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Impact of threat level, task instruction, and individual characteristics on cold pressor pain and fear among children and their parents

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Abstract

Abstract: The cold pressor task (CPT) is increasingly used to induce experimental pain in children, but the specific methodology of the CPT is quite variable across pediatric studies. This study examined how subtle variations in CPT methodology (e.g., provision of low- or high-threat information regarding the task; provision or omission of maximum immersion time) may influence children's and parents' perceptions of the pain experience. Forty-eight children (8-14 years) and their parents were randomly assigned to receive information about the CPT that varied on two dimensions, prior to completing the task: (1) Threat level: High-threat (task described as very painful, high pain expressions depicted) or low-threat (standard CPT instructions provided, low pain expressions depicted); (2) Ceiling: Informed (provided maximum immersion time) or uninformed (information about maximum immersion time omitted). Parents and children in the high-threat condition expected greater child pain, and these children reported higher perceived threat of pain and state pain catastrophizing. For children in the low-threat condition, an informed ceiling was associated with less state pain catastrophizing during the CPT. Pain intensity, tolerance, and fear during the CPT did not differ by experimental group, but were predicted by child characteristics. Findings suggest that provision of threatening information may impact anticipatory outcomes, but experienced pain was better explained by individual child variables.

Keywords: cold pressor task; pediatric pain; experimental methods; fear; children; parents; threat

Introduction

The cold pressor task (CPT) is a safe and ethically acceptable experimental method of inducing mild to moderate pain that has been increasingly used in pain research [1,2]. Use of the CPT has allowed researchers to address research questions not feasible for examination in a clinical setting, thereby leading to many advances in our understanding of pain in childhood [3]. However, it is unclear how the documented methodological variability between studies [2] may influence children's pain outcomes and participant satisfaction with research, limiting the extent to which the CPT can appropriately be used to develop and evaluate pain management interventions [4].

One example of such methodological variability is the manner in which the task is verbally described to children, which may influence children's anticipatory anxiety regarding the task. Previous research has employed a social stress task, in which the children were given socially threatening information, to safely increase children's anticipatory anxiety prior to completion of the CPT [8]. While this procedure was effective at increasing state anxiety and did not negatively influence parents' and children's overall experiences taking part in the research [9], immediate pain outcomes were not impacted [8]. Other researchers have modified parental expectations about other experimental pain tasks (e.g., heat) by providing parents of children participating in the task with threat-related information that increased parents' state catastrophic thinking and feelings [10]. Among adults, providing threatening information (e.g., consequences of frostbite) prior to the CPT has resulted in higher pain catastrophizing and lower pain tolerance [11], although pain ratings were not impacted. Although these manipulations might increase the generalizability of the results, from an ethical standpoint, the impact that such threat manipulations have on parents' and children's perceptions of research participation is unknown,

and the effect of such manipulations have not been explored using a threat manipulation specific to cold-induced pain in children. It could be that increasing the threat of the CPT might also increase the perceived similarity of the experimental pain setting to anxiety-inducing clinical pain contexts (e.g., receiving a needle).

An additional area of methodological variability in pediatric CPT studies is that researchers have varied in their use of informed versus uninformed ceilings (i.e., whether or not children are informed about the maximum allowable immersion time of their hand in cold water) [2]. Published guidelines recommend using uninformed ceilings when pain tolerance is of interest and informed ceilings when pain intensity is of interest [12]. However, informed ceilings may pose several problems, such as increasing demand characteristics (i.e., children feel pressured to leave their hand immersed until the ceiling time), focusing children's attention on the passage of time rather than on pain sensations, and potentially increasing perceived control [2]. Importantly, all of these factors could influence the child's pain experience and generalizability of this research. Nevertheless, research to date has not empirically examined the impact of using an informed versus and uninformed ceiling on children's pain experience.

This is the first study to examine the impact of providing parents and children with threat-related information and ceiling time on their perceptions of the pain experience and participation in CPT research. We hypothesized that providing parents and children with threat-related information about the CPT and not informing them about ceiling time would lead to greater anticipatory and experienced threat, anxiety, and pain amongst parents and children, and that this would result in children perceiving the CPT to be comparable to real-world pain experiences while still maintaining participant satisfaction with taking part in research. Similar to previous

research, we expected that individual differences in dispositional anxiety-related variables (trait catastrophizing) would predict CPT responses.

Methods

Participants

Children and parents were recruited from the community, and eligibility was confirmed by telephone. Children were eligible to participate if they were (1) between the ages of 8 and 14 years; (2) they were generally pain-free and healthy; (3) they could speak, write, and read English and had no uncorrected hearing or vision impairments; (4) they had not participated in a CPT study before; and (5) they did not have any conditions that would contraindicate participation in the CPT (i.e., circulation problems, blood or cardiac disorders, current injury or previous frostbite to non-dominant arm or hand).

Participants were 48 healthy children (25 girls, 23 boys) aged 8 to 14 years (M_{age} = 11.01 years, SD = 2.07), who completed the study with a parent (38 mothers, 9 fathers, 1 stepfather). Parent-report of child ethnicity identified the majority of children as "White" (81.3%, n = 39). The majority of parents were married (66.7%, n = 32) and highly educated, with 34 parents (70.9%) having completed university/graduate school/professional training. A power calculation using G*Power [13] indicated that a sample size of 48 children would be sufficient with a power of 0.80 using $\alpha = 0.05$ to detect large effect sizes, which were anticipated based on existing relevant literature [10,14].

Experimental Conditions

Threat manipulation. The basic procedure of the CPT was described to parents and children in a standard format that has been recommended in the literature [3,12] and that is used in our research lab. The script was then modified to either describe the pain associated with the task

as being “a little bit uncomfortable” (low-threat) or alternatively as being “quite painful and difficult to deal with” (high-threat). The high-threat instructions were directly adapted from threat scripts administered in previous research to parents of children undergoing experimental heat pain, which were found to increase parents’ state catastrophizing and feelings of distress [10]. For the purposes of this study, instructions were adapted so that they were relevant to the CPT and directed toward the child (although the parent could also hear them). Similar to previous scripts, the threat manipulation targeted expectations about physical and emotional sensations as well as the child’s ability to cope with the pain. See Appendix A for scripts.

In line with Caes and colleagues [10], these instructions were accompanied by pictures of children who had previously completed the CPT, thereby adding a visual example of how children generally cope with the task. Specifically, parents and children were shown, on a computer screen, four pictures of children (2 male, 2 female), either displaying high (high-threat condition) or low (low-threat condition) facial expressions of pain based on facial coding using the valid and reliable Facial Action Coding System [15]. These pictures were shown for 15 seconds and taken from videos of a previous published CPT study [16] in which parents consented to the use of their child’s videos in subsequent research. Finally, for families in the high-threat condition, a “danger” sign was attached to the side of the cold pressor apparatus. This caution sign was visible to children; however, due to the camera being focused on the child’s facial expression, parents were unable to see it.

Ceiling manipulation. In addition to the standard pre-CPT instructions, a randomly chosen half of the sample received information about the 4-minute maximum immersion time (informed ceiling). This information was omitted (uninformed ceiling) for the other randomly chosen half. See Appendix A for scripts.

Equipment

CPT. All children immersed their non-dominant hand in an electric-cooled cold pressor apparatus (Techne© www.techne.com). This cold pressor has an 8L capacity stainless steel tank filled with cold water that was circulated at 10L/minute using an external pump attached to the tank. The cold pressor cooled the water using a dip cooler and contains an electric thermoregulator that kept the water temperature stable to within ±0.1°C of 10°C.

Measures

Pain intensity (expected and experienced during CPT). Children's self-reported expected and experienced pain intensity was measured using the *Faces Pain Scale – Revised* (FPS-R) [17]. The FPS-R is a well-validated self-report measure assessing the intensity of children's pain. It is the most highly recommended self-report measure for the assessment of acute pain for children aged 5 and older [18]. Parent ratings of their child's expected and experienced pain was also measured using the FPS-R.

Pain tolerance. Pain tolerance was considered the length of time in seconds from when the child immersed their hand into the CPT until the time that they removed their hand.

Perceived threat of pain (anticipatory and experienced during CPT). Parents and children each completed an 8-item measure of their perceived threat of the pain related to completion of the CPT. The parent and child measure was based on the *Perceived Threat of Pain* (PTPQ) scale developed by Vlaeyen and colleagues [14] for use with adults undergoing experimental pain. Wording of the original PTPQ was modified to be more developmentally appropriate for use with children, and relevant to parents observing their children undergo the CPT. Items include questions such as "I wonder whether this cold water task might be harmful for my/my child's hand", and participants respond on an 11-point Likert scale ranging from 0

('not at all') to 10 ('very much'). The possible range of scores for the PTPQ is 0 to 80, with higher scores indicating a greater perceived threat of pain. Internal consistency was acceptable, with Cronbach's alpha of 0.76 for parents pre-CPT, 0.83 for parents post-CPT, 0.86 for children pre-CPT, and 0.92 for children post-CPT.

Children's experienced fear during CPT. Children's pain-related fear during the CPT was measured using the *Children's Fear Scale* [19]. This one-item scale includes five faces representing various levels of fear and children choose the face that best depicts how "scared" they feel. Scores range from 0-4. The CFS has been shown to have good construct validity as well as test-retest and inter-rater reliability [19].

Trait pain catastrophizing. Children's general tendency to catastrophize about their own pain (*Pain Catastrophizing Scale for Children*; PCS-C [20]) and parents' general tendency to catastrophize about their child's pain (*Pain Catastrophizing Scale for Parents*; PCS-P [21]) was measured. Each measure consistent of 13 items, and participants responded on a 5-point Likert scale, with simplified anchors used for children (e.g., 0 = not at all to 4 = extremely). Additionally, for children, the stem "When I have pain" was placed in front of each item. Internal consistency was high, with a Cronbach's alpha of 0.90 for the child version and 0.94 for the parent sample. Both the widely used PCS-C and PCS-P have been shown to be both reliable and valid [20,21]. Total scores were used for all analyses in the present study.

State pain catastrophizing (anticipatory and experienced during CPT). Parents completed an English version of the *Pain Catastrophizing Scale for Parents – State Version* to assess their situational catastrophizing about their child's pain. Children completed a similar measure about their situational catastrophizing about their own pain, the *Pain Catastrophizing Scale for Children – State Version.* The parent and child versions of the Pain Catastrophizing

Scale (state version) were adapted from Dutch versions of these measures [22,23] that were subsequently back translated to English using the trait PCS-P and PCS-C, respectively, as a standard for formulating the items. Each measure consisted of 6 items; 2 from each subscale (magnification, rumination, helplessness). Items on this English version were modified to specifically refer to the CPT, to be developmentally appropriate for use with children, to correct grammatical errors, and to be consistent with wording used in the English trait versions of these measures. Item wording was modified to refer to past tense when the scale was administered following the CPT. Parent and child versions each had a possible range of scores from 0 to 60, with higher scores indicating greater levels of state catastrophizing. Cronbach's alpha was acceptable in the present sample: 0.80 for parents pre-CPT, 0.71 for parents post-CPT, 0.88 for children pre-CPT, and 0.84 for children post-CPT.

Parental stop tendency. Parents completed the *Parental Stop Tendency Scale* [23], in which they rated their desire to stop the CPT during the task on an 11-point scale from 0 ('not at all') to 10 ('a lot'). Validity of this measure is supported by its relationship with parents' feelings of distress and catastrophizing about child pain [23].

Children's follow-up and ecological validity questionnaire. Children completed an investigator-created questionnaire inquiring about the ecological validity of the cold pressor task. Children were presented the questions orally by a research assistant, and responded on a 5-point Likert scale. As a manipulation check, children were asked about their level of anxiety at two different stages of the research protocol ("*How worried or nervous did it make you when we described the cold water task to you before you put your hand in the water?*" and "*How worried or nervous did it make you when we showed you pictures of other children completing the cold water task before you put your hand in the water?*"), where 1 indicated 'not at all', 2 indicated 'a

little bit', 3 indicated 'somewhat', 4 indicated 'quite a bit', and 5 indicated 'a lot'. Three questions inquired about how their pain, fear, and nervousness during the CPT compared to the last time they received a needle procedure, where 1 indicated 'not at all as scary/painful/nervous', 2 indicated 'a little less scary/painful/nervous', 3 indicated 'the same', 4 indicated 'a little more scary/painful/nervous', and 5 indicated 'much more scary/painful/nervous'.

Research Participation Questionnaire. To assess their level of satisfaction with their experience participating in this study, parents and children completed an investigator-created questionnaire. To reduce social desirability, this form was identifiable only by experimental group and not by participant number. Completed questionnaires were also placed in a sealed box that was not opened until completion of the study.

Procedure

Approval for the present study was granted by the institution's Research Ethics Board. Prior to the beginning of the study, all participant IDs were randomized to experimental conditions (high threat/informed; high threat/uninformed; low threat/informed; low threat/uninformed) using a computerized random numbers generator. Group allocation was enclosed in sealed, opaque envelopes identified only by study ID. Parents and children provided informed consent and assent, respectively. They were then separated, where they completed baseline measures: parent completed a demographics questionnaire and both parents and children completed measures of trait pain catastrophizing. Parents and children then came together and a research assistant delivered the appropriate randomized script about the CPT (high-threat or low-threat). They were then showed the corresponding series of pictures of children displaying either high pain (high-threat) or low pain (low-threat) facial expressions and told these were examples

of the ways in which children typically cope with CPT pain.

After being presented with the task instructions and pictures, parents and children were separated for a 3-minute period during which they were left alone to anticipate the CPT. They were then asked to complete a second battery of questionnaires (state pain catastrophizing, perceived threat of pain, and expected child pain intensity).

Children then completed the CPT while their parents watched via short-circuit television in an adjoining room. In this adjoining room, parents could hear the audio of their child receiving the CPT instructions, but could not hear the child's responses to any of the questionnaires administered after the CPT. Children randomized to the informed ceiling condition were then told about the maximum immersion time of four minutes, while children in the uninformed ceiling condition were not. All children were then asked to immerse their non-dominant hand up to their wrist in 10^{o}C water, and were told that they could remove their hand at any time if it became too uncomfortable or too painful to leave it in the water. Children were asked to repeat back the instructions to ensure comprehension prior to beginning the CPT, and research assistants ensured that children in the informed ceiling condition indicated awareness of the 4-minute maximum immersion time. The research assistant remained in the room with the child during the CPT to monitor for safety, but sat behind the child to reduce social desirability effects. The research assistant recorded the child's pain tolerance in seconds using a digital stopwatch.

Immediately following the child's removal of their hand from the cold water, children rated their experienced pain intensity and fear during the CPT. Parents provided proxy ratings of their child's experienced pain intensity and rated their tendency to want to stop the task. In addition, children and parents once again completed measures of state pain catastrophizing and perceived threat of pain related to the CPT. Children completed the follow-up and ecological

validity questionnaire, while parents answered a series of questions about their emotional responses to viewing their child completing the pain task (i.e., Parental Distress and Sympathy Questionnaire).

Finally, both the child and the parent were fully debriefed together by a research assistant. Following debriefing, and with the research assistant in another room to reduce social desirability, parents and children completed the research participation questionnaires. Children received a junior scientist certificate and a $20 CAD honorarium. Parents received $5 CAD to help cover any transportation expenses.

Results

Baseline differences between groups

Table 1 presents baseline characteristics for each of the four experimental groups. Group differences in major demographic variables were examined using a series of one-way analyses of variance (ANOVA), and chi-square analyses for categorical variables. As shown in Table 1, no significant differences were observed between experimental groups based on child age or sex, or trait pain catastrophizing in children or parents. When considering the sample as a whole, using clinical reference cut-offs proposed for youth with chronic pain [24], 35.4% of the child sample (n=17) were classified as low pain catastrophizers, 35.7% (n=17) as moderate pain catastrophizers, and 29.2% (n=14) as high pain catastrophizers [24].

Impact of threat level on parents' and children's pre-CPT measures: Manipulation check

A series of t-tests examined the impact of the threat manipulation of CPT instructions on parents' and children's outcomes prior to completing the CPT. Means and standard deviations are provided in Table 2. As hypothesized, children in the high-threat condition rated their expected pain significantly higher than children in the low-threat condition, $t(42.38) = -2.24$, $p =$

.031. They also reported higher levels of perceived threat of pain, $t(40.57) = -2.15$, $p = .037$ and state pain catastrophizing, $t(32.35) = -2.08$, $p = .046$, than children in the low-threat condition. Parents in the high-threat condition expected their child's pain to be significantly higher than parents in the low-threat condition, $t(46) = -4.59$, $p < .001$, but did not differ on their perceived threat of pain ($t(46) = -1.36$, $p = .181$) or state pain catastrophizing ($t(46) = -1.60$, $p = .117$).

Two follow-up questions at the end of the study also served as a manipulation check. There were no significant differences between groups in how nervous children were after hearing the description of the task. However, there was a significant difference between groups in how nervous children were viewing pictures of other children completing the CPT, ($t(37.69) = -2.83$, $p = .007$). Children in the high-threat condition reported that they were significantly more nervous/worried ($M = 2.25$, $SD = 1.36$) when viewing the pictures than children who received the low-threat information ($M = 1.33$, $SD = 0.82$).

Impact of threat level and ceiling manipulation on parents' and children's cold pressor task outcomes

A series of 2 (high-threat/low-threat) by 2 (informed/uninformed ceiling) ANOVAs examined the impact of the differential manipulations on parents' and children's expected and experienced pain outcomes, with the Bonferroni test used to probe significant main effects. Of note, due to equipment malfunction, one parent was not able to view their child completing the cold pressor task, and as such the sample size for the parent sample for cold pressor outcomes was n=47.

Pain and fear. No significant findings emerged for any child- or parent-reported measures of pain and fear during the CPT based on threat or ceiling manipulation.

Pain catastrophizing. A significant interaction between threat and ceiling condition was

observed for children's state pain catastrophizing during the cold pressor task, $F(1,44)= 5.67$, $p=.022$. Children who received low-threat information and who were uninformed about the maximum CPT ceiling time ($M = 14.83$, $SD = 7.35$) had higher levels of state pain catastrophizing than children who received low-threat information but who were informed about the ceiling time ($M = 7.58$, $SD = 6.20$), $t(22)= 2.61$, $p = .016$. There was not a significant difference between the ceiling conditions for children who received the high-threat information. Additionally, no significant difference was observed between groups for parents' state pain catastrophizing during the CPT.

Parental stop tendency. A main effect of threat condition was observed for parents' desire to stop their child from completing the CPT, with parents who received the high-threat information ($M = 1.91$, $SD = 2.98$) rating their stop tendency as higher than parents who received the low-threat information ($M = 0.39$, $SD = 1.12$), $F(1,42)=5.10$, $p=.029$.

Influence of individual child and parent characteristics on pain and anxiety outcomes

Correlations between baseline variables and pain outcomes. Bivariate correlations were conducted between baseline child variables (child age and trait pain catastrophizing) and outcome measures. With regard to pre-CPT measures, increased baseline trait pain catastrophizing in children was associated with higher expected pain intensity ($r = .378$, $p= .008$), anticipatory perceived threat of pain ($r = .608$, $p < .001$), and state pain catastrophizing prior to the CPT ($r = .633$, $p < .001$). Increased parental baseline trait pain catastrophizing was associated with increased parental perceived threat of pain ($r = .529$, $p < .001$) and state pain catastrophizing prior to the CPT ($r = .447$, $p= .002$).

With respect to outcomes during the CPT, older child age was significantly correlated with increased pain tolerance ($r = .297$, $p= .040$). Increased baseline trait pain catastrophizing in

children was associated with higher self-reported pain intensity (r = .355, p= .013), self-reported fear (r = .485, p < .001), perceived threat of pain (r = .540, p < .001), and state pain catastrophizing during the CPT (r = .454, p= .001). Conversely, parental baseline trait pain catastrophizing was not associated with any parent-reported outcomes assessed during the CPT.

Hierarchical regression analyses. Hierarchical regression analysis was conducted to examine the relative contribution of children's age and trait pain catastrophizing on their pain outcomes during the CPT. Children's age was a significant predictor of child pain tolerance (β = 14.42, $t(45) = 2.16$, p = .036), and accounted for 9% of the variance. Of note, when added to the model, trait pain catastrophizing did not significantly influence pain tolerance over and above the effects of child age.

Over and above the effect of child age, children's trait pain catastrophizing significantly influenced children's self-reported pain intensity (β = 0.34, $t(45) = 2.46$, p = .018). The model was significant ($F(2,45) = 3.59$, p = .036) and accounted for 10% of the variance in children's pain intensity.

Over and above the effect of child age, children's trait pain catastrophizing significantly influenced children's self-reported fear during the CPT (β = 0.49, $t(45) = 3.71$, p = .001). The model was significant ($F(2,45) = 6.93$, p = .002) and accounted for 24% of the variance in children's fear.

Impact of threat level and ceiling on children's perceptions of the ecological validity of the CPT

Children responded to a series of follow-up questions to investigate their perceptions of the ecological validity of the CPT. As there were no significant differences between groups, results pertaining to the follow-up questions will be presented as means for the entire sample.

Children generally reported that they were "a little bit" (M = 1.96, SD = 1.07) worried or nervous when the CPT was described to them. They reported that compared to the last time they got a needle, the CPT was "a little less scary" (M = 2.08, SD = 1.07) and they were "a little less nervous" (M = 2.31, SD = 1.07). However, children indicated that compared to the last time they got a needle, the CPT was between "a little less painful" and "the same" amount of pain as the needle (M = 2.65, SD = 1.23).

Given the finding that child trait characteristics significantly influenced child CPT outcomes irrespective of experimental group, exploratory regression analyses were conducted to examine the impact of child characteristics on the follow-up questions comparing the CPT experience to the child's last needle experience. Children's age was a significant predictor of how painful children reported the CPT to be in comparison to previous needle experiences (β = 0.29, $t(46) = 2.08$, p= .043). Older age was associated with higher ratings (i.e., they reported that the CPT was similar to or more painful than previous needles). The model was significant ($F(1,46) = 4.32$, p = .043) and accounted for 9% of the variance in children's pain. Of note, when added to the model, trait pain catastrophizing did not significantly influence child ratings of the comparability of the CPT to needles.

Over and above the effect of child age, children's trait pain catastrophizing significantly influenced how scary children reported the CPT to be in comparison to a previous needle experiences (β = 0.39, $t(45) = 2.82$, p = .007), with higher levels of trait pain catastrophizing related to higher fear ratings (i.e., that children reported the CPT to be more similar to past needle experiences in terms of how scary it was). The model was significant ($F(2,45) = 3.97$, p = .026) and pain catastrophizing accounted for 15% of the variance.

Over and above the effect of child age, children's trait pain catastrophizing significantly influenced how nervous children reported being about the CPT compared to the last time they got a needle ($\beta = 0.30$, $t(45) = 2.11$, $p = .041$). That is, children who endorsed a greater tendency to catastrophize about their pain rated the CPT as being more similar to past needle experiences in terms of their nervousness.

Impact of threat level and ceiling on parents' and children's satisfaction with research participation.

When asked to rate their experience participating in the present study on a scale of 0 (very negative) to 10 (very positive), both children ($M = 7.52$, $SD = 2.36$, range = 0-10) and parents ($M = 8.89$, $SD = 1.62$, range = 5-10) indicated they generally had a positive experience. There were no significant differences across experimental conditions ($F(3,44) = 0.04$, $p = .99$ for children and $F(3,42) = 0.92$, $p = .44$ for parents). Nearly all parents (n=46, 95.8%) and all children (n=48, 100%) indicated that they were happy that they took part in the study.

Discussion

Impact of threat and ceiling manipulations

The results of the present study indicate that receiving threatening information prior to the CPT increased children's and parents' expectations about child pain, as well as children's perceived threat of pain and state pain catastrophizing. This demonstrates that a relatively subtle manipulation of wording and presentation of visual stimuli related to the task had significant effects on certain outcomes, highlighting the importance of researchers considering such methodological issues in their use of the CPT. Previous research of venipuncture in adults found that negative affective priming through the use of specific words to describe the pain experience was associated with greater self-reported pain intensity, which was hypothesized to be due to

increased hypervigilance to pain [25]. However, in the present study, children in the high-threat group self-reported that their anxiety was higher than children in the low-threat group only after viewing the pictures of previous children completing the CPT. In contrast, there were no differences between threat groups in their level of anxiety that they attributed to hearing the task instructions. Given children's responses to the follow-up questions about the different aspects of the threat manipulation, it appears that the use of the pictures increased anxiety more than the verbal description of the task.

Children who were uninformed about the maximum CPT ceiling time reported higher state pain catastrophizing during the CPT than children who were informed of the 4-minute ceiling time, but this effect was only observed amongst children who were in the low-threat condition. Research using informed ceilings may buffer children against heightened catastrophizing when the task is of low threat value. Being uninformed about the ceiling time increases the unpredictability and uncontrollability of the task, which may be involved in activating a stress response [26,27]. An alternative explanation is that fearful appraisal of pain associated with the high-threat condition makes it difficult for participants to disengage from catastrophic thoughts [28], which would influence their interpretation of the ceiling information. This finding is of particular relevance when interpreting previous CPT research, as the low-threat instructions are standard instructions that are typically provided to children participating in such studies. Given variability between previous studies in the use of an informed or uninformed ceiling, researchers would be prudent to consider the impact that ceiling knowledge may have on children's catastrophizing during the CPT and related outcomes.

Interestingly, child pain tolerance was not related to experimental group assignment, which contradicts previous research in adults which found that decreased threat value of the CPT

was related to greater pain tolerance [29,30]. However, the threatening information in the adult studies were related to the potential for physiological damage as a result of prolonged cold exposure, unlike the present study wherein the threat manipulation was related more to describing the intensity of the pain experience and the difficulty it poses to coping. Additionally as described below, age was a significant predictor of pain tolerance in the present study. Given that age was evenly distributed across the experimental groups, it is possible that age-specific effects were stronger in predicting pain tolerance than any impact of the experimental manipulation [31,32].

Parents who were in the high-threat condition had a greater tendency to want to stop their child from completing the CPT than parents in the low-threat condition. However, it is worth noting that the mean parental stop tendency of parents in the high-threat condition was quite low (i.e., 2/10 with 0 = not at all and 10 = a lot), therefore even among parents in the high-threat condition the desire to stop the task was not particularly high, although this is comparable to previous lab-based studies [23].

Generally, parents and children were highly satisfied with their experience participating in this research, regardless of which experimental manipulations they received, indicating that the use of either of the manipulations would be appropriate in future research as needed for the experimental design. Researchers are increasingly acknowledging the importance of assessing parents' and children's perceptions of lab-based methods for determining their ethical acceptability [1,9] and the present study is the first to examine this in the context of increasing the threat value of the experimental pain task.

Perceived similarity of the CPT to clinical pain

Children reported that the pain of the cold pressor was moderately comparable to the pain of getting a needle, and this effect did not differ between experimental groups but was significantly predicted by child age. However, children reported less fear and nervousness than the last time they remembered getting a needle, which also did not differ between experimental groups. Acute clinical pain experiences (e.g., needle-related procedures) often involve high levels of anxiety and fear [5] that are not reported to the same degree among children undergoing the CPT and their parents [6]. Perhaps even with the threat manipulation and the uninformed ceiling (which is similar to clinical pain experiences where children often do not know how long the pain will last), the task is not perceived to be as threatening as clinical pain experiences. However, children's fear and nervousness compared to the last time they remembered getting a needle was significantly predicted by levels of trait pain catastrophizing, in that individuals with higher levels of trait pain catastrophizing reported that their fear and nervousness regarding the CPT was the same or higher compared to their last needle experience. The fact that individual characteristics were stronger predictors of experimental pain outcomes than lab-based task manipulations supports the generalizability of these findings to a real-world context where individual characteristics are also likely to play an important role [33,34].

Impact of individual characteristics

Children's trait pain catastrophizing predicted self-reported pain intensity and fear during the CPT, with greater levels of trait pain catastrophizing associated with increased pain and fear. Additionally, similar to previous research, child age was a significant predictor of child pain tolerance, with older children keeping their hand in the water for longer [31,32]. Overall, the results of the present study highlight the importance of considering individual characteristics in understanding the experience of pain, and that these individual differences may make an

individual more or less susceptible to experiencing increased anxiety in the context of receiving information about the pain experience. Previous research on the impact of threat or attending to threatening information on parents' responses to their child's pain has highlighted the critical role of parental pain catastrophizing in these processes [10,35]. Importantly, findings from Caes and colleagues [10] indicated that the impact of threatening instructions on parental engagement in protective behaviour was moderated by parents' trait level of pain catastrophizing. The present study extends from these findings to illustrate the additional impact of children's own pain catastrophizing. Clinically, this holds importance in understanding the disposition of an individual child in choosing how to describe a painful procedure, rather than ascribing to a "one-size-fits-all" approach. This finding also supports the comparability of CPT findings between research labs despite potential differences in task instructions (e.g., ceiling information) or other factors.

Limitations

This study had a number of limitations that can be addressed in future research. First, the sample size was small, but the study was powered to detect large effects, which was supported by existing literature on the effect of threatening information on pain experiences [10,14]. Second, the threat manipulation was based on previous research with parents of children undergoing heat pain [10] and instructions were adapted to be relevant to the context of the CPT. It is possible that further adaptations to the threat instructions (e.g., descriptions of potential physiological outcomes of frostbite) and pictures shown could have a larger effect on parents' and children's perceptions of the pain experience. Third, children in the current study ranged in age from 8-14 years thereby spanning the developmental periods of late childhood to early adolescence. Recent research revealed differences in pain responses to the CPT as a function of child age [31] and sex

differences in pain outcomes that emerge in early adolescence around the onset of puberty [36], highlighting the critical developmental changes that may be occurring across the age span of the present study. The importance of examining developmental differences in pain catastrophizing [33] and parent responses to child pain [34] has been highlighted in the literature. Future research is needed to further clarify the impact of age and developmental factors on children's responses to task instructions and pain.

In addition, perceptions of fear/anxiety and pain were assessed immediately before and after completion of the pain task. Whereas the experimental manipulation did not impact pain outcomes assessed immediately following the CPT, it is possible that children's and parents' subsequent cognitions and emotions were affected [8]. Finally, future research should further examine the role of social context (e.g., observers who may act as safety signals) and its potential moderating effect on threat and pain outcomes [14,37].

Conclusions

In summary, a relatively subtle threat manipulation was successful at increasing levels of state pain catastrophizing and perceived threat of pain in children, and increasing expectations about child pain among children and their parents. As such, this manipulation may be of use to researchers wishing to increase the anticipatory anxiety associated with the CPT. Child pain and fear outcomes experienced during the pain task itself were better predicted by child trait characteristics (e.g., trait pain catastrophizing or age) rather than the experimental manipulation, which also supports the generalizability of the CPT in showing some resistance to manipulation in outcomes. Additionally, children reported that they found the pain of the cold pressor to be comparable to the pain experienced during their last needle procedure. These findings enhance our understanding of the importance of threat and individual factors in influencing children's

pain experiences and how perceptions of experimental pain may approximate those of pain experienced in the real world.

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Table 1.

Baseline data by experimental group.

	Child				
	High-threat/uninformed (*n*=12)	High-threat/informed (*n*=12)	Low-threat/uninformed (*n*=12)	Low-threat/informed (*n*=12)	Group differences [a]
Age	*M*=10.64 *SD*= 1.73	*M*=10.91 *SD*= 2.30	*M*=11.47 *SD*= 2.20	*M*=11.02 *SD*= 2.19	$F(3,44) = 0.314$, $p = .815$
Sex	Girls = 7 Boys = 5	Girls = 5 Boys = 7	Girls = 6 Boys = 6	Girls = 7 Boys = 5	$\chi^2(3, N=48) = 0.918$, $p=.821$
Trait catastrophizing	*M*=14.58 *SD*= 8.57	*M*=22.00 *SD*= 11.57	*M*=20.25 *SD*= 9.24	*M*=18.58 *SD*= 8.04	$F(3,44) = 1.351$, $p = .270$

	Parent				
	High-threat/uninformed (*n*=12)	High-threat/informed (*n*=12)	Low-threat/uninformed (*n*=12)	Low-threat/informed (*n*=12)	Group differences [a]
Trait catastrophizing	*M*=30.00 *SD*= 7.87	*M*=37.17 *SD*= 9.61	*M*=35.36 *SD*=13.63	*M*=32.73 *SD*= 11.32	$F(3,42) = 1.009$, $p = .398$

[a] Group differences were tested using one-way ANOVAs for continuous variables, and chi-square analyses for categorical variables.

Table 2.

Means and standard deviations for pre-CPT measures by threat condition.

	Child	
	High-threat (*n*=24)	Low-threat (*n*=24)
Expected pain (FPS-R)	*M*=4.17 *SD*= 2.50	*M*=2.75 *SD*= 1.85
Perceived threat of pain (PTPQ)	*M*=22.13 *SD*= 16.69	*M*=13.25 *SD*= 11.37
State catastrophizing (PCS-C)	*M*=17.96 *SD*= 14.17	*M*=11.33 *SD*= 6.53
	Parent	
	High-threat (*n*=24)	Low-threat (*n*=24)
Expected pain (FPS-R)	*M*=5.92 *SD*= 2.00	*M*=3.25 *SD*= 2.03
Perceived threat of pain (PTPQ)	*M*=15.17 *SD*= 9.14	*M*=11.13 *SD*= 11.36

State catastrophizing (PCS-P)	*M*=12.88 *SD*= 8.45	*M*=8.67 *SD*= 9.77

Appendix A

Scripts for threat and ceiling manipulation with key differences in bold

Script for introduction of the CPT: Low-threat

"Soon you'll be doing a cold water task. During this task, you are going to put your hand in cold water. Our experience with the cold water task used in this study has been that most children find the water to be **a little bit uncomfortable**. So, it is possible that putting your hand in the cold water will also be **a little bit uncomfortable for you**. We will now look at some pictures of children doing the same cold water task that you will be doing."

Script for introduction of the CPT: High-threat

"Soon you'll be doing a cold water task. During this task, you are going to put your hand in cold water. Our experience with the cold water task used in this study has been that most children find the water to be **quite painful and have difficulty dealing with it**. So, it is possible that putting your hand in the cold water will also be **quite painful and hard for you to deal with**. We will now look at some pictures of children doing the same cold water task that you will be doing."

Script for providing CPT task instructions: Informed ceiling

"This is the part where you are going to **put your hand in the water for up to 4 minutes.** Don't put your hand in now though, I will tell you when it's time. When I tell you put your hand in the water, put it in up to the part where your wrist bends and keep your hand open. Once you've put your hand in the water, leave it in for as long as you can, even if it is

uncomfortable. If your hand gets too uncomfortable or hurts too much **you can take it out of the water even before the 4 minutes is up.** I will sit behind you and I won't talk to you while you have your hand in the water. Please try to sit as still as possible while you're doing the cold water task."

Script for providing CPT task instructions: Uninformed ceiling

"This is the part where you are going to **put your hand in the water.** Don't put your hand in now though, I will tell you when it's time. When I tell you put your hand in the water, put it in up to the part where your wrist bends and keep your hand open. Once you've put your hand in the water, leave it in for as long as you can, even if it is uncomfortable. If your hand gets too uncomfortable or hurts too much **you can take it out of the water.** I will sit behind you and I won't talk to you while you have your hand in the water. Please try to sit as still as possible while you're doing the cold water task."