PARENTAL ATTENTION TO THEIR CHILD'S PAIN IS MODULATED BY THREAT-VALUE OF PAIN

Category: Original Research article

Number of text pages: 30

Number of tables: 0

Number of Figures: 3

ABSTRACT

OBJECTIVE: The present study investigated parental attention and sensitivity to their child's pain and the moderating role of child's facial pain expressiveness and induced threat. METHODS: Sixty-two parents (49 mothers; 13 fathers) of school children observed their child undergoing painful and non-painful heat trials and were requested to rate the presence of pain after each trial. Painful vs. non-painful trials were signaled by the presence of either a yellow or blue circle; one color served as a cue for possible pain delivery (i.e., conditioned pain cue) while the other served as a cue for a non-painful trial. A subsequent Visual Search Task (VST) assessed attention to pain cues by asking parents to identify a target presented within the conditioned pain cue or one of several other colored circles. Parents were randomly assigned to a 'high threat' or 'low threat' group in which either threatening or neutral information about the child's pain was provided. RESULTS: Signal detection analyses indicated that parents' ability to detect pain (i.e., sensitivity) was enhanced for parents in the high threat group and for parents whose children expressed high pain. Visual search analyses indicated attentional engagement to child pain only among parents in the high threat group whose child showed high pain expressiveness. In all other circumstances, a tendency to avoid pain cues was observed. CONCLUSIONS: The present findings attest to the importance of pain-related threat in understanding parent attention to child pain. Theoretical and clinical implications and future research directions are discussed.

Keywords: Child pain, parents, attention, facial pain expression, threat

Pain demands the pain sufferer's attention and motivates escape and avoidance behaviours (Eccleston & Crombez, 1999; Van Damme, Legrain, Vogt & Crombez, 2010). Pain expression also serves *inter*personal adaptive functions by capturing the attention of others and motivating others to engage in caregiving and helping behaviours (Goubert et al., 2005; Hadjistavropolous et al., 2011; XX et al., 2011). Pain behavior and attentional processes are particularly salient in the context of pediatric pain, where parents carry primary responsibility for their child's well-being. In addition to child pain expression, learned cues of impending pain in the child may also come to capture parents' attention in order to enable prompt and efficient responding. Successful anticipation of child pain may facilitate accurate detection (i.e., sensitivity) and escape from pain when experienced and expressed by the child (Hadijistavropoulos et al., 2011; Van Damme, Crombez & Eccleston, 2004).

Literature on personal pain experience among adult samples has shown that the attentional demand of pain is enhanced by its threat value, particularly by catastrophic thinking about pain and increased pain intensity (Eccleston & Crombez, 1999; Van Damme, Crombez, Van Nieuwenborgh-De Wever, & Goubert, 2008). Recent research suggests that increased threat may similarly influence attention to the pain of *others*, including parental attention to child pain. This evidence is provided by studies using the dot-probe task, where participants are briefly shown a pair of stimuli at two different spatial locations on a screen. One of the stimuli is threatening (e.g., face showing pain expression) while the other is neutral (e.g., neutral expression). When these stimuli disappear from the screen, a dot probe emerges at the location of either the threatening or neutral stimulus ("congruent" vs. "incongruent" trials, respectively). Selective attention to pain faces is inferred when responding is faster to probes on congruent trials than to probes on incongruent trials. Conversely, faster responding to probes on incongruent trials is considered indicative of threat avoidance. Using the dot-probe paradigm, XX et al. (2011) found that parents of school children selectively attended to images of unfamiliar child pain faces. Further, parental attention to child pain faces was enhanced by greater child pain expressiveness and particularly when parental catastrophizing was high. Using the dot-probe task, Kathibi, Dehgani, Sharpe, Asmundson & Pouretemad (2009) similarly found that chronic pain patients with high fear of pain selectively shifted attention toward pain faces.

These dot-probe findings are limited for a number of reasons. First, parental attention to child pain has only been assessed when viewing images of faces of unfamiliar children (XX et al., 2011). Currently, nothing is known about parental attentional responses when actually observing *their own* child's pain. Second, although selective attention may be observed within the dot-probe task, the paradigm has low ecological validity given the constraint of only two attentional targets (i.e., neutral stimulus versus threatening stimulus). In line with real-world situations, attention is best measured in a context where various stimuli compete for attention (Weierich, Treat, & Hollingworth, 2008). Third, the dot-probe provides an overall index of selective attention to pain and does not assess attentional subcomponents. In response to threat (e.g., pain), two separate but interrelated components of attention can be distinguished: 1) attentional engagement to threat and 2) disengagement from threat (Van Damme et al., 2004; Weierich et al., 2008). Attentional engagement refers to the relative ease or speed with which attention is drawn to a particular stimulus. Attentional engagement to threat is inferred when attention is more quickly drawn to threat stimuli compared to neutral stimuli. Complementary to attentional engagement, attentional avoidance of threat is inferred when attention is more quickly drawn to neutral stimuli. Finally, disengagement difficulty occurs when a threat stimulus captures attention and impairs switching attention to another stimulus. Research on personal pain experience has identified a robust phenomenon of disengagement difficulty among high catastrophizing individuals (see e.g. Sharpe, Dear, Schrieber, 2009; Van Damme et al., 2004). In the context of interpersonal pain processes, differentiating between these subcomponents of attention holds both theoretical and clinical importance. Increased parental attention to child pain may reflect disengagement difficulty rather than attentional engagement, thus suggesting a problem of attention regulation in response to emotional stimuli. In the clinical context, such parental difficulties with attentional regulation may facilitate excessive focus on pain and pain-controlling behaviour at the cost of other important (non-pain) goals, possibly even contributing to greater child disability (Caes, Vervoort, Eccleston, Vandenhende, & Goubert, 2011; Walker et al., 2006).

The present study comprised a subsequent phase of the XX et al. study (2011) in which the above issues were taken into account. Specifically, we examined parental attention to their *own* child's pain as well as to cues signaling pain in their child. As part of the study protocol, parents (i.e., the participant sample from the XX et al. study) rated the presence or absence of pain during a child heat pain task. Painful vs. non-painful trials were signaled by abstract stimuli (blue or yellow circles). One color signaled painful trials and thus became conditioned as a pain cue; the other color signaled non-painful trials and was thus conditioned as a safety cue. The conditioned pain cue was subsequently employed in a Visual Search Task (VST). The VST allowed investigation of both engagement to and disengagement from pain cues by asking parents to identify a target presented within the conditioned pain cue (i.e., the blue or yellow circle) or one of several other colored circles (i.e., a range of competing visual stimuli). Since attention to pain is likely enhanced when the threat value of pain is high, parents were randomly assigned to receive either threatening or neutral information about the child pain task. Additionally, child facial pain expressiveness was examined as a possible moderator for parental attention and sensitivity to presence of child pain.

We expected that, particularly in the case of high threat, parents would demonstrate enhanced sensitivity to presence of child pain and increased attention to child pain cues. We expected these associations to be particularly pronounced when child facial pain expressiveness was high. Finally, we explored whether parental attention to child pain cues was characterized by attentional engagement and/or disengagement difficulty.

METHOD

Participants

Participants were recruited from a sample of parents and school children (grades 6 -9) who had consented to be recontacted following participation in a questionnaire study 2 years prior (*n* = 280 parent-child dyads). This initial pool did not comprise younger children since questionnaires used in the study that took place 2 years earlier had not been validated with younger age groups. To ensure a homogeneous sample representative of parents of healthy school children, children and their parents were eligible to participate if the child did not suffer from chronic illness, including recurrent or chronic pain, or a developmental disorder. Moreover, the child and parent had to be able to speak and write XX. A weighted random sampling procedure was used (Herzog, 1996) to ensure equal representation of boys and girls with an equal age distribution. Of the 280 parent-child dyads, only a subset of 133 were randomly selected and contacted, as power analysis had indicated that a sample size of 60 to 70 participants was sufficient to detect a medium effect (d = .50) with power .80 using α = .05, two-tailed. Previous studies using the VST paradigm on average identified effect sizes of .50 (e.g., Notebaert et al., 2011). Of those contacted, 98.5% (*N* = 131 dyads) met inclusion criteria and 58.0% (*N* = 76 dyads) agreed to participate. Main reason for refusal to participate was lack of time due to work/family demands. Ten parent-child dyads later withdrew participation because of child illness or family responsibilities, and one parent did not perform the Visual Search Task (VST) due to late arrival at the lab. One parent-child dyad was further excluded because the child withdrew participation at an early phase of the pain task. Additionally, two participants could not take part due to technical failure of the pain induction apparatus.

The final sample consisted of 62 parents (49 mothers, 13 fathers) and their child (32 boys, 30 girls; Mean age = 13.08 years, SD = 1.31; age range 11-15 years). Parents were randomly assigned to either a high threat group (*N*= 32) or low threat group (*N*= 30). Parents ranged in age from 34 to 55 years (*M* = 44.2 years, *SD* = 4.7). Most parents (69.4%) were married or co-habiting, and the majority (72.6%) had higher education (beyond the age of 18 years). In general, parents indicated themselves to be in good to very good health (*M* = 1.27, *SD* = .93; rated on a 4-point scale with 0 = excellent, 1 = very good, 2 = good, 3 = moderate). All participants were Caucasian. Participants were compensated 35€ for taking part in this study. The study was approved by the Ethics Committee of the Faculty of Psychology and Educational Sciences of XX University, XX. The present sample was examined in a prior study of parental selective attention to unfamiliar child pain faces by means of the dot-probe paradigm. These data have been described previously in detail (XX et al., 2011).

Study overview

Parents first observed their child undergo painful and non-painful trials as part of a child pain task. The child and parent were in separate rooms and parents observed their child on a video monitor. During the child pain task, parents were asked to indicate the presence vs. absence of pain. Each trial was preceded by a yellow or blue circle (presented on a separate PC monitor), where one color signaled that their child *might* receive a painful trial and the other color signaled a non-painful trial. Prior to the child pain task, parents (but not the children) were randomly assigned to a 'high threat' or 'low threat' group in which they were provided with either threatening or neutral information, respectively, about the pain that their child would undergo. Following the pain task, attention to conditioned child pain cues (i.e., yellow or blue circles) was measured by means of Visual Search Task (the VST) during which parents had to identify a target presented within the conditioned pain cue or one of several other colored circles (e.g., green, orange).

Apparatus

The Contact Heat Evoked Potentials Stimulator (CHEPS) of the Medoc Neuro Sensory Analyzer, Model TSA-II (Medoc Ltd. Advanced Medical Systems, Ramat, Yishai, Israel) with a thermode contact area of 572.5 mm^2 was used to induce pain in child participants. The thermode-stimulating surface was placed in contact with the inside of the child's right wrist and secured by a Velcro strap. Thermal stimuli were delivered at tolerance level to skin surface for 1500 ms. Pilot testing indicated that this setting was most likely to be associated with facial pain expressiveness subtle enough to ensure variation in parental sensitivity to child pain. Child pain tolerance level was determined by the method of limits. Specifically, heat was gradually increased by 1°C starting from a baseline temperature of 32°C until the child indicated that tolerance level was reached. Continued elevation of heat stimuli was dependent upon the child's decision to press a button. Tolerance level was defined as 'a heat stimulus that was experienced by the child as the maximum level that he/she could endure with further increases being intolerable'[1]. For safety purposes, the temperature elevation stopped automatically at an upper limit of 50°C. During tolerance testing, children were asked to rate the intensity of experienced pain at their perceived tolerance level using a numeric rating scale (NRS) ranging from 0 ('no pain') to 10 ('a lot of pain'). This specific heat pain task has been used in previous studies in comparable age groups (see e.g., Zohsel, Hohmeister, Flor, & Hermann, 2008).

Threat manipulation

In the low threat group, parents were provided with neutral information regarding the heat stimulus their child would experience: "*During this task, your child will receive several heat stimuli of different intensities. Our experience with the heat stimuli used in this study indicates that children might experience some of the heat stimuli as slightly unpleasant.*

[1] Detailed and verbatim instructions for defining child tolerance level can be provided on request by the corresponding author

Therefore, it is possible that some of the heat stimuli are also slightly unpleasant for your child". In addition, parents were shown photographs of children displaying *low* facial pain expression as an example of how their child may behave while experiencing heat pain.

In the high threat group, parents were provided with threatening information about the pain experience of their child: *"During this task, your child will receive several heat stimuli of different intensities, with some of them being possibly painful. Our experience with the heat stimuli used in this study indicates that children might experience some of the heat stimuli as painful and have difficulty dealing with them. Therefore, it is possible that some of the heat stimuli may also be painful and barely tolerable for your child"*. Parents were shown photographs of children displaying *high* facial pain expression as an example of how their child may behave while experiencing heat pain. Information for the threat manipulation was presented on a PC screen using Office PowerPoint.

Child pain task/Pain cue conditioning paradigm and parental sensitivity to child pain

The child pain task consisted of 48 trials and also functioned as the pain cue conditioning paradigm. Figure 1 provides an overview of the study conditions and child pain task/conditioning paradigm. Each trial was preceded by presentation of either a blue or yellow colored circle; circles were concurrently presented to the parent and child on separate computer screens. Each circle was 16 cm in diameter with a colored band of 1.5 cm. Over the course of the experimental protocol, the blue or yellow circle came to be associated with 'pain' or 'safety' through classical conditioning. Specifically, prior to the start of the experiment, parents and children were informed which color (blue or yellow) was a "safety cue" (signaling a trial during which no heat stimulus would be delivered) or a "pain cue" (signaling a trial during which a heat stimulus *could potentially* be delivered to the child). Whether a yellow or blue circle signaled pain vs. safety was counterbalanced across participants.

Of the 48 trials, 24 were preceded by the pain cue and 24 were preceded by the safety cue. Each trial began with the presentation of a white screen for 3-5s followed by presentation of a pain or safety cue (blue or yellow circle) for 8s. The latter was followed by presentation of a white screen for 7-9s during which heat stimuli at tolerance level were administered on 6 of 24 randomly chosen pain-cued trials. This resulted in 6 "valid pain cues" (followed delivery of the heat stimulus) and 18 "invalid pain" cues (not followed by delivery of the heat stimulus). All safety cues were valid, meaning that no heat stimulus followed any of the safety cues. Each trial ended with presentation of a beige screen for 10s.

To measure parental sensitivity to the presence of child pain, during presentation of the beige screen parents were requested to indicate whether their child *had* or *had not* received a painful stimulus during that trial. Total duration of the child pain task was on average 20 to 25 minutes.

Visual Search Task

To examine parental attention to conditioned pain cues, parents performed a Visual Search Task (VST) following conclusion of the child pain task. During performance of the VST, parents were seated in front of a computer at a distance of approximately 60 cm from the screen. Instructions for the VST were presented on screen. The VST was programmed using the E-Prime software package (Schneider, Eschman, & Zuccolotto, 2002) and consisted of 10 practice trials and two blocks of 100 test trials.

On each VST trial, the computer display consisted of 5 variously colored circles (red, turquoise, grey, green, orange, purple, or the conditioned pain cue color blue or yellow). None of the trials included the color associated with the safety cue. All 5 colored circles in the display contained a black line segment, extending 1°, at their centre. One of these line segments was the *target stimulus*, which was either a perfectly horizontal or a vertical line. The remaining four line segments were tilted 22.5° to either side of the horizontal or vertical plane (adopted from Theeuwes, 1991). The VST comprised three types of trials (see Figure 2). During *congruent* trials, the target was presented within the conditioned pain cue (i.e., blue or yellow circle). During *incongruent* trials, the target was depicted within a color circle that did not correspond to the conditioned pain cue. Thus, the conditioned pain cue was displayed during the incongruent trials but did not contain the target. During *neutral* trials, the conditioned pain cue was not displayed and the target was presented within another color circle. To make sure that participants could not strategically use the conditioned pain cue to localize the target, we used the 1/n procedure (where n is number of circles presented; Jonides & Yantis, 1988). Thus, 1 out of 5 trials in which the conditioned pain cue was presented was a congruent trial. Accordingly, each testing block comprised 10 congruent trials, 40 incongruent and 50 neutral trials. Circles were of 2.9° diameter with a 0.5° colored band against a silver background. Colored circles were matched for intensity and luminance and were spaced equidistant from the center of the screen.

Each VST trial started with a fixation cross at the center of the screen for a duration of 1000 ms, after which the stimulus display was presented. Parents were asked to indicate as quickly as possible whether the target stimulus was presented in *a horizontal or vertical manner* by pressing either the '→' or '↓' button on a keyboard. Error feedback was displayed for 500 ms and there was an intertrial interval of 500 ms. Three categories of reaction times were obtained: (1) reaction time for congruent trials, (2) reaction time for incongruent trials and (3) reaction time for neutral trials. These reaction times were subsequently used to calculate attentional indices of attentional engagement, avoidance, and disengagement difficulty (see Date Reduction section). Prior to the VST, parents were informed that the child pain procedure would continue after completion of the VST. Even though this was not actually done, these instructions were provided so that the conditioned pain cue would maintain its affective value during VST performance.

Child facial pain expressiveness

Children's facial expression during the pain task was recorded and coded for three categories of trials: 6 randomly chosen painful trials preceded by a valid pain cue, 6 non-painful trials preceded by an invalid pain cue, and 6 non-painful trials preceded by a safety cue. Facial pain expression (FE) was measured using the Child Facial Coding System [CFCS; Chambers, McGrath, Gilbert & Craig, 1996) by two trained coders. The CFCS is an observational rating system of 13 discrete facial actions (brow lowering, squint, eye squeeze, nose wrinkle, nasolabial furrow, cheek raiser, upper lip raise, lip corner pull, vertical mouth stretch, horizontal mouth stretch, blink, flared nostril and open lips). The CFCS has shown good reliability and validity in coding children's facial pain expressions (see e.g., Breau et al., 2001). From videotape, a single trained coder rated pain behaviour for all participants. A second trained coder rated pain behaviour on a random sample (20%) of the participants to determine inter-rater reliability. Ten facial actions were coded for intensity (no action (0), slight action (1), distinct/maximal action (2), and three facial actions (blink, flared nostril, open lips) were coded as absent or present (0 or 1). Reliability was calculated according to the formula given by Ekman and Friesen (1978), which assesses the proportion of agreement on actions recorded by two coders relative to the total number of actions coded as occurring by each coder. Acceptable interrater reliability was achieved for overall frequency (.80; range .70-.93) and intensity (.77; range .67-.93) of child facial expressions (Breau et al., 2001).

Each trial was coded per second for a 20-second time interval that ended immediately before parents were requested to rate the absence/presence of child pain (i.e., upon presentation of the beige screen). To facilitate facial coding, a user-friendly software program 'PsyPlayer' was developed by an IT specialist that enabled raters to view and re-view each second of the 20-second time interval at a normal rate and at a rate of 1/10 of a second[2]. A

[2] This software program is available on request by the corresponding author

mean score per second was calculated for each facial action. The mean scores of the 13 facial actions of were summed to yield a total CFCS score for each category of trial, ranging between 0 and 138.

Measures

Parental catastrophizing. Before and after observing their child undergo the pain task, parents were asked to report their level of catastrophizing thoughts about their child's heat pain. For this purpose, a state-specific measure of the Pain Catastrophizing Scale for Parents (PCS-P; Goubert, Eccleston, Vervoort, Jordan, & Crombez, 2006) was developed. The PCS-P consists of 13 items and three subscales; i.e. rumination, magnification, and helplessness. The PCS-P has been shown to be reliable and valid (Goubert et al., 2006). The PCS-P-state consisted of one item for each subscale (PCS-P-state; *Rumination*: "At this moment, to what extent do you keep thinking/did you keep thinking about how painful the heat stimuli are/were for your child?"; *Magnification*: "At this moment, to what extent do you keep thinking/did you think something serious might happen to your child during administration of the heat stimuli?"; *Helplessness*: "At this moment, to what extent do you think/did you think you would not be able to endure the administration of the heat stimuli?"). Items on the PCS-P-state were rated on an 11-point numerical rating scale (0: not at all; 10: very much). The total PCS-P-state score could range from 0 to 30 and was used as an index of parents' catastrophizing about their child's anticipated and experienced pain.

Parental Fear. Following each of the 48 trials parents were requested to provide written ratings on how much fear they had experienced in response to presentation of the pain and safety cues. Fear was rated on an 11-point numeric rating scale ranging from 0 (not at all) to 10 (a lot). Parental responses were averaged into a fear score in response to pain cues and a fear score in response to safety cues.

Procedure

Upon arrival at the lab, one of two experimenters (both female) accompanied the parent and child to the test-room. Participants were explained that we were interested in “how parents and children think and feel about the pain that children experience”. The pain procedure was described and the thermal heat stimulator was shown. After obtaining written parental and child consent, experimenter 1 stayed with the child in the test-room while experimenter 2 accompanied the parent to an adjacent room. The child’s heat tolerance level was then assessed in the test-room. Parents did not observe assessment of the child’s tolerance level, neither were they informed that heat stimuli would be delivered at tolerance level. While child tolerance level was being assessed, parents were provided with the threat manipulation using the procedure described above and parental catastrophizing thoughts about anticipated child pain were assessed[3]. Following child pain tolerance assessment and threat manipulation, parents observed their child during the pain task, which also functioned as pain/safety cue conditioning paradigm. The child could not see the parent throughout the duration of the pain task. After observing the child pain task, parents performed the Visual Search Task (VST). The VST was followed by a second assessment of parental catastrophizing thoughts about their child’s pain experience. After completion of the entire study procedure, parents and children reunited in the test-room and were fully debriefed about the purpose of the study.

Data reduction and statistical plan

Signal detection analysis was performed to investigate parents’ *sensitivity* to the presence of child pain during the child pain task (i.e., ability to correctly detect pain in their child; Wickens, 2002). Hit rates (correctly identifying the presence of a pain stimulus when one was actually delivered) and false alarm rates (identifying a non- painful trial as one where a pain stimulus was delivered) were calculated across the 24 of the 48 trials that were

[3] During child tolerance assessment, but prior to the remainder of the present study procedure, parents also performed a dot-probe task measuring parental attention to unfamiliar child pain faces (XX et al., 2011).

preceded by a pain cue. Sensitivity for their child's pain was assessed by calculating A' (Wickens, 2002).

To assess for the impact of child pain expression, we calculated a "Child Pain Expressiveness" index by subtracting the average child facial pain display during non-painful trials from child facial pain display during painful trials. Higher scores on the Child Pain Expressiveness index indicate a child's greater ability to discriminatively signal the presence versus absence of pain experience. As such, higher scores are likely to increase the salience of a cue signaling potential impending pain.

Two attentional bias indices were calculated for VST analyses (see Notebaert, Crombez, Van Damme, De Houwer, & Theeuwes,, 2010; Notebaert et al., 2011). A *facilitation index* was calculated by subtracting the average reaction time on congruent trials from the average reaction time on neutral trials. Positive values on the facilitation index suggest increased attentional engagement to pain cues whereas negative values suggest attentional avoidance of pain cues. A *disengagement index* was calculated by subtracting the average reaction time on neutral trials from the average reaction time on incongruent trials. Positive values on the disengagement index suggest increased difficulty disengaging from pain cues. VST trials with incorrect responses (2%) and outliers (1.5%) were removed. Outliers were defined as reaction times that deviated more than two and a half standard deviations from the individual mean of correct responses. Four participants met these criteria and their data were discarded from further analyses, resulting in a final sample of 58 parents (N = 29 in each group).

To investigate parental attentional engagement, avoidance and disengagement (VST) and sensitivity to child pain, Univariate Analyses of Covariance (ANCOVA) were performed with induced threat (low threat versus high threat) as a between Group factor and Child Pain Expressiveness entered as a covariate. In case interactions including Child Pain

Expressiveness were significant, additional ANOVAs were performed for low (- 1SD below the mean), and high (+1SD above the mean) values of the centered moderator variable (i.e., Child Pain Expressiveness). Moderation analyses followed the procedure outlined by Holmbeck, 2002. We calculated effect sizes for independent samples following Thalheimer and Cook (2002).

RESULTS

Descriptive statistics & Manipulation check

Children reported a mean pain intensity of 6.97 (*SD* = 2.04) during assessment of tolerance level. Tolerance was on average 48.26°C (*SD* = 2.40). Children's mean facial displayof pain during painful trials ($M_{\text{valid pain cue}}$ = 7.48 *SD* = 4.80) was significantly higher compared to non-painful trials ($M_{\text{invalid pain cue}}$= 5.08 *SD* = 3.32; $M_{\text{safety cue}}$ = 5.51 *SD* =2.97; both $t(57) \geq 4.06$, $p < .0001$; $d = .54$), indicating that actual pain induction was reliably signaled as such. T-tests for independent samples revealed no significant differences on any of the measures for boys vs. girls, and mother vs. fathers, respectively (all $t(56) \leq |.90|$, ns). However, heat tolerance which was significantly higher for boys ($t(56) = 2.33$, $p <.05$). Including parent or child sex into analyses reported below did not impact findings; sex was therefore not entered into final analyses.

To assess the effectiveness of our threat manipulation, independent sample t-tests were performed for parental catastrophic thoughts about their child's heat pain. Findings indicated that our manipulation was successful; both before and after the child pain task, parental catastrophizing thoughts were significantly higher in the high threat group ($M_{\text{pre-task}}$ = 2.39, *SD* = 1.76, $M_{\text{post-task}}$ = 4.52, *SD* = 4.54) in comparison to the low threat group ($M_{\text{pre-task}}$ = 1.67, *SD* = .94; $M_{\text{post-task}}$ = 2.66 *SD* = 2.32; both $t(56) \leq -1.97$, $p<.05$; both $d = .51$).

Analyses of parental fear responses further attested to the success of our threat manipulation and the cue conditioning paradigm. Repeated measures ANOVA with Cue (pain versus safety cue) x Group (low versus high threat group) indicated parental fear reported during pain cues (*M* = 1.73, *SD* =1.82) was significantly higher than during safety cues (*M* = 1.13; *SD* = 1.62; $F(1,56) = 25.97$, $p < .001$; $d = .35$). Moreover, the interaction between Cue and Group showed a trend toward significance ($F(1,56) = 2.85$, $p = .09$), indicating that while parents in both low and high threat groups reported greater fear during pain cues (both $t(28) \geq 3.39$, $p < .005$), fear in anticipation of pain tended to be more pronounced for parents in the high threat group (*M* = 2.19, *SD* = 2.27) as compared to parents in the low threat group (*M* = 1.28, *SD* = 1.09; $t(56) = -1.94$, $p = .06$; $d = .51$).

Parental sensitivity to child pain (Signal detection analysis)

ANCOVA on parental sensitivity to presence of child pain showed a main effect of Group ($F(1,54) = 8.04$, $p < .01$; $d = .62$) indicating that compared to parents in the low threat group (*M* = .63, *SD* = .20), parents in the high threat group (*M* = .74, *SD* = .15) were better able to discriminate painful from non-painful trials, thus showing higher sensitivity to their child's pain. There was also a significant main effect of Child Pain Expressiveness ($F(1,54) = 19.12$, $p < .0001$; $d = .73$) indicating enhanced parental sensitivity to child pain in case of high Child Pain Expressiveness. There was no significant interaction between group and child facial pain expressiveness ($F < 1$).

Parental attention to child pain cues (Visual search analysis)

Attentional facilitation to pain cues

ANCOVA performed on the *facilitation* index of parental attention. There was no significant effect of Child Pain Expressiveness ($F(3,54)=1.76$, ns). However, there was a significant effect of Group ($F(3,54) = 4.44$, $p < .05$; $d = .56$), indicating significant avoidance of pain cues in the low threat group ($M_{facilitation}$= -47.99, *SD*=101.53; $t(28) = -2.55$, $p < .05$). This pattern was not observed in the high threat group ($M_{facilitation}$= 3.81, *SD* = 93.47; $t(28) = .22$, ns). However, the interaction between Group and Child Pain Expressiveness also reached significance ($F(3,54) = 3.92$, $p = .05$; $d = .53$) indicating that the impact of threat was dependent upon the child's facial display of pain. To interpret the significant two-way interaction, two ANOVAs were performed with group as between subject factor and high (+1SD above the mean) or low values (-1SD below the mean) of Child Pain Expressiveness as the covariate. Findings showed that the effect of threat was significant for high Child Pain Expressiveness ($F(3,54) = 8.90$, $p < .005$). As shown in Figure 3, in case of high Child Pain Expressiveness, parents in the low threat group showed significant attentional *avoidance* of pain cues whereas parents in the high threat group showed significant *engagement* to pain cues. In case of low Child Pain Expressiveness, there was no significant impact of threat on the facilitation index ($F < 1$). Additional analyses indicated that facilitated attentional engagement to child pain cues occurred only among parents in the high threat group whose child showed high facial display of pain. In case of low Child Pain Expressiveness, both parents in the high and the low threat group showed significant avoidance of pain cues ($F(1,27) = 5.25$, $p < .05$).

Disengagement from pain cues

ANCOVA performed on the *disengagement* index of attention revealed no significant main or interaction effects (all $F < 1$).

DISCUSSION

The present study examined parental sensitivity to presence of pain in their child and attention to cues signaling pain in their child, as well as the moderating role of the child's pain expressiveness and induced threat. Parents assigned to a low or high threat condition observed their child participate in a pain task comprised of painful and non-painful trials. Trials were signaled by safety cues and either valid or invalid pain cues. During the pain task, parents indicated the presence or absence of actual pain stimulation to their child, allowing us to examine parental sensitivity to child pain. Subsequently, parents participated in a Visual

Search Task, which allowed us to examine various dimensions of parental attention (i.e., engagement/avoidance and disengagement) to the pain and safety cues conditioned as part of the child pain task. The results can be summarized as follows: in terms of parental sensitivity to presence of child pain, signal detection analyses indicated that parental ability to accurately discriminate painful from non-pain trials was significantly enhanced for parents in the high threat group and for parents whose children expressed high levels of pain during pain stimulation. Similarly, our VST findings indicated that attentional engagement to child pain cues occurred only among parents in the high threat group whose child showed high facial display of pain. In all other circumstances (i.e., low threat irrespective of child facial pain display and high threat but low child pain display), a remarkable tendency to *avoid cues signaling pain* was observed.

To the best of our knowledge, the current study is the first to employ this innovative methodology to examine, within a live context, parental attention to pain in their own child. Our results attest to the importance of pain-related threat in understanding parental attention to child pain, corroborating prior research on attention to pain within the personal and interpersonal pain context. Increased threat is known to increase attention to personal pain (see e.g. Keogh, Ellery, Hunt, & Hannent, 2001; Van Damme et al., 2004). Analogously, detection of another adult's pain is facilitated by negative affective processing (Yamada & Decety, 2009). Further, our findings support and extend dot-probe examining attentional response to the pain of unfamiliar children (XX et al., 2011). In line with this prior literature, our VST findings suggest that activation of threat representations (facilitated by such top down processes as parental pain catastrophizing) and enhanced stimulus threat value (i.e., child facial display of pain) must exceed a threshold in order to *facilitate engagement* of parental attention to cues signaling pain in their child. Below such threshold, we observed attentional *avoidance* of such pain cues.

Mechanisms underlying why (and when) parents switch from an avoidant to a vigilant attentional mode are as yet unknown. One potential explanation pertains to the critical role of attention in the regulation of emotions (Koole, 2009). In line with previous findings, our results indicate that anticipating or viewing another's pain elicits an aversive state of fear in observers which, in turn, likely predisposes avoidance responses (Avenanti, Minio-Paluello, Sforza, & Aglioti, 2009). It is possible that the attentional avoidance observed during the VST represents an attempt by parents to regulate negative emotional reactions (Koole, 2009; Mogg & Bradley, 1998). However, borrowing from anxiety literature (Mogg, Bradley, Miles, & Dixon, 2004), our results also suggest that attentional avoidance of child pain as a means of emotion regulation may only be successful under relatively mild threat conditions; this strategy is compromised with increasing levels of threat. Specifically, whereas parents in the low threat group demonstrated avoidance of pain cues regardless of child pain expressiveness, parents in the high threat group were only able to do so in the case of low child pain expressiveness.

Importantly, analysis of parental sensitivity to child pain during the pain task did *not* suggest avoidance tendencies among parents in the high threat group. Regardless of the child's pain expressiveness, parents in the high threat group were significantly more sensitive to presence of child pain than were parents in the low threat group. This finding may reflect the differential salience of stimuli observed by parents during the child pain task (i.e., child pain behavior) in comparison to the subsequent VST procedure (i.e., pain cue without accompanying child pain behavior). Thus, it is possible that the avoidant tendencies displayed by parents in the high threat group in response to VST pain cues fail in the face of their children's actual pain experience. Stimulus salience may also explain why attentional engagement to child pain cues was not accompanied by a corresponding disengagement difficulty from pain cues. It is plausible that pain cues were not a sufficiently salient stimulus and that disengagement difficulty would become apparent if the stimulus comprised actual child behavior.

In terms of the clinical implications of the current findings, it is important to note that both attentional engagement and avoidance may serve adaptive functions, as both likely enable efficient parental response to their child's pain. Specifically, attentional engagement may allow prompt behavioral response to control (or eliminate) child pain, while attentional avoidance may underlie emotion regulation strategies intended to manage parental distress. Such emotional regulation is likewise necessary for adaptive responding to occur (Goubert, Vervoort, & Crombez, 2009; Yamada & Decety, 2009). In this way, these ostensibly competing attentional processes are highly interdependent.

Our results likewise suggest that the adaptive value of attentional engagement vs. avoidance may be dependent upon context (e.g., child pain expressiveness, high threat). For example, attentional engagement may be particularly adaptive in the context of acute pain or emergency situations, where the goal is immediate escape from pain/injury. However, when pain becomes chronic -- implying limited possibilities for control or escape -- the costs of continued high vigilance and related efforts to escape/control pain may begin to outweigh benefits. Moreover, enhanced efforts to control pain may occur at the expense of important *non-pain related goals*, such as the child's engagement in valued daily activities and other parent-child interactions. Paradoxically, persistently amplified attention to child pain may facilitate increased control efforts associated with greater child disability and pain behavior (Goubert et al., 2006; Walker et al., 2006). Such persistent attention will likewise serve to maintain and amplify parental distress (Goubert et al., 2005; Crombez, Eccleston, De Vlieger, Van Damme, & De Clercq, 2008). Within reasonable bounds, attentional avoidance of child pain and pain cues may actually facilitate parental mood regulation and attainment of valued non-pain related goals for both parent and child (Koole, 2009). Ironically, evidence suggests prioritization of pain-related goals (versus non-pain related goals) is particularly pronounced in situations where pain is perceived as highly threatening (Caes et al., 2011) and when one has little control over the pain stimulus such as in the context of chronic pain (Eccleston & Crombez, 1999).

In concert with previous studies on intrapersonal pain experience (Eccleston & Crombez, 1999; Van Damme et al., 2010), our findings suggest that attention may comprise an important underlying mechanisms in the association between adaptive vs. deleterious parental responses and child outcomes in the context of child pain (Walker et al., 2006). Accordingly, research is needed to further examine how different dimensions of parental attention (e.g., engagement vs. avoidance) subserve attainment of various goals (e.g., emotional regulation, pain control) and how these goals translate into parental behaviors. Increased understanding of these mechanisms should contribute to clinical interventions aimed to optimize adjustment for both parents and children, with the goal of flexible parent attunement to child pain and non-pain needs.

The results of the present study are preliminary and await replication. Several study limitations deserve consideration. First, we used experimental pain in a controlled environment; thus extrapolation to naturally occurring or clinical and chronic pain should be done cautiously. Future studies are needed that assess attentional processing among parents who have children suffering chronic or clinical pain. While our experimental manipulation of threat was successful, it did not provoke high levels of catastrophizing or distress, which may be amplified in the clinical setting. Second, the present study included a sample of young adolescents. It is possible that parents of younger children (who are much more dependent upon parental care) may show a different pattern of responses when faced with their child's pain. In addition, heat stimuli were associated with rather low levels of child facial pain display. Although subtle expression of pain was necessary to ensure sufficient variation in parental sensitivity to child pain, further research using different protocols is necessary to assess whether current findings regarding parental attention to/ avoidance of child pain generalize to more intense parent catastrophizing and distress and more intense child facial display of pain. Finally, measurement of attention by means of the VST is limited in that attention can only be inferred indirectly from manual response latencies. More ecologically valid methodologies, such as eye tracking technology, might represent a significant advance in the study of attentional processing of another's pain, as these may provide a direct window onto behavioural mechanisms as they unfold in real time (Weierich et al., 2008).

Acknowledgments The authors would like to thank XX and XX for their help with the data collection and XX for thoughtful suggestions regarding the design of the study. There are no conflicts of interest that may arise as a result of the research presented in this article. This study was supported by a Pain Research EFIC Grünenthal Grant Prize and a IASP Early Career Research Grant, both awarded to XX.

FIGURE CAPTION

Figure 1: Overview of study conditions and child pain task/pain cue conditioning paradigm

Figure 2: Examples of the different VST stimulus displays (not to scale). The grey circle represents the conditioned pain cue . (A) Congruent trial with vertical target. (B) Incongruent trial with horizontal target. (C) Neutral trial with vertical target.

Figure 3: Mean facilitation indices for the low threat group and high threat group as a function of low (-1SD below the mean) and high (+1SD above the mean) child facial expressiveness of pain (* $p < .05$; ** $p < .005$)

REFERENCES

Avenanti, A., Minio-Paluello, I., Sforza, A., & Aglioti, S. M. (2009). Freezing or escaping? Opposite modulations of empathic reactivity to the pain of others. *Cortex, 45*, 1072-1077.

Breau, L.M., McGrath, P.J., Craig, K.D., Santor, D., Cassidy, K.L., & Reid, G.J. (2001). Facial expression of children receiving immunizations: A principal components analysis of the Child Facial Coding System. *The Clinical Journal of Pain, 17*, 178-186.

Caes, L., Vervoort ,T., Eccleston, C., Vandenhende, M., & Goubert, L. (2011). Parental catastrophizing about child's pain and its relationship with activity restriction: the mediating role of parental distress. *Pain, 152,* 212-222.

Chambers, C.T., McGrath, P.J., Gilbert, C.A., & Craig, K.D. *Child Facial Coding System – Revised manual- 1996.* IWK-Grace Health Centre, Dalhousie University & University of British Columbia. Halifax, Nova Scotia.

Crombez, G., Eccleston, C., De Vlieger, P., Van Damme, S., & De Clercq, A. (2008). Is it better to have controlled and lost than never have controlled at all? An experimental investigation of control over pain. *Pain, 137,* 631-639.

Eccleston, C., & Crombez, G. (1999). Pain demands attention: A cognitive-affective model of the interruptive function of pain. *Psychological Bulletin, 125,* 356-366.

Eccleston, C., & Crombez, G. (2007). Worry and chronic pain: A misdirected problem solving model. *Pain, 132,* 233-236.

Ekman, P., & Friesen, W. (1978). *Investigator's guide to the Facial Action Coding System.* Palo Alto, CA: Consulting Psychologists Press.

Goubert, L., Craig, K.D., Vervoort, T., Morley, S., Sullivan, M.J.L., Williams A C de C, Cano A, Crombez G. (2005). Facing others in pain: the effects of empathy. *Pain, 118,* 285-288.

Goubert, L., Eccleston, C., Vervoort, T., Jordan, A., & Crombez, G. (2006). Parental catastrophizing about their child's pain: the parent version of the pain catastrophizing scale (PCS-P): a preliminary validation. *Pain, 123,* 254-263.

Goubert, L., Vervoort, T., & Crombez, G. (2009). Pain demands attention from others: The approach/avoidance paradox. *Pain, 143,* 5-6.

Hadjistavropolous, T., Craig, K.D., Duck, S., Cano, A., Goubert, L., Jackson, P.L., Mogil, J.S., Rainville, P., Sullivan, M.J.L., Williams, A.C. de C., Vervoort, T., & Fitzgerald, T.D. (2011). A biopsychosocial formulation of pain communication. *Psychological Bulletin, 137,* 910-993.

Herzog, T. (1996). *Research methods in the social sciences*. Harper Collins College Publishers.

Holmbeck, G.N. (2002). Post-hoc probing of significant moderational and mediational effects in studies of pediatric populations. *Journal of Pediatric Psychology, 27,* 87-96.

Jonides, J., & Yantis, S. (1988). Uniqueness of abrupt visual onset in capturing attention. *Perception & Psychophysics, 43*, 346-354.

Khatibi, A. Dehgani, M., Sharpe, L., Asmundson, G.J.G. & Pouretemad, H. (2009). Selective attention towards painful faces among chronic pain patients: Evidence from a modified version of the dot-probe. *Pain, 142,* 42-47.

Keogh, E., Ellery, D., Hunt, C., & Hannent, I. (2001). Selective attentional bias for pain-related stimuli amongst pain fearful individuals. *Pain, 91,* 91-100.

Koole, S.L. (2009). The psychology of emotion regulation: an integrative review. *Cognition and Emotion, 23,* 4-41.

Mogg, K., & Bradley, B.P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy, 36,* 809-848.

Mogg, K., Bradley, B.P., Miles, F., & Dixon, R. (2004). Time course of attentional bias for threat scenes: Testing the vigilance-avoidance hypothesis. *Cognition and Emotion, 18,* 689-700.

Notebaert, L., Crombez, G., Van Damme, S., De Houwer, J., & Theeuwes, J. (2010). Looking out for danger: an attentional bias towards spatially predictable threatening stimuli. *Behaviour Research and Therapy, 48,* 1150-1154.

Notebaert, L., Crombez, G., Vogt, J., De Houwer, J., Van Damme, S., & Theeuwes, J. (2011). Attempts to control pain prioritize attention towards signals of pain: An experimental study. *Pain, 152,* 1068-1073.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime User's Guide.* Pittsburgh: Psychology Software Tools Inc.

Sharpe, L., Dear, B.F., & Schrieber, L. (2009). Attentional biases in chronic pain associated with Rheumatoid Arthritis: Hypervigilance or difficulty disengaging? *Journal of Pain, 10,* 329-335.

Thalheimer, W., & Cook, S. (2002). How to calculate effect sizes from published research: A simplified methodology. Retrieved from http://www.work-learning.com.

Theeuwes, J. (1991). Cross-dimensional perceptual selectivity. *Perception & Psychophysics, 50,* 184-193.

Van Damme, S., Crombez, G., & Eccleston, C. (2004). Disengagement from pain: the role of catastrophic thinking about pain. *Pain, 107,* 70-76.

Van Damme, S., Crombez, G., & Eccleston, C. (2008). Coping with pain: a motivational perspective. *Pain, 139,* 1-4.

Van Damme, S., Crombez, G., Van Nieuwenborgh-De Wever, K., & Goubert, L. (2008). Is distraction less effective when pain is threatening? An experimental investigation with the cold pressor task. *European Journal of Pain,* 12, 60-67.

Van Damme, S., Legrain, V., Vogt, J., & Crombez, G. (2010). Keeping pain in mind: A motivational account of attention to pain. *Neuroscience and Biobehavioral Reviews, 34,* 204-213.

XX et al. (2011). Parental catastrophizing about children's pain and selective attention to varying levels of facial expression of pain in children: A dot-probe study. *Pain, 152,* 1751-1757.

Walker, L.S., Williams, S.E., Smit, C.A., Garber, J., Van Slyke, D.A., & Lipani, T.A. (2006). Parent attention versus distraction: Impact on symptom complaints by children with and without chronic functional abdominal pain. Pain 2006;122:43-52.

Weierich, M. R., Treat, T.A., & Hollingworth, A. (2008). Theories and measurement of visual attentional processing in anxiety. *Cognition & Emotion, 22,* 985-1018.

Wickens, T.D. (2002). *Elementary Signal Detection Theory.* Oxford University Press.

Yamada, M., & Decety, J. (2009). Unconscious affective processing and empathy: An investigation of subliminal priming on the detection of painful facial expressions. *Pain*, *143*, 71-75.

Zohsel, K., Hohmeister, J., Flor, H., & Hermann, C. (2008). Somatic pain sensitivity in children with recurrent abdominal pain. *American Journal of Gastroenterology*, *103,* 1517-1523.

Figure 1

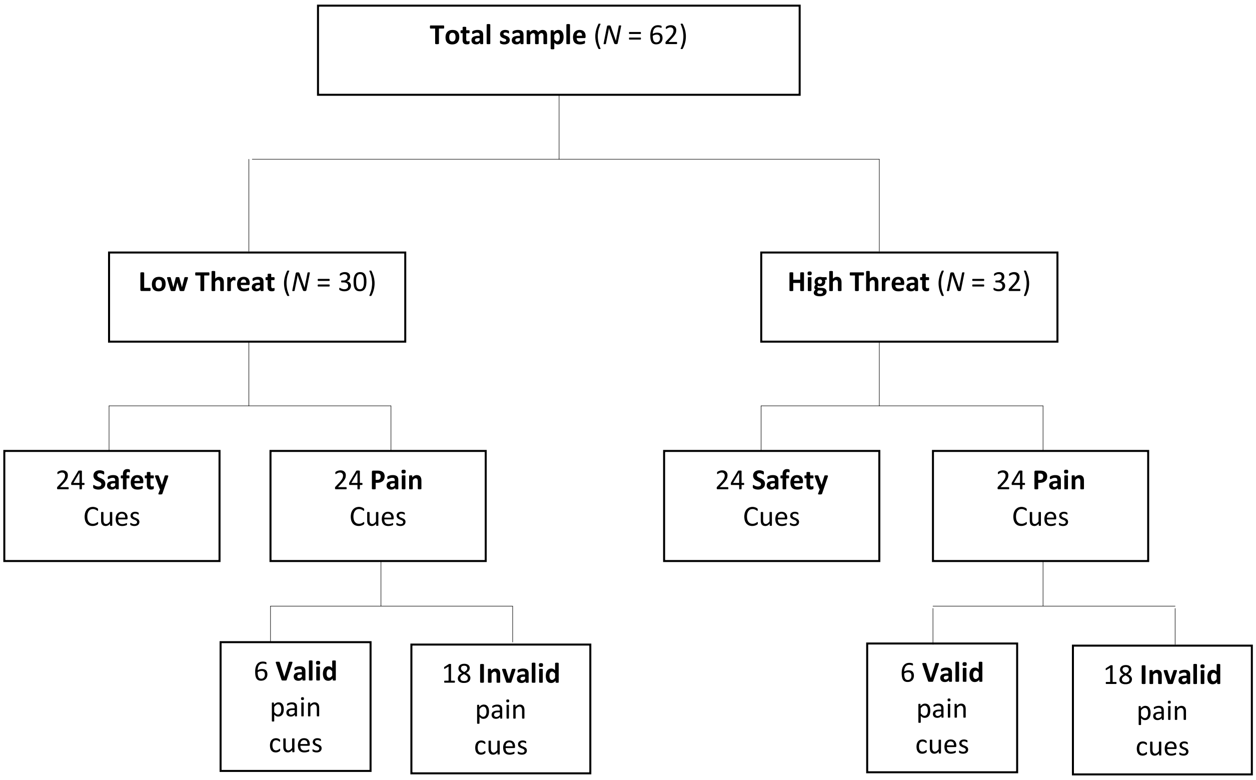
Total sample (N = 62)
Low Threat (N = 30)
High Threat (N = 32)
24 Safety Cues
24 Pain Cues
24 Safety Cues
24 Pain Cues
6 Valid pain cues
18 Invalid pain cues
6 Valid pain cues
18 Invalid pain cues

Figure 2

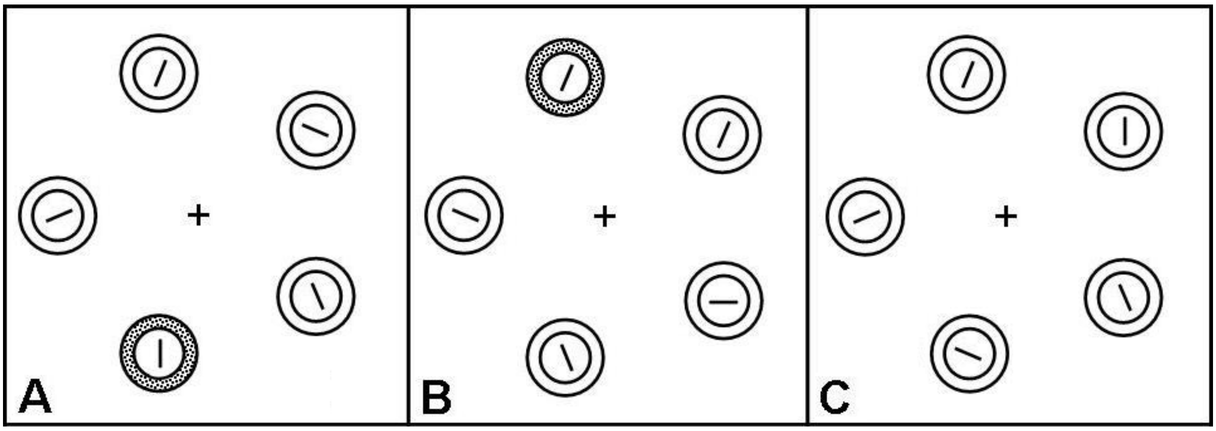

Figure 3