The Role of State Anxiety in Children’s Memories for Pain

Melanie Noel,1 MSc, Christine T. Chambers,1,2 PhD, Patrick J. McGrath,1,2,3 PhD, Raymond M. Klein,1 PhD, and Sherry H. Stewart,1,3,4 PhD
1Department of Psychology, 2Department of Pediatrics, 3Department of Psychiatry, 4Department and Community Health and Epidemiology, Dalhousie University

All correspondence concerning this article should be addressed to Melanie Noel, Centre for Pediatric Pain Research, IWK Health Centre, 5850/5980 University Avenue, Halifax, NS, Canada B3K 6R8.
E-mail: melanie.noel@dal.ca

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Objective To investigate the impact of experimentally manipulated state anxiety and the influence of anxiety-related variables on children’s memories for pain. Methods A total of 110 children (60 boys) between the ages of 8 and 12 years were randomly assigned to complete a state anxiety induction task or a control task. Following experimental manipulation, children completed a laboratory pain task, pain ratings, and questionnaire measures of anxiety-related variables. 2 weeks later, children provided pain ratings based on their memories of the pain task. Results The experimental manipulation effectively induced state anxiety; however, pain memories did not differ between groups. Irrespective of group assignment, children with higher state anxiety had more negative pain memories. State anxiety uniquely predicted children’s pain memories over and above other well established factors. Anxiety sensitivity and trait anxiety were significant predictors of recalled pain-related fear. Conclusions These data highlight the importance of anxiety in the development of children’s memories for pain.

Key words anxiety sensitivity; children; fear; memory; pain; state anxiety; trait anxiety.

Medical procedures including immunizations and venipunctures are a common source of pain in childhood (Public Health Agency of Canada, 2006). In addition to experiencing pain during medical procedures, many children also experience fear before procedures even begin, which can heighten a child’s pain perception (Rhudy & Meagher, 2003). The impact of pain and fear can persist long after medical procedures end; the manner in which children remember painful experiences can influence how they cope with and manage future painful procedures (Chen, Zeltzer, Craske, & Katz, 2000). Pain memories are rooted early in life (for reviews see: Ornstein, Manning, & Pelpfrey, 1999; von Baeyer, Marche, Rocha, & Salmon, 2004). Children as young as six months of age can form memories of painful procedures that then influence their reactions to future painful procedures (Taddio, Katz, Ilerisch, & Koren, 1997; Weisman, Bernstein, & Schechter, 1998). Early pain memories can persist into adulthood and influence the level of fear and avoidance of medical care later in life (Pate, Blount, Cohen, & Smith, 1996). It has been suggested that memories for pain may initiate the development and maintenance of chronic pain syndromes over time (Flor & Birbaumer, 1994; Sun-ok & Carr, 1999). In fact, memories for pain are often a better predictor of future pain experiences than the initial experience of pain itself (Gedney & Logan, 2006).

1 These studies demonstrated that previous painful experiences could cause changes in infants’ behavioral reactions to subsequent pain, suggesting that the infants were sensitized to pain. As noted in a review by von Baeyer et al. (2004), it is possible that these infants had learned to anticipate pain cues and formed some form of long-term memory of the pain experience. These types of long-term memories are implicit (unconscious, nonverbal) and differ from explicit memories (conscious, verbal).
Although young children’s recall of previous painful experiences can be accurate (Badali, Pillai, Craig, Geisbrecht, & Chambers, 2000; Lander, Hodgins, & Fowler-Kerry, 1992), remembering is an interpretive process and memories are continually being reconstructed, which makes them susceptible to distortion over time (Bruck, Ceci, Fracouer, & Barr, 1993). Negatively distorted memories of painful medical procedures have been linked to greater distress during subsequent procedures (Chen, Zeltzer, Craske, & Katz, 1999). Furthermore, the level of distress that children experience during painful procedures influences the manner in which pain memories are framed. Across a range of medical procedures, children who report higher levels of pain and distress (e.g., trait anxiety, pain intensity, behavioral distress) tend to develop negatively exaggerated pain memories (Chen et al., 2000; Noel, McMurtry, Chambers, & McGrath, 2010; Rocha, Marche, & von Baeyer, 2009); however, this research has primarily been correlational, which has precluded examination of the causal impact of distress on memory.

Theorists have posited that memory biases exist because highly trait anxious individuals selectively encode and/or retrieve threatening information (Eysenck, Derakshan, Santos, & Calvo, 2007), particularly when those individuals experience high levels of state anxiety (i.e., short-term anxiety that arises in threatening situations; Beck & Clarke, 1997). However, research has largely neglected investigating the role of state anxiety in children’s memories for pain, perhaps due to previous assertions of a lack of relationship between the two (Lander et al., 1992; Versloot, Veerkamp, & Hoogstraten, 2008), which could have been due to methodological issues (e.g., timing of the measurement of state anxiety, reliance on parent- vs. self-report measures). Moreover, no study to date has directly examined the impact of state anxiety prior to an acute pain experience on children’s memories for pain.

In addition to trait and state anxiety, anxiety sensitivity (i.e., the fear of anxiety-related sensations) could also influence children’s pain memories. Anxiety sensitivity is a trait-like variable that is thought to heighten one’s propensity to experience anxiety which then increases pain perception (Schmidt & Cook, 1999; Stewart & Asmundson, 2006). Indeed, there is evidence of a robust relationship between child anxiety sensitivity and pain-related anticipatory anxiety, which is a strong predictor of children’s pain ratings during laboratory pain (Tsao, Lu, Kim, & Zeltzer, 2006). In addition, anxiety sensitivity in adults has been found to be related to memory biases toward threat-related information (McCabe, 1999). Nevertheless, no study has examined the influence of anxiety sensitivity on children’s memories for pain, particularly in the context of other important anxiety-related variables.

The current laboratory-based study investigated the impact of experimentally manipulated state anxiety on children’s memories for pain. The impetus for inducing state anxiety among children in the present study was to examine the impact of state anxiety on pain memories as well as to ensure sufficient variability in levels of state anxiety among children immediately prior to completing the pain task. Unlike medical procedures, children do not report being anxious prior to completing laboratory pain induction tasks like the cold pressor task (Tsao, Myers, Craske, Bursch, Kim, & Zeltzer, 2004; Wilby, Chambers, & Perrot-Sinal, 2010). As such, induction of state anxiety was also deemed necessary in order to establish a greater degree of ecological validity and to provide a more accurate analog of a clinical medical procedure context. Therefore, in addition to investigating the impact of experimentally induced state anxiety on pain memories, it was also of conceptual interest to examine state anxiety as a continuous variable that varied among children and that might impact the framing of their pain memories. As such, this study also examined the influence of anxiety-related individual difference variables on children’s recall of pain using a correlational design. It was hypothesized that children in the state anxiety induction group would have more negative pain memories than children in the control group. Additionally, it was hypothesized that children with higher scores on a variety of anxiety-related questionnaires (state and trait anxiety, anxiety sensitivity) would also have more negative memories of pain.

Method

The data for this article was collected as part of a larger study examining two distinct research questions that are presented in two empirical papers. The present article examined the impact of state anxiety on children’s memories for experimental pain, as well as the influence of anxiety-related individual difference variables on their recall. The other article by Noel et al. (in press) examined the influence of children’s pain memories on their expectations and experience of a subsequent painful experience, through investigation of changes in children’s distress during multiple exposures to the same pain stimulus over time. This other paper utilized data obtained from an additional laboratory visit, which was not included in the present article and is not relevant to the research questions or aims of the present investigation. As a result, the methods reported below contain only those details relevant
to the present study and are an abbreviated version of the larger study protocol. All study materials and procedures were approved by the health centre research ethics board (REB).

**Participants**

Participants were 110 healthy children (60 boys, 50 girls; $M_{\text{age}} = 9.45$ years, $SD = 1.35$) and one of their parents/guardians (99 mothers, 1 stepmother, 9 fathers, 1 stepfather; $M_{\text{age}} = 40.3$ years; $SD = 5.94$). By parent-report, the majority of participating children and parents were identified as “white” (86.4%; $n = 95$). The educational breakdown of the parents was self-identified as follows: (a) graduate school/professional training ($n = 30$); (b) university graduate ($n = 39$); (c) partial university (i.e., at least 1 year) ($n = 5$); (d) trade school/community college ($n = 25$); (e) high school graduate ($n = 9$); or (f) some high school ($n = 2$). Children in the state anxiety induction group did not differ from children in the control group on any of the demographic variables (e.g., age, sex, ethnicity, parental education).

In order to participate in the study, children had to be between 8 and 12 years of age and accompanied by a parent/guardian. Participants were excluded from the study if they did not speak English as a first language or had developmental delays or significant hearing or vision impairments. Participants were also excluded if children had been diagnosed with an Anxiety Disorder or Attention Deficit Hyperactivity Disorder and/or had chronic illnesses or health-related medical conditions, including: circulation disorders; heart problems; injuries to their arms or hands. In order to ensure that memory for the experimental pain task was not affected by previous scripts of similar pain experiences, children who had previously completed the experimental pain task (the cold pressor task) were excluded. Finally, children were excluded from the study if they experienced pain (such as headaches, stomach aches, ear/throat pain, muscle or joint pain) on a regular basis (i.e., at least once a month for three consecutive months) that was typically of moderate or severe intensity, that interfered with school or social functioning, and/or for which they took medication. Following enrolment, no families withdrew from the study and no adverse events were reported.

**Measures**

**Pain Intensity**

Pain intensity was measured using the one-item Faces Pain Scale-Revised (FPS-R; Hicks, von Baeyer, Spafford, van Korlaar, & Goodenough, 2001). The FPS-R consists of six gender-neutral faces depicting “no pain” (neutral face) to “most pain possible” expressions. Children select a face that represents how much pain she/he feels and the faces are scored: 0, 2, 4, 6, 8, and 10. The FPS-R is the most psychometrically sound self-report measure of pain intensity in children between the ages of 4 and 12 years (Stinson, Kavanagh, Yamada, Gill, & Stevens, 2006).

**Pain-related Fear**

Pain-related fear was measured using the one-item Children’s Fear Scale (CFS; McMurtry, Noel, Chambers, & McGrath, 2011), which was adapted from the Faces Anxiety Scale (McKinley, Coote, & Stein-Farbury, 2003). The CFS consists of five faces representing varying degrees of anxiety/fear. Children are instructed to select a face that represents how scared she/he feels and the ordered faces are scored from 0 to 4. The CFS has shown good evidence of test-retest ($r_s = .76, p < .001$) and inter-rater ($r_s = .51, p < .001$) reliability as well as construct validity among children (McMurtry et al., 2011).

**Anxiety**

**Visual Analog Scale**

Using a 10-cm visual analog scale (VAS) with the anchors “not nervous/anxious” and “most nervous/anxious”, children provided self-report ratings (VAS–child) and parents provided proxy ratings (VAS–parent) of children’s state anxiety. Possible scores ranged from 0.00 to 10.00 cm. VASs have previously been used to measure child anxiety among children (Chen, Craske, Katz, Schwartz, & Zeltzer, 2000) and parents (Smith, Shah, Goldman, & Taddio, 2007). There is evidence for the validity of a 10-cm VAS to assess perioperative anxiety among children aged 7–16 years. (Bringuier et al, 2009).

**State Trait Anxiety Inventory for Children (STAIC; Spielberger, 1973)**

Children’s state and trait anxiety was measured using the STAIC. The STAIC consists of both state and trait subscales containing 20 items each. The items on the state subscale of the STAIC (STAIC-s) ask children to rate how they feel at a particular moment in time. The tool was designed to measure transitory anxiety states (i.e., subjective and consciously perceived feelings of state anxiety that vary in intensity and that can fluctuate over time), which are typically elevated in stressful situations. The items on the trait subscale of the STAIC (STAIC-t) ask children to rate how they generally feel and measures relatively stable individual differences in the tendency to experience anxiety states and perceive situations as threatening. The STAIC-s has been found to have good internal consistency (Cronbach’s $\alpha = .82–.87$) and evidence of construct
validity. Similarly, the STAIC-t shows evidence of good internal consistency ($\alpha = .78 \sim .81$) and concurrent validity (Spielberger, 1973). Given the strong psychometric properties of the STAIC-s, this measure was used as the operationalization of state anxiety in all primary analyses.

**Anxiety Sensitivity**

Anxiety sensitivity was measured using the Childhood Anxiety Sensitivity Index (CASI; Silverman, Fleisig, Rabian, & Peterson, 1991), which consists of 18 items that assess the tendency to interpret anxiety-related bodily sensations as threatening (e.g., “It scares me when I have trouble getting my breath”). The CASI has been found to have adequate test-retest reliability (range $= .62 \sim .78$ over 2 weeks) and high internal consistency ($\alpha = .87$; Silverman et al., 1991). Although the measure has a moderate correlation with trait anxiety ($r = .55 \sim .69$), the construct explains variance in fear that is unaccounted for by trait anxiety (Weems, Hammond-Laurence, Silverman, & Ginsburg, 1998).

**State Anxiety Induction Task**

Children assigned to the state anxiety induction group completed a modified version of the Trier Social Stress Task for Children (TSST-C; Buske-Kirschbaum et al., 1997), in which they anticipated having to complete the task vs. actually completing it. Like the unmodified task, the modified version used in the current study involved bringing children into a room containing three chairs, a table, three clipboards containing red pens and rating tools, a television, and a video camera on a tripod. Children completing the TSST-C were told that they would be asked to prepare and deliver a speech in front of three judges who were doctors and researchers in the hospital and who had experience judging public speaking competitions with children their age. They were told that the judges would be rating and evaluating their speeches for quality and that they would be videotaped during that time. Children were instructed that they would have 4 min to prepare the speech and 4 min to deliver the speech. Then, they were told that they would be asked to complete a difficult mental arithmetic task by subtracting specific numbers and that every time they provided an incorrect answer, they would be asked to complete the arithmetic task once again from the beginning. Finally, children were told that many children considered the task to be difficult and that the judges would be arriving soon.2 The TSST-C involves elements (e.g., uncontrollability, unpredictability, threats to the social self) that have been identified as being strong psychological triggers of the HPA axis that regulates the release of cortisol (i.e., the stress hormone; see Dickerson & Kemeny, 2004; Gunnar, Talge, & Herrera, 2009). Several studies have shown that the TSST-C and modifications of the task are successful in provoking heightened self-perceptions of stress and anxiety among children (Buske-Kirschbaum et al., 1997; 2003; Gunnar, Frenn, Wewerka, & Van Ryzin, 2009; Stroud et al., 2009). Moreover, anticipation of completing the TSST vs. actual completion of the task—which was the modified version of the TSST-C used in the present investigation—has been shown to be as effective in eliciting a stress/anxious response (e.g., increased subjective anxiety, perceived stress, heart rate, cortisol) as the actual completion of the task (Hermann, Vogl, & Maras, 2004).

**Control Task**

Children assigned to the control group were brought into the same room as children in the state anxiety induction group (described above) and were told that they would be asked to watch a nature video from the video series “Planet Earth” that showed different animals and wildlife. They were reassured that the video camera would not be used for them. Children were instructed that they would watch the video for 12 min and were told that many children thought that the videos were interesting.

**Cold Pressor Task**

The cold pressor task is an ethically acceptable pain induction technique for use with children (Birnie, Noel, Chambers, von Baeyer, & Fernandez, 2011). It involves children submerging their nondominant hand up to their wrist fold into 10°C water for an informed ceiling of 4 min. Children were asked to leave their hand in the water even if it was uncomfortable; however, they were told that they could remove their hand at any time if it became too uncomfortable or painful to leave it in. The cold pressor device was a commercially manufactured plastic cooler filled with water with a temperature that was maintained at $10 \pm 1°C$ (in keeping with published guidelines; von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005). A plastic screen separated the cooler into two sections and ice cubes were placed in the first section to cool the water. The device measured 43.5-cm long, 23.5-cm wide, and 28.0-cm deep. Children lowered their hand into the water in the second section through a round opening (13 cm in diameter) in the lid of the cooler. A bilge pump circulated the water to prevent local warming around the child’s hand.

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1 A copy of the experimental and control group scripts used in this study are available from the corresponding author upon request.

2
Procedure

Participants were recruited using paper and online advertisements distributed in the community surrounding the health centre. Interested parents contacted the research centre by telephone and completed a series of screening questions to determine study eligibility. Following screening, participating families came to the research centre for an initial visit. Parents and children were separated from each other and remained separated for the entire testing session. Parents provided full and informed consent from a separate adjoining room and watched the entire experiment via video monitors. Children provided assent; however, they were not fully informed about the nature of the experimental or control conditions (i.e., that they would not actually be required to fully complete the tasks). They were also not aware about the memory component of the study in order to ensure that their experience and ratings would not be affected by knowledge that their memories for the pain task would later be assessed. Following provision of assent, children completed the VAS–child to assess their baseline level of anxiety. Then, a different research assistant disclosed to the children to which group they had been randomly assigned. This research assistant assumed a friendly demeanor whereas the research assistant who obtained assent from children assumed a serious demeanor. The research assistant who obtained assent informed them that they did not have to complete the speech ("the judge could not make it") or watch the video ("the video equipment is not working"). Children then completed measures of trait anxiety and anxiety sensitivity using the STAIC-s and the CASI. The administration order of these scales was counterbalanced across children.

Prior to leaving the laboratory, parents were given a scaled envelope containing copies of the pain intensity and pain-related fear scales, which were individually contained in sealed and numbered envelopes. Parents were asked to refrain from opening the sealed envelope until a researcher called them to conduct the memory interview. They were also asked to minimize discussion about the experiment in the interim between the laboratory visit and subsequent telephone interview. Children were aware that a research assistant would call them in approximately two weeks to ask them questions; however, they were not aware that they would be asked about their memories of the pain experience. Prior to leaving the laboratory, appointments to conduct the telephone interviews were scheduled with parents.

Approximately 2 weeks following the laboratory visit (M = 14.00 days, SD = 1.24 days, Range = 9–19 days), parents were contacted over the telephone to conduct the memory interviews. Telephone interviews for research on children’s memory for cold pressor, venipuncture, and postoperative pain have been effectively conducted with children (Badali et al., 2000, Lander et al., 1992; Noel et al., 2010; Zonneveld, McGrath, Reid, & Sorbi, 1997). Previous memory research has used time frames ranging from 1 week to 1 year (e.g., Badali et al., 2000; Chen et al., 2000). The present study employed a 2-week time frame in an attempt to limit exclusions as a result of intervening pain experiences and attrition. This attempt was successful in that all participants (100%) who participated in the initial laboratory visit completed the telephone interviews. At the beginning of the interview, parents were asked to refrain from influencing their children’s responses so as to not bias their recall. The memory assessment followed a similar protocol to that used with children aged 5–10 years in previous research examining children’s memory for venipuncture and cold pressor pain (Badali et al., 2000; Noel et al., 2010). During the memory interview, children could not physically point to the faces in front of the researcher as they had done immediately following completion of the CPT. Therefore, to facilitate ease of telephone communication and to avoid introducing a confounding numerical scale, letters of the alphabet were placed in random order under the faces on each of the scales used during the telephone interviews. Children were re-instructed in the use of each rating scale and oriented to the placement of letters under each face. The order of scale presentation was counterbalanced and randomly numbered from 1 to 2 for ease of telephone communication. Children were asked to recall when they completed the CPT and provided pain intensity and pain-related fear ratings based on their memories of the pain task.
Results

Data Analysis

To determine if the experimental manipulation was effective in inducing state anxiety among children, independent samples t-tests were conducted between children in the state anxiety induction group and the control group on all state anxiety measures obtained immediately after completion of the TSST-C. Next, a series of between subjects analyses of covariance (ANCOVA) were conducted between the groups on their recalled pain and pain-related fear scores while controlling for initial pain intensity and pain-related fear scores. In order to examine the relative influences of anxiety-related variables on children’s recall, bivariate correlations were first conducted between key variables to justify their inclusion in predictive models. Similar to the approach taken by Gedney and Logan (2004), hierarchical linear regression modeling was used to test the ability of state anxiety (STAIC-s) to account for variance in 2-week recall of pain intensity and pain-related fear. Preliminary analyses revealed that girls had higher levels of baseline state anxiety [VAS–child; M = 3.56, SD = 2.40; M = 2.63, SD = 2.28, respectively; t (108) = 2.08, p < .05], anxiety sensitivity [M = 29.06, SD = 5.21; M = 26.47, SD = 5.03, respectively; t (108) = 2.65, p < .01] and trait anxiety [M = 34.44, SD = 6.32; M = 32.00, SD = 6.34, respectively; t (108) = 2.01, p < .05] than boys. Therefore, sex was controlled in the first step of all regression models. Stable anxiety-related variables (trait anxiety and anxiety sensitivity) were entered in step 2, 3 followed by baseline pain intensity and pain-related fear ratings in step 3. Finally, state anxiety (STAIC-s) was entered in step 4 to predict recall scores. Descriptive data for all included measures obtained at baseline, immediately postpain task, and during recall for the total sample and each experimental condition are shown in Table I.

Manipulation Check

Prior to being told which group they were in, children in the state anxiety induction group did not differ from children in the control group in their baseline levels of state anxiety [VAS–child; t (108) = .61, p > .05, \( \eta^2_p = .00 \)]. They also did not differ in levels of trait anxiety [t (108) = 1.40, p > .05, \( \eta^2_p = .02 \)] or anxiety sensitivity

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total Sample (N = 110)</th>
<th>State Anxiety Induction Group (n = 55)</th>
<th>Control Group (n = 55)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>Range</td>
<td>M (SD)</td>
</tr>
<tr>
<td>Baseline state anxiety (VAS–child)</td>
<td>3.05 (2.37)</td>
<td>0.00–9.70</td>
<td>3.19 (2.26)</td>
</tr>
<tr>
<td>State anxiety postmanipulation (VAS–child)</td>
<td>3.46 (2.60)</td>
<td>0.00–10.00</td>
<td>4.56 (2.31)</td>
</tr>
<tr>
<td>State anxiety postmanipulation (STAIC-s)</td>
<td>29.07 (4.98)</td>
<td>21.00–49.00</td>
<td>30.89 (5.81)</td>
</tr>
<tr>
<td>Experienced pain intensity (FPS-R)</td>
<td>3.22 (2.20)</td>
<td>0.00–10.00</td>
<td>2.91 (2.03)</td>
</tr>
<tr>
<td>Experienced pain-related anxiety (CFS)</td>
<td>0.45 (0.71)</td>
<td>0.00–4.00</td>
<td>0.38 (0.65)</td>
</tr>
<tr>
<td>State anxiety postmanipulation (VAS–parent)</td>
<td>33.11 (6.42)</td>
<td>20.00–51.00</td>
<td>32.25 (6.35)</td>
</tr>
<tr>
<td>Anxiety sensitivity (CASI)</td>
<td>27.65 (5.25)</td>
<td>18.00–41.00</td>
<td>26.96 (5.01)</td>
</tr>
<tr>
<td>Trait anxiety (STAIC-t)</td>
<td>0.70 (0.76)</td>
<td>0.00–4.00</td>
<td>0.65 (0.91)</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01, ***p < .001.
higher among children in the state anxiety induction that state anxiety was successfully manipulated and was significant. Levene’s Test for Equality of Variances was significant. 

\[ F (1, 108) = \frac{1}{4} \]

VAS–child scores revealed a significant interaction \( (1, 108) \) repeated measures analysis of variance (ANOVA) duration 

\[ F = 2.12, p = 0.00, \eta_p^2 = .17 \]

Subsequent paired samples \( t \)-tests revealed that child state anxiety as measured by the VAS–child significantly increased from baseline to postmanipulation for the state anxiety induction group only \( (108) = -5.88, p = 0.00 \). This suggests that state anxiety was successfully manipulated and was higher among children in the state anxiety induction group as compared to children in the control group.

### Impact of Experimentally Manipulated State Anxiety on Pain Memories

To determine the impact of experimentally manipulated state anxiety on children’s memories for pain, a series of between-subjects ANCOVAs were conducted between the state anxiety induction and control groups on remembered pain intensity and pain-related fear scores, while controlling for initial pain intensity and pain-related fear scores. Despite successful manipulation of state anxiety among children in the state anxiety induction group, there were no significant differences between children in the experimental and control groups on their memories for pain intensity \( (1, 107) = 0.45, p > .05, \eta_p^2 = .004 \) or pain-related fear \( (1, 107) = 0.04, p > .05, \eta_p^2 = .00 \).

### Correlations Between Key Variables

Overall, children who had higher levels of state anxiety (STAIC-s) immediately after exposure to the experimental and control task instructions recalled significantly higher levels of pain intensity \( r = .21, p < .05 \) and pain-related fear \( r = .26, p < .01 \) than children who had lower levels of state anxiety. Children with higher levels of trait anxiety and anxiety sensitivity recalled higher levels of pain-related fear \( r = .27, p < .01 \) than children who had lower levels of trait anxiety. Trait anxiety and anxiety sensitivity were significantly positively correlated with each other \( r = .64, p < .001 \). Experienced pain intensity was significantly positively correlated with experienced pain-related fear \( r = .27, p < .01 \) and both experienced pain intensity and pain-related fear were significantly positively correlated with recalled pain intensity \( r = .70, p < .01 \) and pain-related fear \( r = .49, p < .01 \), respectively) and pain-related fear \( r = .49, p < .01 \), respectively. These significant correlations in addition to theoretical and empirical support (e.g., Beck & Clark, 1997; Gedney & Logan, 2006; McNally, 1995; 1999) justify the inclusion of these variables in the regression models.

### Influence of Anxiety-Related Variables on Pain Memories

Table II presents results for all groups reporting the effect of sex, stable anxiety-related variables, experienced pain intensity, and state anxiety (STAIC-s) in predicting recalled pain intensity. After controlling for sex, stable anxiety-related variables (trait anxiety and anxiety sensitivity), and experienced pain intensity, state anxiety accounted for a significant portion of variance in recalled pain intensity. As expected, experienced pain intensity was also a unique predictor of recalled pain intensity. Collectively, this model accounted for 52% of the variance in recalled pain intensity.

Table III presents results for all groups reporting the effect of sex, stable anxiety-related variables, experienced pain-related fear and state anxiety (STAIC-s) in predicting

### Table II. Summary of Hierarchical Regression Analyses for State Anxiety Predicting Children’s Recalled Pain Intensity

<table>
<thead>
<tr>
<th>N = 110 (Entire Sample)</th>
<th>Variable</th>
<th>( \beta )</th>
<th>( \Delta R^2 )</th>
<th>( p \leq )</th>
<th>( \Delta R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Sex</td>
<td>0.031</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>Trait anxiety, Anxiety sensitivity</td>
<td>0.275</td>
<td>0.028</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Step 3</td>
<td>Experienced pain intensity</td>
<td>0.697</td>
<td>0.494</td>
<td>0.494</td>
<td></td>
</tr>
<tr>
<td>Step 4</td>
<td>State anxiety</td>
<td>1.158</td>
<td>0.318</td>
<td>0.318</td>
<td></td>
</tr>
</tbody>
</table>

Note. The following measures were used: STAIC-t (trait anxiety), CASI (anxiety sensitivity), FPS-R (experienced pain intensity), STAIC-s (state anxiety) in the regression model. Collectively, this model accounted for 52% of the variance in recalled pain intensity. When the order of steps 3 and 4 were reversed, both variables continued to account for a significant portion of the variance in recalled pain intensity suggesting that state anxiety did not mediate the relationship between experienced pain intensity and recall. *\( p < .05 \).
recalled pain-related fear. After controlling for sex, stable anxiety-related variables (trait anxiety and anxiety sensitivity), and experienced pain-related fear, state anxiety accounted for a significant portion of variance in recalled pain-related fear. As expected, experienced pain-related fear was also a unique predictor of recalled pain intensity. Stable anxiety-related variables (trait anxiety and anxiety sensitivity) also accounted for a significant portion of the variance in recalled pain-related fear. Collectively, this model accounted for 35% of the variance in recalled pain-related fear.

**Discussion**

Children’s memories for pain have implications for their health throughout life (Chen et al., 2000; Pate et al., 1996). Although the role of trait anxiety in pain memories has been previously investigated (Rocha et al., 2009), far less is known about the role of state anxiety in children’s memories for pain. This study represents the first examination of the impact of state anxiety on children’s memories for pain. It also extends research by examining the influence of general levels of state anxiety on children’s pain memories over and above the contributions of other well established factors implicated in those memories (e.g., experienced pain intensity and pain-related fear, and stable anxiety-related variables). Although state anxiety was successfully manipulated among children who underwent the state anxiety induction task (TSST-C), children in the experimental group did not develop pain memories that were more negative than those of children in the control group. However, irrespective of group assignment, children who reported higher levels of state anxiety recalled higher levels of pain intensity and pain-related fear than children with lower levels of state anxiety. Furthermore, the influence of state anxiety on pain memories persisted over and above the contributions of sex, trait anxiety, anxiety sensitivity and the powerful influence of pain intensity and pain-related fear experienced at baseline. Collectively, these models accounted for a large portion of the variance in children’s memories of pain intensity and pain-related fear (52% and 35%, respectively). This extends research on adult acute pain experiences (Gedney & Logan, 2004) to provide a similar model for earlier developmental periods.

There are several possible reasons why children in the state anxiety induction group did not have more negative memories than children in the control group; but, that irrespective of group, state anxiety was a significant predictor of pain memories. First, by comparing experimental groups using ANOVA (i.e., analyzing state anxiety as a categorical variable), there was less power to detect effects as compared to analyzing state anxiety continuously (Aiken & West, 1991). Moreover, the individual variation in state anxiety among children within each experimental group following the manipulation (e.g., higher state anxiety among some children in the control group; lower state anxiety among some children in the state anxiety induction group) was treated as random/error variance in ANOVA. Conversely, in the regression models, the individual variability in state anxiety among children in each group (when treated as a continuous variable) was used to predict individual memory scores, thereby capturing individual variation among children and creating power to detect effects. Second, there were likely other trait variables that were not accounted for in the current study such as individual coping style/attentional orientation (Krohne, 1993), which could have influenced whether or not individuals exhibited state anxiety in response to experimental instructions. Indeed, the relationship between anxiety and memory is thought to be mediated through attention, and high anxious individuals may differ in their attentional style (e.g., hypervigilant vs. avoidant of pain cues; see Krohne, 1993; Noel et al., in press). This could have introduced additional variability within experimental groups that might have obscured the ability to detect effects using ANOVA. Future research should investigate the impact of individual attentional style among highly anxious children to determine its impact on the development of their pain memories.

**Summary of Hierarchical Regression Analyses for State Anxiety Predicting Children’s Recalled Pain-Related Fear**

<table>
<thead>
<tr>
<th>N = 110 (Entire Sample)</th>
<th>Variable</th>
<th>β</th>
<th>ΔF</th>
<th>p&lt;</th>
<th>ΔR²</th>
<th>Cumulative R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Sex</td>
<td>.145</td>
<td>2.31</td>
<td>.132</td>
<td>.021</td>
<td>.021</td>
</tr>
<tr>
<td>Step 2</td>
<td>Trait anxiety, Anxiety sensitivity</td>
<td>.149, .169</td>
<td>4.61</td>
<td>.012*</td>
<td>.078</td>
<td>.099</td>
</tr>
<tr>
<td>Step 3</td>
<td>Experienced pain-related fear</td>
<td>.459</td>
<td>30.20</td>
<td>.001*</td>
<td>.201</td>
<td>.300</td>
</tr>
<tr>
<td>Step 4</td>
<td>State anxiety</td>
<td>.222</td>
<td>7.51</td>
<td>.01*</td>
<td>.047</td>
<td>.348</td>
</tr>
</tbody>
</table>

Note. The following measures were used: STAIC-t (trait anxiety), CASI (anxiety sensitivity), FPS-R (experienced pain intensity), STAIC-s (state anxiety) in the regression model. Collectively, this model accounted for 33% of the variance in recalled pain-related fear. When the order of steps 3 and 4 were reversed, both variables continued to account for a significant portion of the variance in recalled pain-related fear suggesting that state anxiety did not mediate the relationship between experienced pain-related fear and recall. *p < .05.
memories. Finally, regression models, unlike ANOVA, allowed for examination of the relative contribution of varying degrees of state anxiety on pain memories that were contextualized among the contributions of other important factors (e.g., sex, experienced pain and pain-related fear, stable anxiety-related variables). The relationship between state anxiety and children’s pain memories is likely complex and therefore examination of other factors that impinge on this relationship may be necessary to fully understand it.

The limited research that has previously examined state/preprocedural anxiety and children’s pain memories concluded a lack of relationship when assessed in clinical contexts (e.g., venipuncture, dental treatment; Lander et al., 1992; Versloot et al., 2008). However, limitations inherent in these study designs might have precluded accurate assessment of this relationship. For example, among children undergoing dental treatment, preprocedural pain was inferred by parent report of general dental fears that were not necessarily specific to the procedure that children later recalled. Moreover, these parents were not present during the dental treatments and therefore did not directly observe their children in the procedural context. Among children who underwent venipunctures (Lander et al., 1992), it is unclear whether or not state anxiety was measured immediately prior to the pain experience. Moreover, given the unpredictability inherent in clinical settings, it is unlikely that the duration between assessment of state anxiety and pain exposure was consistent across children, which could have introduced measurement error. The present laboratory-based study offers advantages over these previous investigations by enabling standardization of these variables across children. The fact that state anxiety was a significant predictor of more negative pain memories, even over and above the influences of stable anxiety-related variables and experienced pain, suggests that children who perceive themselves as being relatively more anxious immediately prior to a painful experience are at risk for developing negative pain memories. Although children higher in trait anxiety and anxiety sensitivity are more likely to experience relatively higher levels of state anxiety, this is not a perfect relationship and fails to capture the range of children who might exhibit higher levels of state anxiety prior to a painful experience (Tsao et al., 2006; Dorn et al., 2003). Children who are relatively less high in trait anxiety or anxiety sensitivity yet who still exhibit higher levels of state anxiety in a procedural context may not be identified a priori as being at risk for having negative pain experiences that could later shape their pain memories. Nevertheless, the present research suggests that children who have higher levels of state anxiety are at risk for developing negative pain memories, which could negatively affect their subsequent pain experiences. This implies that identification of, and intervention with, children with relatively higher levels of state anxiety in the immediate pain context may also be important for preventing such longitudinal outcomes.

The relationship between trait anxiety and children’s pain memories (Rocha et al., 2009), has been previously documented. Furthermore, there is a wealth of literature documenting the effect of trait anxiety (see review in Mitte, 2008) and anxiety sensitivity (for discussion see Noel et al., 2011) on memory for threatening information among adults. However, this is the first study to examine the relative contributions of stable anxiety-related variables, initial pain experience, and state anxiety to children’s pain memories. In addition to state and trait anxiety, the present study demonstrated the importance of anxiety sensitivity in influencing children’s memories of pain-related fear. To date, no study has examined the role of anxiety sensitivity (i.e., the fear of anxiety-related symptoms) in children’s memories for pain. Anxiety sensitivity is thought to heighten one’s susceptibility to experience anxiety which then increases pain perception (Schmidt & Cook, 1999; Stewart & Asmundson, 2006). It is also thought that anxiety sensitivity promotes catastrophic cognitions about pain and the development of fear of pain (Norton & Asmundson, 2004). Indeed, previous research revealed a robust relationship between child anxiety sensitivity and pain-related anticipatory anxiety, which is strongly predictive of children’s ratings of laboratory pain intensity (Tsao et al., 2006). The present study suggests that higher levels of anxiety sensitivity in addition to trait anxiety are predictive of more negative memories of pain-related fear but not pain intensity. This also suggests that children’s memories of pain-related fear, although related to their memories of pain intensity, encompass a unique aspect of children’s remembered pain experience. Memories of pain are multidimensional and involve representations of sensory (i.e., pain intensity), affective (i.e., fear/anxiety), and contextual aspects of the pain experience (O’Meara et al., 1999). Despite this, the majority of research on children’s memories for pain has primarily focused on recalled pain intensity as opposed to recalled pain-related fear (for an exception see Noel et al., 2010). Although memories for pain intensity and pain-related fear are related to one another, they reflect different aspects of the pain experience and have different relationships with established predictors of pain and pain memories (e.g., anxiety sensitivity and trait anxiety). Future research should further examine aspects of pain memories beyond the somatosensory...
representation in order to better capture the complexity inherent in children’s memories for pain.

In addition to several strengths, the present research had some potential limitations that highlight avenues for future empirical investigation in this area. First, the children included in the present study were healthy and did not have clinically significant levels of anxiety that warranted diagnosis of an anxiety disorder. As such, the generalizability of these findings to clinical samples of children with high levels of anxiety is currently unknown. Second, the research largely relied on self-report measures reflecting children’s subjective perceptions of their own levels of anxiety, pain intensity, and pain-related fear. Future examinations should assess anxiety and pain using a variety of measurement tools, including physiological and behavioral measures, as well as self- and proxy-report completed by different informants (e.g., children, parents, experimenters), as this would likely refine our understanding of the nature of these relationships. Finally, the anxiety-related measures used in the current study assessed children’s general levels of anxiety (i.e., their general tendency to perceive threat in their environments), as opposed to anxiety that is specific to pain-related threat. Indeed, similar to the present findings, previous research has shown that both anxiety sensitivity and trait anxiety are not consistently related to healthy children’s initial pain ratings following cold pressor pain induction in laboratory settings (Tsao et al., 2004). Moreover, although anticipatory anxiety related to pain has been found to strongly predict children’s initial pain reports (Tsao et al., 2004), the measure of state anxiety used in the current study did not assess state anxiety that was specific to pain; rather, children’s general levels of anxiety following exposure to task instructions was assessed. The lack of relationship between general state anxiety and experienced pain is consistent with previous research (Arntz, van Eck & Heijmans, 1990; Lander et al., 1992). On the other hand, the relationships between these general anxiety-related variables and children’s pain memories were expected and were likely found because higher scores on the anxiety-related measures reflected a tendency for children to develop more catastrophic cognitions, characterized by amplified perceptions of threat. These types of cognitions and associated appraisals could have contributed to negative exaggerations in memory over time as children recalled the pain experience in the interim between the first laboratory visit and the telephone interview. It is also possible that although children were instructed to provide recall ratings based on how they specifically felt about the pain task, their recalled pain ratings could have also reflected their perceptions of the overall emotional context surrounding the pain experience (i.e., the general level of threat that they perceived in their environments before and during the pain task) and not solely the somatosensory or affective experience related to pain. Future investigations should increase the specificity of anxiety constructs for pain contexts through the use of recently developed measures of pain-specific anxiety and fear (e.g., Pediatric Pain Fear Scale, Huguet, McGrath, & Pardos, 2011; Child Pain Anxiety Symptoms Scale, Pagé, Fuss, Martin, Escobar, & Katz, 2010). Such examinations could potentially increase the explanatory power of the models presented herein.

The impact of pain and fear is not over when the painful stimulus is removed. The quality of children’s pain experiences can influence the development of their pain memories over time. Although the relationship between children’s initial pain experience (e.g., self-reported pain intensity, behavioral distress), trait anxiety, and pain memories has been previously established (Chen et al., 2000; Noel et al., 2010; Rocha et al., 2009), the present study extends this research by showing that state anxiety is also an important and unique predictor of children’s memories for pain. This implies that children who report higher levels of state anxiety (irrespective of their natural tendencies to experience anxiety and fear and the quality of their initial pain experiences) will likely develop more negative pain memories. Previous research also suggests that these children may be at risk for experiencing greater distress at subsequent painful experiences (Chen et al., 2000) and developing fear and avoidance of medical care into adulthood (Pate et al., 1996). The present study also extends previous research by showing that anxiety sensitivity in addition to trait anxiety is an important predictor of the development of children’s memories for pain-related fear. There is evidence suggesting that a brief cognitive-behavioral intervention designed to reduce anxiety sensitivity among high anxiety sensitive individuals results in concomitant reductions in pain-related fear and anxiety in adults (Watt, Stewart, LeFäivre, & Uman, 2006). Although this has yet to be examined among children, it suggests potential avenues for intervention which could prevent the development of negative pain memories from forming.

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**References**


