rule out the possibility that criers differed from the non-criers in specific personality characteristics (Peter et al., 2001; Vingerhoets, 2013) or states related to changes in crying, mood and pain responses after the exposure to emotional stimuli (Vingerhoets, 2013). Despite some attempts to solve this methodological issue (Kraemer & Hastrup, 1988), the current quasi-experimental design seems the best option to explore the effects of tears on mood and pain responses. However, this methodology cannot yield conclusive results due to its inherent limitations. More specifically, an ideal, really experimental design is not possible since crying is a spontaneous reaction to specific stimulation, which cannot be manipulated with instructions that do not interfere with that particular stimulation (e.g. instruction to suppress an urge to cry). Comparing the effects of crying and non-crying episodes in individuals who were initially observed to be prone to crying in a laboratory, as we did by conducting our follow-up in Study 2, is, admittedly, just a part of the solution because this approach fails to eliminate the fact that the conditions differed not only in crying but also in mood levels.

While the absence of mood improvement immediately after a crying episode in both studies corroborates earlier laboratory findings, its lack over the long run in Study 2 contrasts with the only comparable earlier study (Gračanin et al., 2015). Importantly, in the current study, the final (i.e. the 4th) mood measurement occurred 40 min earlier than in the latter study, potentially precluding the possibility to observe negative mood decreases. Perhaps we failed to find any effects of crying on pain responses because the crying participants also did not show more long-term mood improvements. In other words, we cannot exclude that participants would have displayed the expected mood improvement over the longer run, accompanied with corresponding changes in pain responses, possibly due to changes in oxytocin and opioid levels (Burgdorf et al., 2016; Grewen & Light, 2011; Heinrichs et al., 2003; Meier et al., 2016). Finally, the detrimental effects of crying on mood immediately after a crying episode could theoretically have alleviated pain via distraction, which we did not observe. Interestingly, as in the current study, Sharman et al., 2020) assessed negative mood changes from before to after the emotional films (in contrast to the pain tolerance that they only evaluated after the films), and they also failed to find a difference between criers and non-criers. Possibly, the lack of difference between the two groups in pain responses in that earlier and in the current studies was simply due to the absence of difference in distraction (criers and non-criers had comparable mood responses, so they were equally distracted). Nevertheless, this fails to support the notion of distraction-driven effects of crying (or related emotion) on pain responses. Overall, the present findings challenge the more general hypothesis about beneficial intra-individual effects of crying. An interesting remaining question is whether the individual differences in the beneficial effects of crying on mood (see Rottenberg et al., 2008) are also related to variations in pain responses. Future studies dealing with that question could focus on pre-selected crying-prone participants to gain sufficient variability in mood and pain responses following crying.

The current hypothesis about the effects of crying on pain responses was inspired by the presumed parallel with other emotional expressions such as swearing (Stephens & Umland, 2011) and laughter (Dunbar et al., 2012), which both seem to modulate pain responses. It was also based on more specific putative mechanisms related to either the release of endogenous opioids and oxytocin or emotional distraction. Because laughter seems to increase both pain threshold (Dunbar et al., 2012) and opioid levels (Manninen et al., 2017), and it was also speculated to stimulate oxytocin release (Panksepp & Burgdorf, 2003), we expected that similar biochemical reactions might follow crying as well. The current findings are not in line with such a claim since crying in both studies did not influence pain responses as a proxy for the release of opioids and oxytocin. Similarly, crying did not alleviate pain via distraction, at least not through mood deterioration that might immediately follow it. However, it is essential to note that experimentally induced crying is often modest in intensity and devoid of some of its distinct components, such as sobbing—which might have a crucial role in its mood and pain effects. This might be especially important when in pain, as specific breath-holding patterns may impact pain perception (Jafari et al., 2016). Whether the convulsive inhaling and exhaling (which also involves breath-holding) typical of sobbing could produce similar pain-alleviation effects remains an interesting and challenging research question (see Gračanin et al., 2014).

A significant shortcoming of both studies was that our participant samples consisted exclusively of female students. Research has consistently shown that women cry more often, more intensely, and longer than men (Vingerhoets & Scheirs, 2000). Relatedly, it cannot be excluded that female crying may be functionally different from male crying and may involve quite different psychological

and physiological processes (Martin et al., 1993). That would imply that crying may have differential effects on the criers depending on their sex. Furthermore, previous research has revealed sex differences in pain perception (e.g. Nyklícek et al., 1999). Therefore, without further investigation in a male sample and with a broader age range, we cannot assert that crying or a general high tendency to express distress through tears do not positively affect both male and female mood and pain. Next, various individual differences variables, including the crier's mental condition (Rottenberg et al., 2008), were previously related to the psychological consequences of emotional crying. In addition, people more likely report mood improvement after crying over a controllable situation and when observers provide emotional support and comfort (Rottenberg et al., 2008). The induction of crying in a laboratory typically does not include these features.

Future studies should also consider the possibility that crying might affect chronic and acute pain differently. Another crucial issue to tackle concerns the fact that the exposure to pain in our study occurred only after crying, when potentially beneficial distraction effects of crying could act only indirectly via negative mood. Relatedly, crying because of pain itself might have different effects on pain perception than crying for other reasons. Thus, future studies could focus on the effects of pain-induced and no-pain-induced crying *during* pain exposure. Finally, our sample sizes only allowed us to test for medium to large effects of crying on pain. New studies that would test for smaller effects should certainly have a larger number of participants. Relatedly, while the current research failed to observe statistically significant effects of crying on pain responses, it is impossible to conclude that there are no such effects at all. Perhaps, a better insight into the role of crying could be gained by testing the a-priori hypothesis about the non-existence of the effects of crying on pain, which could include equivalence testing based on the Bayesian approach and which could use the current findings as a starting position (see e.g. Harms & Lakens, 2018).

In sum, our findings failed to support the hypothesis that crying promotes psychological homeostasis via its effects on mood and pain responses. This finding thus once more seems to emphasize that the primary function of crying most likely can be found in the inter-individual domain (see Vingerhoets, 2013), more precisely, on how it communicates a need for assistance and solicits certain support-providing behaviours in others.

AUTHOR CONTRIBUTIONS

Asmir Gračanin, Michelle Hendriks and Ad Vingerhoets contributed equally, although all analyses were conducted by Asmir Gračanin. All authors discussed the results and commented on the manuscript.

FUNDING INFORMATION

This work was supported by the NEWFELPRO fund under grant number 32 and the UNIRI grant number uniri-drustv-18-231.

CONFLICTS OF INTEREST

None declared.

ORCID

Asmir Gračanin https://orcid.org/0000-0002-4824-9046
Michelle C. P. Hendriks https://orcid.org/0000-0002-7924-6294
Ad J. J. M. Vingerhoets https://orcid.org/0000-0001-8840-6379

REFERENCES

Benarroch, E. E. (2012). Endogenous opioid systems: Current concepts and clinical correlations. *Neurology*, *79*, 807–814. https://doi.org/10.1212/WNL.0b013e3182662098

Birnie, K. A., Caes, L., Wilson, A. C., Williams, S. E., & Chambers, C. T. (2014). A practical guide and perspectives on the use of experimental pain modalities with children and adolescents. *Pain Management*, *4*, 97–111. https://doi.org/10.2217/pmt.13.72

Burgdorf, C., Rinn, C., & Stemmler, G. (2016). Effects of personality on the opioidergic modulation of the emotion warmth-liking. *The Journal of Comparative Neurology*, *524*, 1712–1726. https://doi.org/10.1002/cne.23847

Cornelius, R. R. (1997). Toward a new understanding of weeping and catharsis? In A. J. J. M. Vingerhoets, F. J. Van Bussel, & A. J. W. Boelhouwer (Eds.), *The (non)expression of emotions in health and disease* (pp. 303–321). Tilburg University Press.

Cornelius, R. R. (2001). Crying and catharsis. In A. J. J. M. Vingerhoets & R. R. Cornelius (Eds.), *Adult crying: A biopsychosocial approach* (pp. 199–211). Brunner-Routledge.

Darwin, C. (1872/1965). *The expression of the emotions in man and animals*. University of Chicago Press.

Dunbar, R. I. M., Baron, R., Frangou, A., Pearce, E., van Leeuwen, E. J. C., Stow, J., ... van Vugt, M. (2012). Social laughter is correlated with an elevated pain threshold. *Proceedings of the Royal Society B: Biological Sciences*, *279*, 1161–1167. https://doi.org/10.1098/rspb.2011.1373

Edens, J. L., & Gil, K. M. (1995). Experimental induction of pain: Utility in the study of chronic pain. *Behavior Therapy*, *26*, 197–216. https://doi.org/10.1016/S0005-7894(05)80102-9

Fields, H. (1991). Depression and pain: A neurobiological model. *Neuropsychiatry, Neuropsychology, & Behavioral Neurology*, *4*, 83–92.

Flowers, M., Ellis, Y., Briers, R., & Dance, C. (2002). *The canine conspiracy [motion picture]*. BBC.

Gračanin, A., Bylsma, L., & Vingerhoets, A. J. J. M. (2014). Is crying a self-soothing behavior. *Frontiers in Psychology*, *5*, 502. https://doi.org/10.3389/fpsyg.2014.00502

Gračanin, A., Vingerhoets, A. J. J. M., Kardum, I., Zupčić, M., Šantek, M., & Šimić, M. (2015). Why crying does and sometimes does not seem to alleviate mood: A quasi-experimental study. *Motivation and Emotion*, *39*, 953–960. https://doi.org/10.1007/s11031-015-9507-9

Grewen, K. M., & Light, K. C. (2011). Plasma oxytocin is related to lower cardiovascular and sympathetic reactivity to stress. *Biological Psychology*, *87*, 340–349. https://doi.org/10.1016/j.biopsycho.2011.04.003

Hallström, L. (2009). Hachi: A dog's tale [motion picture]. Stage 6 Films.

Harms, C., & Lakens, D. (2018). Making 'null effects' informative: Statistical techniques and inferential frameworks. *Journal of Clinical and Translational Research*, *3*(Suppl 2), 382–393. 10.17605/OSF.IO/48ZCA

Heinrichs, M., Baumgartner, T., Kirschbaum, C., & Ehlert, U. (2003). Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. *Biological Psychiatry*, *54*, 1389–1398. https://doi.org/10.1016/S0006-3223(03)00465-7

Hendriks, M. C. P., Rottenberg, J., & Vingerhoets, A. J. J. M. (2007). Can the distress-signal and arousal reduction views of crying be reconciled? Evidence from the cardiovascular system. *Emotion*, *7*, 458–463. https://doi.org/10.1037/1528-3542.7.2.458

Herpertz, S. C., Schmitgen, M. M., Fuchs, C., Roth, C., Wolf, R. C., Bertsch, C., Flor, H., Grinevich, V., & Boll, S. (2019). Oxytocin effects on pain perception and pain anticipation. *Journal of Pain*, *20*, 1187–1198. https://doi.org/10.1016/j.jpain.2019.04.002

Inagaki, T. K., Hazlett, L. I., & Andreescu, C. (2020). Opioids and social bonding: Effect of naltrexone on feelings of social connection and ventral striatum activity to close others. *Journal of Experimental Psychology: General*, *149*, 732–745. https://doi.org/10.1037/xge0000674

Jafari, H., Van de Broek, K., Plaghki, L., Vlaeyen, J. W. S., Van den Bergh, O., & Van Diest, I. (2016). Respiratory hypoalgesia? Breath-holding, but not respiratory phase modulates nociceptive flexion reflex and pain intensity. *International Journal of Psychophysiology*, *101*, 50–58. https://doi.org/10.1016/j.ijpsycho.2016.01.005

Jennings, E. M., Okine, B. N., Roche, M., & Finn, D. P. (2014). Stress-induced hyperalgesia. *Progress in Neurobiology*, *121*, 1–18. https://doi.org/10.1016/j.pneurobio.2014.06.003

Kohl, A., Rief, W., & Glombiewski, J. A. (2013). Acceptance, cognitive restructuring, and distraction as coping strategies for acute pain. *Journal of Pain*, *14*, 305–315. https://doi.org/10.1016/j.jpain.2012.12.005

Kraemer, D. L., & Hastrup, J. L. (1988). Crying in adults: Self-control and autonomic correlates. *Journal of Social and Clinical Psychology*, *6*, 53–68. https://doi.org/10.1521/jscp.1988.6.1.53

Manninen, S., Tuominen, L., Dunbar, R. I., Karjalainen, T., Hirvonen, J., Arponen, E., … Nummenmaa, L. (2017). Social laughter triggers endogenous opioid release in humans. *The Journal of Neuroscience*, *7*, 6125–6131. https://doi.org/10.1523/JNEUROSCI.0688-16.2017

Martin, R. B., Guthrie, C. A., & Pitts, C. G. (1993). Emotional crying, depressed mood, and secretory immunoglobulin a. *Behavioral Medicine*, *19*, 111–114. https://doi.org/10.1080/08964289.1993.9935179

Martin, R. B., & Labott, S. M. (1991). Mood following emotional crying: Effects of the situation. *Journal of Research in Personality*, *25*, 218–244. https://doi.org/10.1016/0092-6566(91)90017-K

Meier, I. M., Bos, P. A., Hamilton, K., Stein, D. J., van Honk, J., & Malcolm-Smith, S. (2016). Naltrexone increases negatively-valenced facial responses to happy faces in female participants. *Psychoneuroendocrinology*, *74*, 65–68. https://doi.org/10.1016/j.psyneuen.2016.08.022

Mitchell, L. A., MacDonald, R. A. R., & Brodie, E. E. (2006). A comparison of the effects of preferred music, arithmetic and humour on cold pressor pain. *European Journal of Pain*, *10*, 343–351. https://doi.org/10.1016/j.ejpain.2005.03.005

Nixon, N. P. (1994). *30 years National Geographic Specials [motion picture]*. NGT.

Nyklícek, I., Vingerhoets, A. J. J. M., & Van Heck, G. L. (1999). Hypertension and pain sensitivity: Effects of gender and cardiovascular reactivity. *Biological Psychology*, *50*, 127–142. https://doi.org/10.1016/s0301-0511(99)00006-x

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. Oxford University Press.

Panksepp, J., & Burgdorf, J. (2003). "Laughing" rats and the evolutionary antecedents of human joy? *Physiology & Behavior*, *79*, 533–547. https://doi.org/10.1016/s0031-9384(03)00159-8

Pérez-Aranda, A., Hofmann, J., Feliu-Soler, A., Ramírez-Maestre, C., Andrés-Rodríguez, L., Ruch, W., & Luciano, J. V. (2019). Laughing away the pain: A narrative review of humour, sense of humour and pain. *European Journal of Pain*, *23*, 220–233. https://doi.org/10.1002/ejp.1309

Peter, M., Vingerhoets, A. J. J. M., & van Heck, G. L. (2001). Personality, gender, and crying. *European Journal of Personality*, *15*, 19–28. https://doi.org/10.1002/per.386

Quiton, R. L., & Greenspan, J. L. (2007). Sex differences in endogenous pain modulation by distracting and painful conditioning stimulation. *Pain*, *132*, 134–149. https://doi.org/10.1016/j.pain.2007.09.001

Rottenberg, J., Bylsma, L. M., & Vingerhoets, A. J. J. M. (2008). Is crying beneficial? *Current Directions in Psychological Science*, *17*, 400–404. https://doi.org/10.1111/j.1467-8721.2008.00614.x

Scholes, R. P., & Tamahori, L. D. (1994). *Once were warriors [motion picture]*. Footprint Films.

Sharman, L. S., Dingle, G. A., Vingerhoets, A. J. J. M., & Vanman, E. J. (2020). Using crying to cope: Physiological responses to stress following tears of sadness. *Emotion*, *20*, 1279–1291. https://doi.org/10.1037/emo0000633

Staub, E., & Kellett, D. S. (1972). Increasing pain tolerance by information about aversive stimuli. *Journal of Personality and Social Psychology*, *21*, 198–203. https://doi.org/10.1037/h0032150

Stephens, R., & Umland, C. (2011). Swearing as a response to pain: Effect of daily swearing frequency. *Journal of Pain*, *12*, 1274–1281. https://doi.org/10.1016/j.jpain.2011.09.004

Timmers, I., Kaas, A. L., Quaedflieg, C. W. E. M., Biggs, E. E., Smeets, T., & de Jong, J. R. (2018). Fear of pain and cortisol reactivity predict the strength of stress-induced hypoalgesia. *European Journal of Pain*, *22*, 1291–1303. https://doi.org/10.1002/ejp.1217

Tursky, B. (1974). Physical, physiological, and psychological factors that affect pain reaction to electric shock. *Psychophysiology*, *11*, 95–105. https://doi.org/10.1111/j.1469-8986.1974.tb00830.x

Van der Veen, F. M., Jorritsma, J., Krijger, C., & Vingerhoets, A. J. J. M. (2012). Paroxetine reduces crying in young women watching emotional movies. *Psychopharmacology*, *220*, 303–308. https://doi.org/10.1007/s00213-011-2477-z

Van Tilburg, M. A. L., & Vingerhoets, A. J. J. M. (2002). The effects of alcohol on mood induced by an emotional film. A study among women. *Journal of Psychosomatic Research*, *53*, 805–809. https://doi.org/10.1016/s0022-3999(02)00325-2

Vingerhoets, A. J. J. M. (2013). *Why only humans weep: Unravelling the mysteries of tears*. Oxford University Press.

Vingerhoets, A. J. J. M., & Scheirs, J. G. M. (2000). Sex differences in crying: Empirical findings and possible explanations. In A. H. Fischer (Ed.), *Gender and emotion: Social psychological perspectives* (pp. 143–165). Cambridge University Press.

von Baeyer, C. L., Piira, T., Chambers, C. T., Trapanotto, M., & Zeltzer, L. K. (2005). Guidelines for the cold pressor task as an experimental pain stimulus for use with children. *The Journal of Pain*, *6*(4), 218–227. https://doi.org/10.1016/j.jpain.2005.01.349

Weaver, J., & Zillmann, D. (1994). Effect of humor and tragedy on discomfort tolerance. *Perceptual and Motor Skills*, *78*, 632–634. https://doi.org/10.2466/pms.1994.78.2.632

Weisenberg, M., Raz, T., & Hener, T. (1998). The influence of film-induced mood on pain perception. *Pain*, *76*, 365–375. https://doi.org/10.1016/S0304-3959(98)00069-4

Willoughby, S. G., Hailey, B. J., Mulkana, S., & Rowe, J. (2002). The effect of laboratory-induced depressed mood state on responses to pain. *Behavioral Medicine*, *28*, 23–31. https://doi.org/10.1080/08964280209596395

Zelman, D. C., Howland, E. W., Nichols, S. N., & Cleeland, C. S. (1991). The effects of induced mood on laboratory pain. *Pain*, *46*, 105–111. https://doi.org/10.1016/0304-3959(91)90040-5

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Gračanin, A., Hendriks, M. C. & Vingerhoets, A. J. (2022). Crying does not alleviate acute pain perception: Evidence from an experimental study. *European Journal of Pain*, *00*, 1–15. https://doi.org/10.1002/ejp.1970