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Version: Post-print

Publisher's version: Birnie, K.A., Chambers, C.T., Chorney, J., Fernandez, C.V., & McGrath, P.J. (2016). Dyadic analysis of child and parent trait and state pain catastrophizing in the process of children's pain communication. *PAIN*, 157(4), 938-48. DOI: 1097/j.pain.0000000000000461

This is a non-final version of an article published in final form in Birnie, K.A., Chambers, C.T., Chorney, J., Fernandez, C.V., & McGrath, P.J. (2016). Dyadic analysis of child and parent trait and state pain catastrophizing in the process of children's pain communication. PAIN, 157(4), 938-48

Dyadic analysis of child and parent trait and state pain catastrophizing in the process of
children's pain communication

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Total number of text pages in manuscript: 41

Number of Tables: 3

Number of Figures: 3

Keywords: pain catastrophizing, children, parents, cold pressor, pain behaviours, dyadic analysis

Abstract

Explored separately, child and parent catastrophic thoughts about child pain show robust negative relations with child pain. The objective of this study was to conduct a dyadic analysis to elucidate intra- and inter-personal influences of child and parent pain catastrophizing on aspects of pain communication, including observed behaviours and perceptions of child pain. A community sample of 171 dyads including a child aged 8-12 years (89 girls) and parent (135 mothers) rated pain catastrophizing (PCS-C and PCS-P trait and state versions), and child pain intensity and unpleasantness following a cold pressor task (CPT). Child pain tolerance was also assessed. Parent-child interactions during the CPT were coded for parent attending, non-attending, and other talk, and child symptom complaints and other talk. Data was analyzed using the actor-partner interdependence model and hierarchical multiple regressions. Children reporting higher state pain catastrophizing had greater symptom complaints regardless of level of parent state pain catastrophizing. Children reporting low state pain catastrophizing had similar high levels of symptom complaints, but only when parents reported high state pain catastrophizing. Higher child and parent state and/or trait pain catastrophizing predicted their own ratings of higher child pain intensity and unpleasantness, with child state pain catastrophizing additionally predicting parent ratings. Higher pain tolerance was predicted by older child age and lower child state pain catastrophizing. These newly identified interpersonal effects highlight the relevance of the social context to children's pain expressions and parent perceptions of child pain. Both child and parent pain catastrophizing warrant consideration when managing child pain.

Dyadic analysis of child and parent trait and state pain catastrophizing in the process of children's pain communication

Pain catastrophizing has emerged as an important cognitive-affective factor associated with maladaptive emotional, behavioural, and physiological, and interpersonal responses to chronic, acute, and experimental pain across the lifespan [61,67]. Models of pain communication highlight intra- and inter-personal influences in how pain is internally experienced and expressed (encoded), and how it is appraised and responded to by others (decoded) [21,37,38]. Parents are central to the social context of children's pain, and previous research supports a role of both child and parent catastrophizing about child pain in the process of pain communication, as evidenced with children with and without chronic pain across clinical and experimental pain contexts.

Higher child pain catastrophizing has been associated with increased self-reported pain, fear, and distress, as well as greater verbal and nonverbal pain expression, protective behaviours, and disability [10,40,79-84]. Interpersonal associations of child pain catastrophizing include greater discouraging, solicitous, and protective parent responses [25,36,40,85,91], which are related to poorer child pain outcomes, particularly for children with higher pain catastrophizing [25,36,79,82,91,92]. Greater parental pain catastrophizing is also associated with child and parent report of poorer child pain and functioning [31,33,48,84] through its influence on parents' emotional and behavioural responses [11-15,30,34,40,46].

Given the unique contributions and interdependence of child and parent factors in children's pain [55,56], studies have concurrently examined child and parent pain catastrophizing [25,27,49,52,59,62,83,87,89,91,93,94]. Poorer child pain outcomes have been reported in dyads with both high pain catastrophizing children with chronic pain and their

parents [93], as well as dyads with a high pain catastrophizing child and low pain catastrophizing [49]. Most studies find significant associations between child and parent pain catastrophizing [25,27,49,59,62,80,91], with parent pain catastrophizing influencing child pain and coping via child pain catastrophizing [25,59,62,89,94]. However, studies of pediatric post-surgical [27,52] and experimental pain [87] report a direct contribution of parent pain catastrophizing to children's attentional avoidance to pain and pain tolerance, parent behaviours, and parent and child pain memories, in addition to the influence of child pain catastrophizing.

Existing work lacks multilevel modeling designed to investigate interpersonal effects and address the non-independence of dyadic data [45]. Prior work is also limited by its focus on trait pain catastrophizing [24,31], largely ignoring state pain catastrophizing, which focuses on specific pain experience and appears more strongly implicated in experimental pain and acute fluctuations in chronic pain [16,66].

This study is the first to examine dyadic influences of child and parent trait and state pain catastrophizing on observed parent-child interactions during child pain, and ratings of child pain. Consistent with the social communication model of pain [21,38], actor effects were expected for parent and child pain catastrophizing and reports of child pain [32,33,62,79,80,82,84]. Higher pain catastrophizing by children and parents was expected to relate to their own and others' engagement in observed pain-focused talk, as well as decreased child pain tolerance [27,40,79,80,82,83].

Methods

Data reported in this paper was collected as part of a larger study examining two main research questions that are presented in separate papers. The current paper examines the role of child and parent pain catastrophizing in parent-child interactions during a cold pressor task, and

subsequent ratings of child pain. The other paper (Birnie, Chambers, Chorney, Fernandez & McGrath, submitted manuscript) examines the role of family functioning in children's pain. The IWK Health Centre research ethics board approved the study.

Participants

A total of 171 parent-child dyads participated in the study. Eligible participants were recruited from the community and included dyads comprised of one child (8-12 years old) and a parent. Based on parent report, children were excluded from the study if they were unable to speak, write, or read sufficiently to answer written questions or converse in English, if they had uncorrected vision or hearing impairments, if they had a developmental delay or disability, if there was any contraindication to participating in the cold pressor task [88], or if they had previously completed the cold pressor task. Parents were excluded if they were unable to speak, write, or read sufficiently to answer written questions or converse in English, or if they had previously completed the cold pressor task. Twenty parent-child dyads were excluded for not meeting eligibility criteria. An additional six participating dyads were excluded as they did not speak in English for at least half of the parent-child interaction during the cold pressor task ($n=4$), the interaction was accidentally not recorded ($n=1$), or they withdrew from the study early ($n=1$).

Participating children had a mean age of 10.03 years ($SD=1.38$) and 89 (52.0%) were female. As reported by parents, most children were White ($n=142$; 83.0%), followed by mixed race ($n=17$; 9.9%), Asian ($n=5$; 2.9%), First Nations/Aboriginal ($n=4$; 2.3%), Arab ($n=2$; 1.2%), Black ($n=1$; 0.6%), Latin American ($n=1$; 0.6%), or other ($n=1$; 0.6%). Based on parent report, 23 children (13.5%) experienced some sort of chronic pain (i.e., arthritis/joint pain, chronic back pain, headaches/migraines, chronic muscle pain, and/or recurrent abdominal pain), although only

2 children (1.2%) took medication for pain more than once per week.

Parents had a mean age of 41.23 years ($SD=6.01$) and most were mothers ($n=135$; 78.9%), currently married ($n=122$; 71.3%), had an undergraduate university degree or higher ($n=105$; 61.4%), and reported an annual household income $> \$75,000$ CAD ($n=108$; 63.2%). The majority of parents self-identified as White ($n=147$; 85.9%), followed by mixed race ($n=8$; 4.7%), Asian ($n=6$; 3.5%), First Nations/Aboriginal ($n=3$; 1.8%), Black ($n=2$; 1.2%), Arab ($n=2$; 1.2%), or other ($n=3$; 1.8%).

Experimental Pain Task

Participating children completed the cold pressor task (CPT) with their parent present in the room. The CPT is the most commonly used experimental pain task in children [2,5] and has been used to successfully observe parent-child interactions during children's pain [50]. Use of experimental pain offers benefits of standardization of the pain stimulus and increased feasibility of examining parent-child interactions during child pain over real world pain experiences [2,3]. The CPT is considered safe and ethical for use with children [3,88]. Children immersed their non-dominant hand to the wrist in $10 \pm 1^\circ\text{C}$ water for up to an uninformed maximum of four minutes. Children were given the following instructions: *You need to lower your hand all the way down so that where your wrist bends is in the water. Keep your hand open. Once you've put your hand in the water, we'd like you to leave it in for as long as you can, even if it is uncomfortable, until a second beep from the timer tells you that it's time to take your hand out of the water. If your hand gets too uncomfortable or hurts too much, you can take it out of the water at any time.* No information was provided to suggest how painful the task might be for the child. To minimize audience effects, the parent and child were left alone while completing the CPT and were directed to talk to each other as they normally would. Parent-child dyads had a one-minute

period to interact prior to the immersion of the child's hand in the water and another minute following the child's removal of the hand from the water. A beep from a digital watch signaled the start and end of both of these waiting periods, as well as to signal the child's removal of their hand from the water if they reached the maximum allowable immersion of time of four minutes. The interaction was digitally audio- and video-recorded. To ensure study protocol was being followed and for safety reasons, the research assistant observed the interaction in real-time from a separate room via closed circuit television.

Measures

Trait Pain Catastrophizing

Children completed the Pain Catastrophizing Scale for Children (PCS-C) [24] and parents completed the Pain Catastrophizing Scale for Parents (PCS-P) [31]. Both scales are adapted from the original Pain Catastrophizing Scale [69] and are widely used self-report measures reflecting children's or parents' trait tendency to catastrophize when the child has pain. Both scales are comprised of 13 items responded to on a 5-point scale from 0 ('not at all') to 4 ('extremely') and yield a total score (range from 0-52) and three subscale scores for rumination, magnification, and helplessness. Higher scores indicate higher levels of trait pain catastrophizing. Factorial, construct, and criterion validity of the PCS-C and PCS-P have been demonstrated with samples of generally healthy children and children with chronic pain aged 8-16 years, and their parents [24,31,57]. Additional predictive validity of the scales have been demonstrated for children's chronic pain experience and associated functioning, and parent affective responses to children's pain [24,31,59]. Cronbach's alpha of the trait PCS-C and the PCS-P in the current study were .89 and .92, respectively.

State Pain Catastrophizing

Children and parents also completed state versions of the PCS-C and PCS-P, respectively, to assess their catastrophic thoughts relating specifically to the child's pain during the CPT. State versions of these scales have been adapted from the trait versions and have been used in previous research, particularly for examinations of acute clinical or experimental pediatric pain [10,82,84]. Both scales are comprised of 6 items; two from each subscale (magnification, rumination, helplessness). Items are responded to on an 11-point numeric rating scale from 0 ('not at all') to 10 ('a lot') with total scores ranging from 0 to 60. Higher scores indicate higher levels of state pain catastrophizing. Cronbach's alpha of the state PCS-C and PCS-P in the current study were .79 and .76, respectively.

Child Pain Outcomes

Children and parents rated the child's worst pain intensity from the CPT using the Faces Pain Scale-Revised (FPS-R)[41]. The FPS-R is comprised of six faces depicting 'no pain' (neutral face) to 'most pain possible' with excellent demonstrated reliability and validity for self-reported pain in children 4-12 years old [64]. The FPS-R has been used by parents to provide proxy ratings of children's pain in previous research [9,10].

Children and parents rated the child's pain unpleasantness from the CPT using an 11-point numeric rating scale from 0 ('not at all unpleasant/horrible/yucky') to 10 ('most unpleasant/horrible/yucky') that has been previously used to assess acute pain with children aged 8-18 years old with good validity [53,54].

Children's pain tolerance was later coded from videotapes of the CPT by a research assistant and was considered the time elapsed in seconds when the child had their hand immersed in the water during the CPT up to a maximum of four minutes (i.e., 240 seconds). This is consistent with previous studies using the CPT to examine children's pain tolerance [5].

Typicality of Others' Behaviour

As a measure of ecological validity, children and parents rated how different the others' behaviour was during the CPT as compared to how they usually act when the child has hurt or pain. The wording was modified from a previous study observing parent-child interactions during experimental pain [90]. Children and parents were asked: 'was your [mom or dad or child] acting the same as usual today or different than usual today when [you or they] did the cold water task?' Responses were rated on a 5-point scale ranging from 0 'not at all different' to 4 'a whole lot different'. On average, children and parents' rated the others' behaviour during the CPT close to 'a little different' than usual ($M=0.92$, $SD=1.08$ for parent behaviour; $M=1.01$, $SD=1.02$ for child behaviour).

Observed Parent and Child Behaviours

Parent and child verbalizations during the CPT were coded using a set of mutually exclusive and exhaustive subcodes used in similar previous research examining parent-child interactions during the CPT [50]. Parent verbalizations were classified into 9 subcodes, which were then combined into three broad categories: Attending Talk (i.e., any talk by the parent about the child's symptoms), Non-Attending Talk (i.e., any talk by the parent that does not focus on the child's physical sensations or the CPT), or Other Talk (i.e., any talk by the parent that include statements about the procedure, or other). Parent Attending Talk comprised four subcodes, including (1) symptom-focused talk and commands to child (e.g., 'does it hurt?'); (2) sympathy to child (e.g., 'you'll be ok'); (3) procedure-related praise to child (e.g., 'I'm proud of you'); and (4) procedure time talk and commands to child (e.g., 'I don't know how much longer'). Parent Non-Attending Talk comprised two subcodes: (1) nonsymptom-focused talk and commands to child (e.g., 'think of nice hot sunny day'); and (2) humour to child (e.g., 'you're

being silly!'). Parent Other Talk comprised three subcodes: (1) other procedure talk and commands to child (e.g., 'leave your hand open'); (2) criticism to child (e.g., 'you're behaving badly'); (3) other talk to child (e.g., 'what did you say?').

Child verbalizations were classified into 7 subcodes, which were then combined into two broad categories: Symptom Complaints (i.e., any talk by the child involving statements about symptoms) or Other Talk (i.e., any other talk by the child). Child symptoms complaints comprised four subcodes: (1) cold/pain symptom talk to parent (e.g., 'It's so cold'); (2) anxiety talk to parent (e.g., 'I'm scared'); (3) procedure time talk to parent (e.g., 'how long does this last?'); and (4) resistance talk to parent (e.g., 'I want to take my hand out'). Child Other Talk comprised three subcodes: (1) other procedure talk to parent (e.g., 'which hand do I use?'); (2) child coping talk to parent (e.g., 'I can handle this'); and (3) other talk to parent (e.g., 'what are you doing?'). Parent and child codes were mutually exhaustive and exclusive. Less than 1.0% of parent and child verbalizations were inaudible and were combined with 'other talk' subcodes for parents and children, respectively.

This coding scheme is based on the Child-Adult Medical Procedure Interaction Scale-Revised (CAMPIS-R), which was originally developed as an observational coding system to capture interactions between children and adults during pediatric medical procedures [6]. Similarly modified versions of the CAMPIS-R have been used to capture parent-child interactions during or following experimental pain, with similar parent codes of pain attending, non-attending/distracting or other/uncodeable talk, and child codes of symptom complaints/pain talk and other talk [15,79,90,92]. In addition to their theoretical basis, subcodes showed consistent and expected relations with one another and with relevant child and parent outcomes where observed in the current study, offering additional empirical support for the selected

groupings.

Parent-child interactions during the CPT were transcribed verbatim before coding. Coding began at the start of the CPT when the child first immersed their hand in the water and ended when the child's pain tolerance was reached (i.e., the child removed their hand from the water) or when 90 seconds had elapsed, whichever came first. Ninety seconds was chosen as the maximum end point of coding to capture the most salient time for demonstrated increases in pain intensity and pain expression [22,29,51,74], as well as demonstrated influences of individual and observer pain catastrophizing on pain communication [68,70], during the first 1-2 minutes of the CPT. Ninety seconds also aligns with the bimodal distribution for pain tolerance consistently observed in studies using the CPT in children of this age range [4,5], including the current study. Just over half (51.5%) of the current study sample reached pain tolerance before 90 seconds, with all but three (1.2%) of the remaining children reaching the maximum allowable immersion time of four minutes (i.e., pain tolerance ceiling).

A primary coder received training from the first author on use of the coding system, and reviewed a coding manual in detail. Nine parent-child interactions from the current study were randomly selected for training purposes. Subcodes were compared and discussed with the first author until adequate reliability was achieved before all remaining videos in the study were coded. To assess interrater reliability, the first author coded a randomly selected 20% of the videos from those not used for training purposes. Kappa statistics were .823 ($SE=.01$) for parent subcodes (.855; $SE=.01$ for broad categories) and .841 ($SE=.02$) for child subcodes (.863; $SE=.02$ for broad categories), indicating excellent interrater agreement [28].

Consistent with previous studies [50,79], proportional scores for each parent and child category were obtained by dividing the number of verbalizations in each category by the total

number of verbalizations made by that individual. This was done to control for variations in the total number of verbalizations made by each parent and child, and to make values comparable across dyads. Proportions were considered appropriate given strong linear relations between total number of parent and child verbalizations and length of parent-child interaction as measured by pain tolerance [94]. Proportions were used in all analyses.

Procedure

After providing informed consent and child assent, parents and children were separated to complete baseline questionnaires, including demographics and trait pain catastrophizing. Following completion of the CPT, parent and children were again separated to provide ratings of state pain catastrophizing about the child's pain, as well as the child's pain intensity and pain unpleasantness. They then completed a measure of typicality of the others' behaviour. After debriefing, parents were given a handout summarizing evidence-based parent responses to minimize children's pain and distress during acute painful experiences.

Data Analyses

Relations between study variables and child age, child sex, and parent sex (mother versus father) were explored using correlations and independent samples t-tests as appropriate to check for significant covariates that should be controlled for in subsequent analyses. Distributions of reported parent and child variables were also checked for normality prior to conducting analyses and were deemed to be normal [71].

Given study objectives and hypotheses, analyses focused on observed parent and child behaviours previously implicated in children's pain responding [12,17,50,79,90,92]. A series of six hierarchical multiple regressions were used to examine the impact of child and parent trait or state pain catastrophizing (in separate models), and their interaction, on observed (1) parent pain

attending talk (2) parent non-attending talk, and (3) child symptom complaints. Given the strong bidirectional influence of parent and child behaviours during parent-child interactions, the observed behaviours of the other member of the dyad were entered as covariates (i.e., child behaviour codes when predicting parent behaviours or vice versa) (Step 1). As appropriate, any additional identified covariates were also added in Step 1. Child and parent pain catastrophizing (trait or state) were entered in the next step (Step 2) to account for main effects before examining their interaction (Step 3). Using the same stepped approach as described above, two additional hierarchical multiple regressions were used to assess the predictive value of child and parent trait or state pain catastrophizing (in separate models) in children's pain tolerance. As is recommended for moderation regression analyses, all predictors were centered [43].

The actor-partner interdependence model (APIM) [20,45] was used to assess the impact of child and parent trait or state pain catastrophizing on child and parent reports of the child's pain intensity and pain unpleasantness. APIM is a statistical approach that tests for bidirectional effects in interpersonal relationships, and requires matched measured variables from both members of the dyad. As such, it is ideally suited for studying children and their parents as it accounts for the non-independence of data derived from dyads. Children and parents were treated as distinguishable dyads. APIM was estimated using multilevel modeling procedures and variables were standardized [20,45]. Figure 1 depicts the general model of actor and partner effects of child and parent pain catastrophizing (trait or state) and their influence on child and parent ratings of the child's pain intensity or unpleasantness. When a significant actor effect is found, it indicates a relation between the respondent's own pain catastrophizing (child or parent) and the same respondent's ratings of the child's pain. When a significant partner effect is found, it indicates a relation between a respondent's own pain catastrophizing (e.g., child or parent) and

the other dyad member's ratings of the child's pain (e.g., parent or child). Interactions test for significant differences between size of actor or partner effects between respondents (child or parent).

Power analyses were conducted to determine the estimated power of the obtained sample of 171 parent-child dyads to detect medium effects. Estimations using G*Power 3.1 indicated that with a sample of 171 dyads, assuming an alpha level of .05, the power of the regression F -test to detect a significant R^2 increase prediction model for pain catastrophizing in observed child symptom complaints is >95% with a medium effect size ($f^2=.15$). Thus, the study sample size was likely sufficient to detect small to medium effect sizes based on a statistical power of .80. Power estimations based on regression analyses were used for APIM analyses [18].

Results

Relations with Child Age, Child and Parent Sex, and Potential Covariates

Significant correlations were observed between child age and child symptom complaints ($r=-.246, p<.01$), child other talk ($r=.268, p<.01$), parent non-attending talk ($r=.254, p<.01$), parent other talk ($r=-.215, p<.01$), and pain tolerance ($r=.268, p<.01$). As such, child age was controlled for in analyses involving observed parent and child behaviours, and pain tolerance. No significant differences were noted based on child sex for observed child behaviours, or for measures of child pain catastrophizing (trait or state), self-reported pain intensity and unpleasantness, or pain tolerance. No significant differences were noted between mothers and fathers for observed parent behaviours, or for measures of parent pain catastrophizing (trait or state), or parent-rated child pain intensity and unpleasantness. As such, child and parent sex were not controlled for in subsequent analyses. Given its potential to impact observed relations, existing child chronic pain as reported by parents was examined as a potential covariate. No

significant group differences were found on reported child or parent study variables or observed behaviours between dyads with reported child pain (i.e., arthritis/joint pain, chronic back pain, headaches/migraines, chronic muscle pain, and/or recurrent abdominal pain) as compared to dyads without. As such, child chronic pain was not controlled for or considered further in study analyses.

Given that children and parents completed a second lab-based interaction task (i.e., a conflict discussion), in addition to the CPT, as part of the larger study (Birnie et al., submitted manuscript), potential task order effects were explored. A significant task order effect was found for child state pain catastrophizing and child self-reported pain, with children who completed the CPT second reporting higher levels of state pain catastrophizing ($M=14.09$; $SD=10.79$ vs. $M=18.04$; $SD=12.62$; $t=-2.21$, $p<.05$) and higher pain intensity ($M=5.08$; $SD=3.02$ vs. $M=4.19$; $SD=2.80$; $t=-1.98$, $p<.05$). Given these findings, task order was controlled for in all subsequent analyses involving child state pain catastrophizing or child self-reported pain intensity.

Child and Parent Pain Catastrophizing and Observed Parent and Child Behaviours

Means and correlations between child and parent measures of pain catastrophizing (trait and state) and observed behaviours are reported in Table 1. Based on clinical reference points derived from children with chronic pain [59], children with low ($n=58$; 33.9%), moderate ($n=49$; 28.7%), and high ($n=64$; 37.4%) levels of trait pain catastrophizing were represented. On average, children engaged in greater proportions of symptom complaints as compared with other talk, and parents engaged predominantly in pain attending talk, followed by other talk and non-attending talk.

Parent Attending Talk

In model 1 (model including trait pain catastrophizing), covariates of child behaviours

and child age accounted for 19.0% of variance in parent pain attending talk (Step 1: $R=.436$, $F(3, 167)=13.03$, $p<.01$), with only child symptom complaints adding significantly ($\beta=.795$, $p<.01$). Neither child or parent trait pain catastrophizing (Step 2: $\Delta R^2=.015$, ns), nor their interaction (Step 3: $\Delta R^2=.000$, ns), were significant predictors.

In model 2 (model including state pain catastrophizing), covariates of child behaviours, child age, and task order accounted for 19.0% of variance parent pain attending talk (Step 1: $R=.436$; $F(4,166)=9.75$, $p<.01$), with only child symptom complaints adding significantly ($\beta=.801$, $p<.01$). Similar to model 1, neither child or parent state pain catastrophizing (Step 2: $\Delta R^2=.010$, ns), nor their interaction (Step 3: $\Delta R^2=.000$, ns), were significant predictors.

Parent Non-Attending Talk

In model 1 (model including trait pain catastrophizing), covariates of observed child behaviours and child age accounted for 30.4% of variance in parent non-attending talk (Step 1: $R=.551$, $F(3, 167)=24.31$, $p<.01$), with only child other talk adding significantly ($\beta=.539$, $p<.05$). Neither child or parent trait pain catastrophizing (Step 2: $\Delta R^2=.006$, ns), nor their interaction (Step 3: $\Delta R^2=.000$, ns), were significant predictors.

In model 2 (model including state pain catastrophizing), observed child behaviours, child age, and task order accounted for 30.5% of variance (Step 1: $R=.552$, $F(4, 166)=18.19$, $p<.01$), with only child other talk adding significantly ($\beta=.590$, $p<.05$). Neither child or parent state pain catastrophizing (Step 2: $\Delta R^2=.017$, ns), nor their interaction (Step 3: $\Delta R^2=.000$, ns), were significant predictors.

Child Symptom Complaints

In model 1 (model including trait pain catastrophizing), covariates of observed parent behaviours and child age accounted for a significant 32.1% of variance in child symptom

complaints (Step 1: $R=.567$, $F(4, 166)=19.64$, $p<.01$), with child age ($\beta=-.156$, $p<.05$) and parent non-attending talk ($\beta=-.739$, $p<.01$) adding significantly. Neither child or parent trait pain catastrophizing (Step 2: $\Delta R^2=.014$, ns), nor their interaction (Step 3: $\Delta R^2=.005$, ns), were significant predictors.

In model 2 (model including state pain catastrophizing), observed parent behaviours, child age, and task order accounted for a significant 32.2% of variance (Step 1: $R=.568$, $F(5, 165)=15.69$, $p<.01$), with child age ($\beta=-.157$, $p<.05$), parent non-attending talk ($\beta=-.746$, $p<.01$), and parent other talk ($\beta=-.386$, $p<.05$) adding significantly. Child and parent state pain catastrophizing (step 2), and their interaction (step 3) all added significantly ($\beta=.247$, $p<.01$, $\beta=.214$, $p<.01$, $\beta=-.131$, $p<.05$, respectively), with the final model accounting for 44.2% of variance in child symptom complaints ($R=.665$, $F(8,162)=16.06$, $p<.01$).

Additional probing of the significant interaction between child and parent state pain catastrophizing was conducted following a recommended process for interpreting significant interactions with continuous variables [43]. To avoid artificially dichotomizing participants into two groups, two new conditional moderator variables were computed at high (+1 SD above the mean) and low (-1 SD below the mean) values using data from all dyads, allowing examination of conditional effects of the continuous moderator on the outcome [43]. To illustrate the interaction effect, regression lines were calculated and plotted (see Figure 2). These analyses indicated that the relation between child state pain catastrophizing and child symptom complaints was only significant at low levels of parent state pain catastrophizing ($\beta=.378$, $p<.01$), but not at high levels of parent state pain catastrophizing ($\beta=.130$, ns). Additional analyses revealed that higher levels of parent state pain catastrophizing were associated with greater child symptom complaints, but only when levels of child state pain catastrophizing were low ($\beta=.343$, $p<.01$)

and not when levels of child state pain catastrophizing were high ($\beta=.095$, *ns*). Stated otherwise, children with high levels of state pain catastrophizing had greater symptom complaints regardless of the level of parent state pain catastrophizing; whereas children with low levels of state pain catastrophizing had significantly more symptom complaints only with parents who reported high levels of state pain catastrophizing.

The significant findings relating child and parent trait and state pain catastrophizing and observed behaviours during child pain are summarized in Figure 3.

Child and Parent Pain Catastrophizing and Child Pain Outcomes

Means and correlations for child pain outcomes with child and parent measures of pain catastrophizing (trait and state) are reported in Table 2. No significant differences were noted between children's and parents' ratings of child pain intensity ($t(170)=-.902$, *ns*) or pain unpleasantness ($t(170)=-.653$, *ns*). Table 3 presents the actor and partner effects, and interactions, for trait and state pain catastrophizing on ratings of child pain intensity and pain unpleasantness.

Pain Intensity

For trait pain catastrophizing, only significant actor effects for the child were observed for self-reported pain intensity. No actor effect for parents, and no partner effects were found.

For state pain catastrophizing, significant actor and partner effects were observed for ratings of children's pain intensity, as well as significant interactions between respondent (parent or child) by actor and respondent by partner effects. More specifically, although both children and parents' state pain catastrophizing predicted their own ratings of child pain intensity, this relation was significantly stronger for children. The partner effects were stronger and only significant for parents, meaning that child state pain catastrophizing predicted parent ratings, while parent state pain catastrophizing did not predict child ratings.

Pain Unpleasantness

For trait pain catastrophizing, significant actor effects were observed for both children and parents, indicating a direct relation between children and parents' trait pain catastrophizing and their own ratings of child pain unpleasantness. No partner effects or interactions were found.

For state pain catastrophizing, significant actor effects and a significant respondent by actor interaction was found, indicating that while both children and parents' state pain catastrophizing predicted their own ratings of child pain unpleasantness, this relation was significantly stronger for children. Significant partner effects were also observed for ratings of child pain unpleasantness, although this was only for parents, meaning that child state pain catastrophizing additionally predicted parent ratings, but not vice versa.

Pain Tolerance

In model 1 (model with trait pain catastrophizing), child age accounted for 7.2% of variance in pain tolerance (Step 1: $R=.268$; $F(1, 169)=13.08$, $p<.01$). Neither child or parent trait pain catastrophizing (Step 2: $\Delta R^2=.006$, *ns*), nor their interaction (Step 3: $\Delta R^2=.004$, *ns*), were significant predictors of child pain tolerance.

In model 2 (model including state pain catastrophizing), covariates of child age and task order accounted for 7.4% of variance in pain tolerance (Step 1: $R=.272$; $F(2,168)=6.74$, $p<.01$), with only child age adding significantly ($\beta=-.269$, $p<.01$). Child and parent state pain catastrophizing accounted for an additional 9.0% of variance (Step 2: $R=.405$; $F(2,166)=8.91$, $p<.01$), with only child state pain catastrophizing adding significantly ($\beta=-.278$, $p<.01$). The interaction between child and parent state pain catastrophizing added no predictive value (Step 3:

$\Delta R^2=.007, ns$).¹

Discussion

This dyadic investigation was ideally suited for examining intra- and inter-personal influences of child and parent pain catastrophizing in the process of children's pain communication. Analyses revealed interpersonal influences of parent state pain catastrophizing on child symptom complaints, and child state pain catastrophizing on parent ratings of child pain. These findings contribute new information to growing evidence identifying catastrophizing about child pain by children and parents as interdependent mechanisms that influence expression and perception of, as well as responses to, children's pain [27,52,87].

A novel finding was the significant interaction between child and parent state pain catastrophizing in predicting child symptom complaints. Children with higher state pain catastrophizing had greater symptom complaints, consistent with previous research [79,80,83]. In line with models of pain communication [21,37,38], this could reflect a communal coping approach to pain, which posits increased pain expression amongst individuals with high pain catastrophizing as a means of eliciting support from others to manage pain and distress [67]. However, given that similar higher amounts of symptom complaints occurred irrespective of parent state pain catastrophizing, this may not reflect any communicative function, but rather

¹ Investigations of normality of pain tolerance revealed the distribution to have substantial negative kurtosis (-1.95). Recommended data transformations were unsuccessful at approximating normality [71]. Given that the bimodal distribution and ceiling effect for pain tolerance are often seen in pediatric CPT studies [4,5], including the current study, two logistic regressions were also conducted examining child and parent trait or state pain catastrophizing in children with low versus high pain tolerance. Children who kept their hand immersed until the maximum allowable immersion time of four minutes (i.e., CPT ceiling) were categorized as having high pain tolerance; all others were categorized as low pain tolerance. An identical pattern of results was found as with hierarchical multiple regressions.

indicate poor self regulatory coping processes [61]. This is consistent with research indicating that children with high pain catastrophizing engage indiscriminately in greater facial pain expression [79]. Higher state pain catastrophizing of children, but not parents, predicted lower pain tolerance, which may also communicate difficulty coping to parents [87].

Children with low state pain catastrophizing and a parent with high state pain catastrophizing had increased symptom complaints, at levels comparable to children with high state pain catastrophizing. This suggests modulation of children's verbal pain expression based on parent pain catastrophizing, although more research is needed to determine specific mechanisms. It may reflect learned behaviours modeled by parents with high pain catastrophizing or parental reinforcement of child pain behaviours [27,29,35]. Although children with low pain catastrophizing appear less dependent on others to cope with pain [80], they reportedly engage in greater facial pain expression when parents versus strangers are present, probably because a solicitous response is more likely [79]. The current study extends those findings by suggesting that parental presence exerts a greater influence on verbal pain expression of children with low pain catastrophizing, specifically when parents have high pain catastrophizing. Given that children with low pain catastrophizing display less facial pain expression, and that parents with higher trait pain catastrophizing increasingly attend away from low facial pain expressions [78], it is also possible that these children engage in greater symptom complaints in an effort to maintain parental attention and support. Greater symptom complaints could also arise from greater pain attending talk by parents with higher pain catastrophizing; although no impact of parent or child pain catastrophizing on parent behaviours was observed. When integrating current and prior findings, it is important to note that facial pain expression reflects more automated processes as compared with verbal pain expression, which depends on

higher mental processes [23,37].

It is probable there are different concurrent mechanisms through which symptom complaints are increased depending on child and/or parent state pain catastrophizing. Nevertheless, interpersonal fear avoidance processes suggest that high parent pain catastrophizing places children with low pain catastrophizing at greater risk for maladaptive pain cognitions and coping, than they would be with a parent with low pain catastrophizing or if considered on their own [32]. Taken together, our findings suggest that the social environment has a stronger influence on the verbal pain behaviours of children with low pain catastrophizing; whereas the internal environment appears more central for children with high pain catastrophizing. Although no significant role of child chronic pain was observed, it remains relevant to future research, as children with chronic pain reportedly engage in fewer verbal expressions of pain to their parents despite generally higher pain catastrophizing [80].

As expected, greater trait and/or state pain catastrophizing by children and parents predicted their own higher ratings of child pain intensity and unpleasantness [10,27,33,79,83,84]. Only parent trait pain catastrophizing did not predict parent ratings of child pain intensity. The interpersonal influence of child state pain catastrophizing on parent ratings has not been previously reported, and likely occurs due to greater pain expression by children with high pain catastrophizing [79,82,83]; however, parents appear differentially sensitive to children's pain expression based on their own pain catastrophizing [78]. Similar to prior work [10], no interpersonal influence of parent pain catastrophizing on child-reported pain was found. Child pain catastrophizing appears most critical to children's internal pain experience, regardless of parent pain catastrophizing and symptom complaints. Future research should explore what dyadic variations of child and parent pain catastrophizing contribute to greater congruency in

child pain ratings [33,82]. Altogether, these findings support both bottom-up (child pain expression) and top-down (parent characteristics) processes in observers' perceptions of other's pain [21,23,30,37,38,79,80,82-84].

A lack of significant associations between overall levels of child and parent pain catastrophizing (trait or state) was inconsistent with research in pediatric chronic pain [25,49,59,62,89,91], but aligns with studies of pediatric post-surgical or procedural pain [52,84,87]. It could be that children and parents come to view pain more similarly through the shared experience of chronic pain, particularly for those who may have a predisposition to cope poorly [49]. Our findings also highlight the important distinction between state and trait pain catastrophizing, and the salience of the former to experimental pain. This is consistent with prior work that more strongly implicates state pain catastrophizing in experimental pain in adults with and without chronic pain [16]. Future research should explore relations between state and trait pain catastrophizing in children and parents, as research indicates that trait pain catastrophizing predisposes individuals to higher state pain catastrophizing, and strengthens maladaptive associations between state pain catastrophizing and daily fluctuations in chronic pain [10,65,66].

Clinically, our findings indicate that both child and parent catastrophic thoughts about specific child pain should be considered, as they were more influential to immediate behaviours and pain experience than dispositional beliefs about pain. Children reporting low pain catastrophizing who have a parent reporting high pain catastrophizing may be more likely to express their pain, placing them also at-risk for pain-promoting interactions and increased pain. Although distraction is generally efficacious for children's acute pain [76], it does not appear effective for children with high pain catastrophizing [77] and is likely ineffectively delivered by parents with high pain catastrophizing given their susceptibility to increased distress [14,26].

Children with high pain catastrophizing may obtain greater benefit from interventions focusing attention on pain in an accepting and non-judgmental way [58,60] or using cognitive-behavioural strategies to restructure catastrophic thoughts [44]. Experimental research with adults offers promising evidence for a brief psychological intervention to reduce state pain catastrophizing, and subsequently improve pain [73], although research specific to children and parents, and clinical pain, is needed. To our knowledge, no interventions explicitly targeting parent pain catastrophizing have been tested, although highly anxious parents, such as those who catastrophize about their child's pain, show decreased distress when directed to focus on versus avoid their child's pain [86].

A limitation of this study is the use of experimental pain. Although parent- and child-report suggest ecological validity of observed behaviours, evidence supporting the external validity of CPT findings is limited [2]. Fear and nervousness regarding the CPT may be more comparable to that experienced during a needle for children with high levels of pain catastrophizing [10]; however, investigation during clinical pain would be valuable. Although child and parent state pain catastrophizing measures have been used [10], were developed from well-validated and reliable trait measures [24,31], and showed acceptable reliability and preliminary construct validity in this study, there is little information regarding their psychometric properties. Significant strengths of this study include its sample size and dyadic analysis with parents and children [20,45], observational methods [19], and >20% representation of fathers who are underrepresented in pediatric pain research [1].

Future research should investigate mechanisms through which observed interpersonal influences of child and parent pain catastrophizing are initiated or maintained. Sequential analysis of parent-child interactions during children's acute pain has revealed important nuances

in the complex bidirectionality of these exchanges [72]. Another goal is to test these intra- and inter-personal influences in an integrated model, taking into account other parent (e.g., distress, sex)[14,39,85], child (e.g., age, sex)[4,8], and contextual (e.g., pain-related threat)[10,15,92] factors shown to influence behaviours and perceptions of children's pain. The relevance of parental chronic pain has received increasing attention, as their children appear at increased risk for a number of maladaptive outcomes [42], including greater pain catastrophizing [94]. Parental chronic pain should be assessed in future studies.

To date, investigations of child and parent pain catastrophizing in the process of pain communication have predominantly explored the constructs in isolation from one another. This dyadic investigation revealed newly identified interpersonal influences of parent and child state pain catastrophizing on children's verbal pain expression and parent appraisals of child pain. Findings reiterate the complex social context of pain communication, and identify the relevance of both child and parent coping to treatment selection, and when interpreting perceptions of children's pain.

Acknowledgements

This study forms part of K.A. Birnie's PhD thesis. While conducting this study, K.A. Birnie was a Vanier Canada Graduate Scholar (Canadian Institutes of Health Research; CIHR) and a Killam Scholar, as well as a trainee member of Pain in Child Health (PICH): a Strategic Training Initiative in Health Research through CIHR. Funding for this study was received through the Society of Pediatric Psychology's Marion and Donald Routh Student Research Grant, the Canadian Pain Society's Trainee Research Award (Clinical), and the Department of Psychiatry Research Fund at Dalhousie University, as well as grant funding from CIHR awarded to C. T. Chambers. C.T. Chambers was supported by a Canada Research Chair during the conduct of this research. The authors wish to thank Leah Wofsy, Hayley Stinson, Colleen O'Connor, Lauren Lumsden, Aimee Dort, Nicole Hart, and Nicole Gray for their research assistance. The authors also wish to thank Dr. Lynnda Dahlquist for her feedback on an earlier version of this manuscript. The authors have no conflicts of interest to disclose.

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Figure Legend

Fig. 1 General model of actor and partner effects of pain catastrophizing on child pain outcomes.

Fig. 2 Regression lines for the significant interaction between child and parent state pain catastrophizing in predicting child symptom complaints.

Fig. 3 Model of significant findings relating child and parent pain catastrophizing and observed parent-child behaviours during the CPT.