Clinical relevance of attentional biases in pediatric chronic pain

Research Paper

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Clinical relevance of attentional biases in pediatric chronic pain: an eye-tracking study

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Abstract

Attentional biases have been posited as one of the key mechanisms underlying the development and maintenance of chronic pain and co-occurring internalizing mental health symptoms. Despite this theoretical prominence, a comprehensive understanding of the nature of biased attentional processing in chronic pain and its relationship to theorized antecedents and clinical outcomes is lacking, particularly in youth. This study used eye-tracking to assess attentional bias for painful facial expressions and its relationship to theorized antecedents of chronic pain and clinical outcomes. Youth with chronic pain (n = 125) and without chronic pain (n = 52) viewed face images of varying levels of pain expressiveness while their eye gaze was tracked and recorded. At baseline, youth completed questionnaires to assess pain characteristics, theorized antecedents (pain catastrophizing, fear of pain, and anxiety sensitivity), and clinical outcomes (pain intensity, interference, anxiety, depression, and posttraumatic stress). For youth with chronic pain, clinical outcomes were reassessed at 3 months to assess for relationships with attentional bias while controlling for baseline symptoms. In both groups, youth exhibited an attentional bias for painful facial expressions. For youth with chronic pain, attentional bias was not significantly associated with theorized antecedents or clinical outcomes at baseline or 3-month follow-up. These findings call into question the posited relationships between attentional bias and clinical outcomes. Additional studies using more comprehensive and contextual paradigms for the assessment of attentional bias are required to clarify the ways in which such biases may manifest and relate to clinical outcomes.

Keywords: Attentional bias, Eye-tracking, Pain facial expressions, Chronic pain, Youth, Pediatric, Pain catastrophizing, Anxiety sensitivity, Fear of pain, Anxiety, Depression, Posttraumatic stress

1. Introduction

Pediatric chronic pain has reached epidemic proportions, affecting 11% to 38% of youth.[37] Left untreated, many youth will experience chronic pain in adulthood[78] and are at heightened risk of mental health disorders even if pain resolves.[61] Symptoms of internalizing mental health disorders (anxiety, depression, and posttraumatic stress symptoms [PTSS]) co-occur with chronic pain at high rates[12,47,66] and are linked to worse pain, daily functioning, quality of life,[35,49,64] and treatment response.[19] The long-term impacts of pediatric chronic pain[78] and co-occurring mental health symptoms[61] call for an understanding of modifiable mechanisms that underlie their co-occurrence.

Theoretical models of adult and pediatric chronic pain, including mutual maintenance,[58] shared vulnerability,[1,30] and fear-avoidance models,[3,76] posit cognitive, affective, and behavioural mechanisms that underlie the development and maintenance of chronic pain and co-occurring internalizing mental health symptoms. These models conceptualize a key role for attentional bias (ie, preferential attention to salient/personally relevant information) as a cognitive mechanism underlying both chronic pain and co-occurring mental health symptoms.[1,30] Moreover, theorized antecedents of attentional biases, such as pain catastrophizing, anxiety sensitivity, and fear of pain, are posited as being associated with the development and maintenance of chronic pain and with internalizing mental health symptoms.[58]

Despite its prominence in theoretical models, a comprehensive understanding of the nature of attentional bias for pain and its relationship to clinical outcomes remains unclear, particularly in childhood and adolescence when pain often becomes chronic.[33] In our recent study that used eye-tracking to assess attentional bias for painful facial expressions in a clinical sample of youth with chronic pain and youth without chronic pain,[65] both groups exhibited attentional biases for painful facial expressions (ie, fixating longer on painful vs neutral faces). However, the mere existence of an attentional bias does not confirm that it has a role in shaping pain outcomes, as posited in conceptual models.[38,67] Very little empirical research has assessed how attentional biases relate to theorized antecedents and clinical outcomes in chronic pain.[18,70] Results of the few pediatric studies echo findings in

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adult samples, with inconsistent associations between attentional biases for pain, theorized antecedents, and outcomes.[7] Thus, the clinical relevance of attentional biases in pediatric chronic pain remains unknown.

In this study, youth with and without chronic pain viewed images depicting painful and neutral facial expressions while their eye gaze was tracked and recorded to measure their attention to the images. The purpose of this study was to (1) examine the association of theorized antecedents (anxiety sensitivity, pain catastrophizing, and fear of pain) with attentional bias in youth with chronic pain and (2) determine the relationship between attentional bias and clinical outcomes (pain and internalizing mental health symptoms) at baseline and 3-month follow-up. We hypothesized that higher levels of anxiety sensitivity, pain catastrophizing, and fear of pain would be associated with greater attentional bias for pain expressions. Furthermore, we hypothesized that greater attentional biases for pain expressions would be associated with worse clinical outcomes.

2. Methods

2.1. Participants

Participants consisted of a sample of youth (ie, children aged 10 years and younger and adolescents aged 12-18 years), 125 with chronic pain (71% girls, M_{age} = 14.10 years; SD = 2.21) and a comparison group of 52 youth without chronic pain (50% girls, M_{age} = 13.49 years; SD = 2.71). Participants were recruited as part of the Pain and Mental Health in Youth (PATH) study, a longitudinal research program investigating mechanisms underlying the co-occurrence of internalizing mental health symptoms and chronic pain. The aims of this study were distinct from previously published reports on the PATH study.[4,40–43,53,65] A subset of the participant data for the sample of youth with chronic pain (ie, baseline data from 102 participants) was analyzed in Soltani et al.[65] to examine the nature of attentional biases in youth with vs without chronic pain. Our initial analyses in the current study established whether the pattern of attentional biases found in Soltani et al. was also present in this larger sample. The primary aims of this study were then addressed in analyses that used both the baseline and follow-up data from the sample of youth with chronic pain only.

2.2. Youth with chronic pain

Youth were eligible for the study if they were between 10 and 18 years of age and were referred to a chronic pain program for pain assessment or treatment. Youth who did not speak English and those diagnosed with a developmental disorder were not eligible for the study. Participants were recruited from 3 outpatient clinics (headache, gastroenterology, and complex pain) housed within the pain and rehabilitation center of a children's hospital in Western Canada. Including a mixed sample of youth with a variety of pain conditions is consistent with previous research on pediatric chronic pain.[47,50,80] For recruitment purposes, clinical staff provided the study team with the contact information of new patients and patients who had received care in the pain clinics from 2016 to 2020. Research staff also generated a list of families who were participating in a clinical outcomes study and who had consented to be contacted about future studies. Research staff contacted potential participants to provide information about the study and invite participation. During recruitment, youth were confirmed to have experienced chronic pain for at least 3 months, consistent with the current definition of chronic pain endorsed by the International Association for the Study of Pain.[45]

2.3. Youth without chronic pain

Youth were eligible for this study if they were between 10 and 18 years of age and did not report the presence of chronic pain (ie, recurrent or persistent pain lasting 3 months or more). As with the chronic pain sample, youth who did not speak English and those diagnosed with a developmental disorder were not eligible for the study. Youth without chronic pain were recruited through a hospital-based registry of families in Western Canada who were interested and willing to participate in pediatric health research. Similar to the protocol used to recruit the chronic pain sample, research staff contacted potential participants through email and telephone to provide information about the study and invite participation.

2.4. Procedure

All study procedures were approved by the University of Calgary Conjoint Health Research Ethics Board (REB #15-3100). Consistent with the Canadian research ethics policy outlined in the 2018 Tri-Council Policy Statement, youth who were at least 14 years of age provided their consent to participate and signed a consent form to this effect. Youth younger than 14 years were asked to provide their assent and signed a corresponding assent form. A parent of each participant (regardless of age) attended the laboratory visit and provided their own consent and, for youth younger than 14 years, consent for their child to participate in the study.

One to 4 weeks before their laboratory visit, youth and parents provided consent using an online consent form and completed questionnaires separately through Research Electronic Data Capture (REDCap), a secure online data collection tool.[25] Parents completed questionnaires that collected sociodemographic information. Youth completed self-report measures to assess pain characteristics (eg, location and duration), constructs theorized to be implicated in chronic pain development and maintenance (pain catastrophizing, anxiety sensitivity, and fear of pain), and key clinical outcomes (pain intensity, interference, anxiety, depression, and PTSS). Before attending an in-laboratory visit, semistructured diagnostic clinical interviews were administered to youth with chronic pain and their parents to assess internalizing mental health disorders and to characterize the sample. Theoretical models of co-occurring chronic pain and internalizing mental health symptoms emphasize the impact of elevated symptoms rather than focusing solely on clinical diagnoses[30]; therefore, the primary aims were tested using self-report measures of internalizing mental health symptoms, whereas the diagnostic clinical interviews were used for descriptive purposes. All interviews were audio-recorded and conducted by trained undergraduate honours students in psychology and graduate students in clinical or counselling psychology.

Youth and their parents visited the hospital-based research laboratory, located within the clinical milieu of a tertiary-level chronic pain and rehabilitation center. At this visit, youth completed an eye-tracking task (described below). Youth with chronic pain subsequently completed 3-month follow-up questionnaires that included the same measures assessing clinical outcomes as administered at baseline. Youth and their parents each received an honorarium ($10 gift cards for parents; $20 gift cards for youth) at each testing point (at baseline and at 3-month follow-up).

2.5. Measures

2.5.1. Sociodemographic and pain characteristics

Parents were asked to report sociodemographic information including youth age, sex, ethnicity, and annual household income. Youth with chronic pain completed the Pain

Questionnaire.[51] They were asked to report their primary pain location using a body map.[56] They also reported how long their pain had been present and its frequency over the past 7 days (rated on a 5-point Likert scale ranging from "not at all" to "daily"). The Pain Questionnaire was originally developed by Palermo et al.[51] to assess a variety of pain characteristics in youth with chronic pain. Comprising a series of single-item questions (eg, "How much do aches or pains bother or upset you?"), the questionnaire has documented reliability and validity in youth with chronic pain.[51] It has been used in previous research to assess various pain characteristics in pediatric clinic samples, such as pain duration, location, unpleasantness, and interference.[5,44]

2.5.2. Descriptive information on mental health diagnoses

2.5.2.1. Schedule for Affective Disorders and Schizophrenia for School Aged Children-Present and Lifetime version

The Schedule for Affective Disorders and Schizophrenia for School Aged Children-Present and Lifetime version (K-SADS-PL) is a semistructured diagnostic interview that is used to assess current and past episodes of psychopathology in youth aged 6 to 18 years based on the Diagnostic and Statistical Manual of Mental Disorders—Fifth Edition (DSM-5) criteria. The K-SADS-PL consists of an unstructured introductory interview, a diagnostic screening interview, diagnostic supplements (administered as appropriate based on the screening interview), and a summary lifetime diagnoses checklist. Where discrepancies occurred between parent and youth report, clinical judgment and consultation were used to complete the summary lifetime diagnosis checklist. The K-SADS-PL is considered the gold standard in posttraumatic stress disorder (PTSD) assessment and has good reliability and predictive validity.[36]

2.5.3. Theorized antecedents

2.5.3.1. Childhood Anxiety Sensitivity Index

The Childhood Anxiety Sensitivity Index (CASI) is an 18-item self-report measure that assesses the tendency to interpret anxiety-related bodily sensations as threatening. Items include "It scares me when my heart beats fast" and "Funny feelings in my body scare me." Respondents are asked to rate the extent to which each statement describes them using a 3-point Likert scale ranging from 1 ("none") to 3 ("a lot"). Higher scores are indicative of higher anxiety sensitivity. The CASI has been shown to have adequate test–retest reliability and high internal consistency in community and clinical samples of youth.[62] In the current study, internal consistency was good for youth with chronic pain (α = 0.87) and for youth without chronic pain (α = 0.86).

2.5.3.2. Pain Catastrophizing Scale—Child Version

The Pain Catastrophizing Scale—Child Version (PCS-C) is a 13-item self-report measure that assesses children's catastrophic thoughts and feelings about their pain.[14] Items include "When I have pain, I worry all the time about whether the pain will end" and "When I have pain, I become afraid that the pain will get worse." Respondents are asked to indicate how strongly they endorse each statement when they are in pain using a 5-point Likert scale ranging from 0 ("not at all") to 4 ("extremely"). Items are summed to produce both a total score and 3 subscale scores (magnification, rumination, and helplessness). Total scores range from 0 to 52, with higher scores indicative of higher pain catastrophizing. Among youth with chronic pain, the PCS-C has shown good validity and reliability.[14] In this study, internal consistency was excellent for youth with chronic pain (α = 0.92) and good for those without chronic pain (α = 0.87).

2.5.3.3. Fear of Pain Questionnaire—Child Report

The Fear of Pain Questionnaire—Child Report (FOPQ-C) was developed to assess pain-related fear and avoidance in patients with pediatric chronic pain.[63] The 24 items comprising the FOPQ-C were derived from 4 validated measures from the adult chronic pain literature: the Tampa Scale for Kinesiophobia,[54,75] the Psychological Inflexibility in Pain Scale,[79] the Pain Anxiety Symptom Scale (PASS-20),[13,39] and the Fear-Avoidance Beliefs Questionnaire.[77] The FOPQ-C consists of 2 factors: fear of pain and avoidance of activities, with higher total scores indicative of a higher degree of pain-related fear and avoidance. Items include "When I feel pain, I am afraid that something terrible will happen" and "I avoid making plans because of my pain." Respondents indicate how strongly they agree with each statement by choosing a response from 0 ("strongly disagree") to 4 ("strongly agree"). The FOPQ-C has been shown to have strong internal consistency and 1-month stability, as well as good construct validity, in a large sample of youth with chronic pain.[63] In the current study, internal consistency was excellent for youth with chronic pain (α = 0.92) and without chronic pain (α = 0.91).

2.5.4. Clinical outcomes

2.5.4.1. Pain intensity and interference

Pain intensity (specifically, average pain intensity during the past 7 days) was rated on an 11-point numerical rating scale ranging from 0 ("no pain") to 10 ("worst pain you can think of"). The numerical rating scale has been shown to be a valid and reliable measure for assessing pain intensity in youth with chronic pain.[9] The Patient-Reported Outcomes Measurement Information System (PROMIS-25) Pediatric Profile (version 1.0) was used to assess pain interference. Patient-Reported Outcomes Measurement Information System instruments are short forms developed by the National Institutes of Health to assess a variety of physical and mental health symptoms across the lifespan. The scales were created using item response theory.[31] The Pain Interference subscale was used as a clinical outcome variable in this study. The 4 items of the Pain Interference subscale are rated using a five-point Likert scale ranging from 0 ("never") to 4 ("almost always"). Scores range from 0 to 16, with higher scores indicating greater difficulty in that domain over the past 7 days. This scale is valid for use with youth with chronic pain.[34] Total raw scores were transformed into standardized T-scores for statistical analysis. For youth with chronic pain, internal consistency of the Pain Interference subscale was good at both baseline (α = 0.82) and 3-month follow-up (α = 0.87).

2.5.4.2. Child Posttraumatic Stress Disorder Symptom Scale

The Child PTSD Symptom Scale (CPSS-5) consists of 27 items and assesses PTSD symptoms according to DSM-5 diagnostic criteria.[23,24] Youth were asked to identify a scary or upsetting incident and rate the frequency of 20 symptoms on a 5-point Likert scale ranging from 0 ("not at all") to 4 ("6 or more times a week/almost always"). These 20 items correspond to PTSD symptom clusters as outlined in the DSM-5 (ie, reexperiencing, avoidance, negative alterations in cognition and mood, and hyperarousal) and are summed to produce a total symptom severity score. In addition, 7 impairment items are

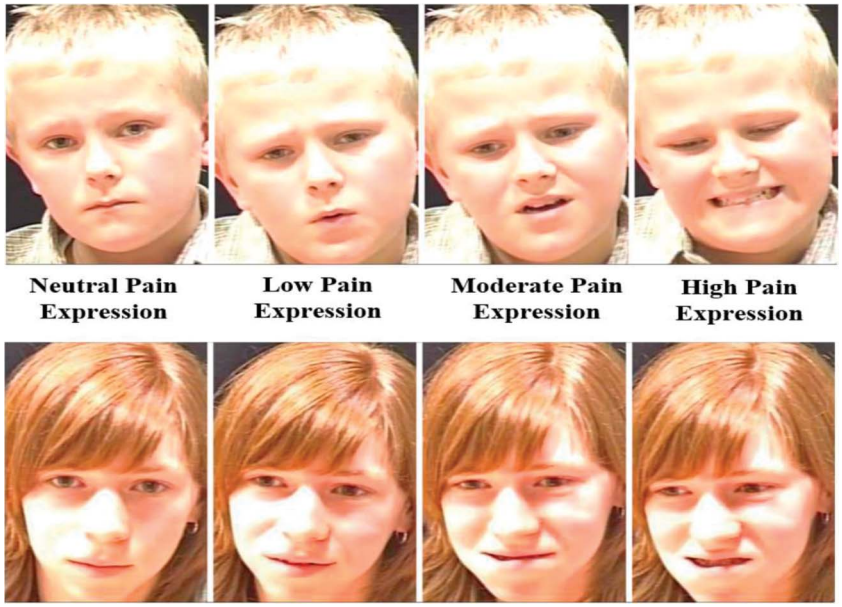

Figure 1. Sample of graded pain expressions. This figure depicts a sample set of face images graded according to their pain expression (ie, neutral, low pain, moderate pain, and high pain).

rated as present or absent. Total symptom severity scores can range from 0 to 80, with higher scores indicating higher PTSD symptoms and impairment. A clinical cutoff score of 31 is indicative of a probable diagnosis of PTSD.[23] The CPSS-5 is based on the CPSS-4, which has excellent reliability and validity[24,46] and has been used in previous research on chronic pain.[49] In this study, for youth with chronic pain, internal consistency was excellent at baseline ($\alpha = 0.94$) and at 3-month follow-up ($\alpha = 0.94$). For youth without chronic pain, internal consistency was excellent at baseline ($\alpha = 0.95$).

2.5.4.3. Revised Child Anxiety and Depression Scale

The Revised Child Anxiety and Depression Scale (RCADS) is a 47-item self-report measure used to assess mental health symptoms across 6 subscales: Separation Anxiety Disorder, Social Anxiety Disorder, Generalized Anxiety Disorder, Panic Disorder, Obsessive-Compulsive Disorder, and Major Depressive Disorder.[11] Items include "I worry about things" (from the Generalized Anxiety Disorder subscale) and "I feel sad or empty" (from the Major Depressive Disorder subscale). Respondents are asked to indicate how frequently each item applies to them, using a scale ranging from 0 ("never") to 3 ("always"). In addition to the individual subscale scores, a total anxiety score is created by summing all 5 anxiety subscales. The RCADS is reliable and valid and has been used in clinical samples of youth.[10,52] In a study using a clinical sample of youth referred for mental health assessment, T-scores of 50.75 and 68.78 were identified as cutoffs indicative of clinically significant symptoms of anxiety and depression, respectively.[10] In this study, the total anxiety T-score and the Major Depressive Disorder subscale T-score were used for primary hypothesis testing. For the current sample of youth with chronic pain, internal consistency was excellent at baseline ($\alpha = 0.96$) and at 3-month follow-up ($\alpha = 0.96$). For youth without chronic pain, internal consistency was excellent at baseline ($\alpha = 0.95$).

2.6. Eye-tracking apparatus

Eye movements were recorded using an EyeLink 1000 eye-tracking system (SR Research Ltd., Ottawa, Canada), which uses infrared video-based tracking technology. The system has a 1000-Hz sampling rate, allowing for a temporal resolution of 1 ms, with an average gaze error of less than 0.5 degrees of visual angle. Images were shown on a 21-inch BenQ XL2430T computer display positioned approximately 90 cm away from the participant. Before the presentation of each pair of images a fixation marker was displayed in the centre of the display for 500 ms to standardize the starting position of participants' gaze. Participants were instructed to focus on the fixation marker during the 500-ms interval and then to view the images subsequently presented. The 2 images were arranged horizontally in the display, with images placed on the left and the right of the fixation marker location. Participants' eye gaze was measured continuously throughout the 3000-ms presentation time for each trial. Images were 14 cm in height and 13 cm in width, and the centre of each image was located 8.5 cm from the fixation marker. The 2 images presented during each trial were defined as interest areas in the software program and fixations to these areas were automatically registered by the eye-tracking system. After data collection, fixation data were processed using the EyeLink Data Viewer software (SR Research Ltd; software version 3.2.48) to filter for blinks, missing data, and other recording artifacts (using the default settings). Individual fixations were defined by the eye-tracking software algorithm.

2.7. Eye-tracking stimuli

Stimuli consisted of 40 gray-scaled images of 10 different children and adolescents (5 boys and 5 girls, ranging in age from 9 to 16 years) depicting painful and neutral facial expressions. The images were used in previous research investigating attentional biases for pain facial expressions in healthy youth.[74] They were taken from video recordings of participants experiencing an experimental pain task (the cold pressor task[73]). Youth and their parents provided permission for the images to be used in research.[72] Levels of pain expression assigned to the images correspond to observer ratings of pain intensity.[71] For each of the

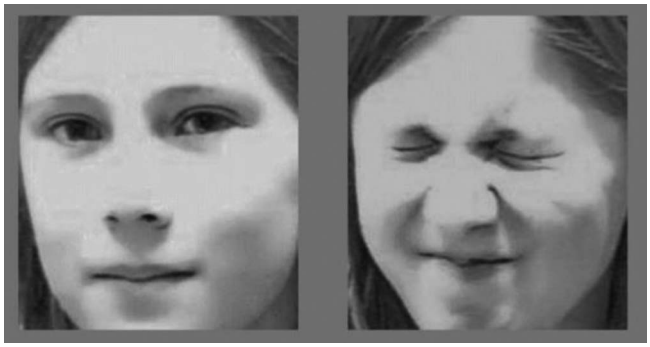

Figure 2. Sample trial presentation. This figure depicts a sample trial for the eye-tracking task. The figure depicts a neutral facial expression (left side) paired with a pain facial expression (right side).

10 youth depicted in the images, 4 images represent 4 categories of facial expression: neutral, low pain, moderate pain, and high pain (**see Fig. 1** for an example set of face images graded according to pain expression). The stimulus set consisted of 30 pairs of images, each pair showing 2 images of the same youth, 1 with a neutral face and the other with 1 of the 3 pain expressions (low, moderate, and high; see **Fig. 2** for a sample trial presentation). Each pair was duplicated, with the neutral and painful faces switching positions, resulting in a total of 60 pairs (20 neutral-low pain pairs, 20 neutral-moderate pain pairs, and 20 neutral-high pain pairs).

2.8. Statistical analyses

Consistent with previous studies on attentional biases,[28,65] first fixation bias and total fixation bias were calculated as parameters to assess the initial orientation of attention and sustained attention, respectively. First fixation bias was calculated as the proportion of trials in which the face depicting pain was fixated on first (as opposed to the neutral face) after the start of the presentation, divided by the total number of trials where the first fixation was made to either face. Proportion scores were calculated for each level of pain facial expressiveness (low, moderate, and high) separately. The resulting proportion scores are interpreted as follows: A first fixation bias greater than 0.5 is indicative of an initial orienting bias toward pain faces; a first fixation bias equal to 0.5 indicates no initial orientation bias toward either face type; and a first fixation bias less than 0.5 indicates an initial orienting bias toward neutral faces.

Total fixation time was calculated by first averaging the total time spent fixating on each type of facial expression (pain and neutral) for each level of pain expressiveness (low, moderate, and high) separately. Three total fixation bias scores (1 for each level of pain face expressiveness) were then calculated by subtracting the averages of the total fixation time for the neutral facial expressions from the averages of the total fixation time for the painful facial expressions. Positive values indicate that total fixation times for painful facial expressions were longer than for the paired neutral facial expressions, reflecting greater attention to painful facial expressions. Negative values indicate that total fixation times for neutral facial expressions were longer than for the paired painful facial expressions, suggesting attentional avoidance of painful facial expressions.

Statistical analyses were conducted using SPSS version 25 (IBM Corp, Armonk, NY). For participants with missing data constituting $< 20\%$ of items within a scale, a prorated score was calculated for that scale.[22] Descriptive, correlational, analysis of variance (ANOVA) and regression analyses were conducted using two-tailed hypothesis testing. Independent-samples *t* tests and chi-square tests were used to test for group differences in key variables.

Statistical power was determined based on effect sizes from previously published research on attentional biases.[28,74] An a priori power analysis for the planned mixed-model ANOVA ($f = 0.25$, $\alpha = 0.05$, groups = 2; repeated measurements = 3) indicated that a total sample size of 82 participants (41 in each group) would provide 80% power to detect a two-way interaction with a partial eta-squared of at least 0.06 (a medium-sized effect). Thus, the current sample of 177 participants (125 youth with chronic pain and 52 without chronic pain) provided more than adequate power to test for group differences in attentional bias. Effect sizes for statistically significant *t* tests (Cohen's *d*) are reported for key comparisons (where *d* values of 0.20, 0.50, and 0.80 correspond to small, medium, and large effects, respectively). An additional power analysis for the linear regression analyses ($f^2 = 0.15$, $\alpha = 0.05$, predictors = 3) indicated that a total sample size of 77 participants would provide 80% power to find a medium effect for the theorized antecedents as predictors of attentional bias, suggesting that our current sample of youth with chronic pain (n = 125) was more than sufficient.

2.9. Between-group differences in attentional bias

To compare the attentional biases of youth with chronic pain and youth without chronic pain, between-group differences were analyzed using mixed-model ANOVAs, with group (chronic pain and no chronic pain) as a between-subject factor and pain facial expression (low, moderate, and high) as a within-subject factor. First fixation bias scores and total fixation bias scores were analyzed separately. Significant interactions were probed using *t* tests.

2.10. Association between theorized antecedents and attentional bias (aim 1)

To examine the relationship between theorized antecedents (pain catastrophizing, anxiety sensitivity, and fear of pain) and attentional bias in youth with chronic pain, 2 hierarchical linear regression analyses were conducted with each of the theorized antecedents entered as predictors of first fixation bias and total fixation bias. Composite scores for first fixation bias and total fixation bias (the means averaged across each of the 3 pain faces) were calculated and entered as the outcome variables. Age and sex were entered in step 1 of each model to control for their potential effects. The 3 antecedents were entered in step 2. The total scores for each of the theorized antecedents were mean centered before being entered into analyses to aid in the interpretation of effects.[26]

Relationships between attentional bias and clinical outcomes at baseline and 3-month follow-up (aim 2)

Zero-order correlations were used to assess relationships between attentional bias variables and clinical outcomes (pain intensity, pain interference, anxiety, depression, and PTSS) assessed at baseline in youth with chronic pain. Partial correlations were used to assess the associations between attentional bias variables and clinical outcomes at 3-month

Table 1

Sociodemographic and pain characteristics of the sample (by group).

Youth with chronic pain (N = 125)		Youth without chronic pain (N = 52)	
Mean age in years	14.10 (2.21)	Mean age in years	13.49 (2.71)
Sex (% female)	71.20*	Sex (% female)	50.00*
Ethnicity (%)		Ethnicity (%)	
White	86.4	White	79.25
Aboriginal	5.71	Aboriginal	9.43
Black	2.14	Black	3.77
Arab/West Asian	2.14	Latin American	3.77
Latin American	2.14	Chinese	3.77
South Asian	0.71	Other	0.00
Chinese	0.71	Declined to answer	0.00
Filipino	0.71		
Japanese	0.71		
Other	5.71		
Declined to answer	1.43		
Household income (%)		Household income (%)	
<$10,000 to $29,999	6.87	<$10,000 to $29,999	0.00
$30,000-$59,999	11.45	$30,000-$59,999	6.98
$60,000-$89,999	13.00	$60,000-$89,999	9.30
More than $90,000	59.54	More than $90,000	76.74
Declined to answer	9.16	Declined to answer	6.98
Pain duration in years	2.67 (3.14)		
Pain location (%)			
One location	51.43		
Multiple locations	44.29		
Headache	70.71		
Musculoskeletal	25.71		
Abdominal	17.14		
Leg	14.29		
Chest	11.43		
Other	22.14		

* Indicates statistically significant group difference ($P < 0.05$) based on the independent-groups t test or chi-square test. SDs in parentheses.

follow-up while controlling for baseline symptoms (eg, the partial correlation between total fixation bias and 3-month pain intensity while controlling for baseline pain intensity). Composite scores for total fixation bias and first fixation bias were calculated by averaging the means across the 3 levels of pain expression.

3. Results

3.1. Preliminary data processing and screening

The raw eye-tracking data were examined before analyses to screen for suboptimal data recording and recording errors. Individual trials for which no data were recorded (ie, trial dwell time equal to 0 ms) were coded as missing (2% of all trials). No eye-tracking data were available for 10 participants (because of inadequate calibration). The data from 6 participants were excluded from all analyses because of suboptimal eye-tracking data (ie, mean overall trial dwell time less than 2000 ms). An additional 7 participants were excluded from all analyses because of being identified as statistical outliers on 1 or more of the attentional bias variables (ie, at least one of the attentional bias variables was determined to be 3 SDs above or below the group mean).

After processing of the eye-tracking data and excluding these participants, 6 additional participants were excluded from all analyses because their scores on several of the self-report questionnaires (the CPSS-5, CASI, and RCADS) were 3 SDs above or below the sample mean. When analyses were conducted with these outliers included, the pattern of the findings did not change. Finally, data from 12 participants in the chronic pain group had to be excluded because they did not complete the 3-month follow-up. The final sample consisted of 177 youth (125 with chronic pain and 52 without chronic pain).

3.2. Sociodemographic and pain characteristics

Sociodemographic information (ie, sex, age, race, and household annual income) is presented in **Table 1**. There were more females in the chronic pain group (71%) than in the group without chronic pain (50%), $X^2(2) = 9.67$, $P = 0.008$. This outcome is consistent with the sociodemographic characteristics of chronic pain samples in previous research,[44,50] as well as the epidemiology of chronic pain in pediatric populations (girls are more likely to be affected by chronic pain than boys[12,37]). Approximately half of the youth with chronic pain (51%) reported pain in 1 location, and 44% reported pain in multiple locations. Among youth with chronic pain, 71% reported headache, 26% musculoskeletal pain, 17% abdominal pain, 14% leg pain, 11% chest pain, and 22% pain in the "other" category. On average, youth with chronic pain reported a pain duration of 2.67 years (SD = 3.14). When asked about pain frequency over the past 7 days, 46.4% of youth in the chronic pain group endorsed daily pain, 14.3% endorsed pain "4 to 6 times per week," 27.9% endorsed pain

Table 2

Descriptive statistics (mean, SD) of key variables.

Variable	Youth with chronic pain (N = 125) *M* (*SD*)	Youth without chronic pain (N = 52) *M* (*SD*)
First fixation bias (low pain face)	0.50 (0.10)	0.47 (0.10)
First fixation bias (moderate pain face)	0.52 (0.10)	0.50 (0.09)
First fixation bias (high pain face)	0.56 (0.10)	0.55 (0.09)
Total fixation bias (low pain face)	57.03 (204.12)	44.14 (313.75)
Total fixation bias (moderate pain face)	82.94 (251.29)	162.94 (272.55)
Total fixation bias (high pain face)	221.55 (296.52)	189.05 (296.28)
CASI total score	26.94 (6.24)	25.83 (5.73)
PCS-C total score	17.54 (10.41)*	9.58 (7.02)*
FOPQ-C total score	27.19 (17.02)*	11.41 (11.19)*
RCADS depression (baseline)	51.69 (13.01)*	43.11 (9.51)*
RCADS anxiety (baseline)	46.79 (12.00)	43.48 (11.91)
CPSS-5 total score (baseline)	14.23 (13.27)	10.43 (13.18)
Pain intensity (baseline)	5.40 (1.83)	—
Pain interference T-score (baseline)	54.12 (8.96)	—
RCADS depression (follow-up)	50.06 (15.16)	—
RCADS anxiety (follow-up)	43.13 (13.41)	—
CPSS-5 total score (follow-up)	10.34 (12.84)	—
Pain intensity (follow-up)	5.25 (2.07)	—
Pain interference T-score (follow-up)	52.51 (9.73)	—

* Statistically significant difference between the chronic pain group and the comparison group on antecedent/outcome variables ($P < 0.01$).
CASI, Childhood Anxiety Sensitivity Index; CPSS-5, Child PTSD Symptom Scale; FOPQ-C, Fear of Pain Questionnaire — Child Report; M, mean; PCS-C, Pain Catastrophizing Scale—Child Version; RCADS, Revised Child Anxiety and Depression Scale.

"2 to 3 times per week," 7.9% endorsed pain "1 time per week," and 3.6% endorsed no pain in the preceding week.

The diagnostic clinical interviews (the K-SADS-PL) indicated that 8% of youth with chronic pain met criteria for Major Depressive Disorder and 1.6% met criteria for a diagnosis of PTSD. Percentages of youth in the chronic pain sample who met criteria for various anxiety disorders are as follows: 17.6% met criteria for Generalized Anxiety Disorder, 11.3% met criteria for Specific Phobia, 3.2% met criteria for Social Anxiety Disorder, 3.2% met criteria for Panic Disorder, and 1.6% met criteria for Separation Anxiety Disorder. It should be noted that youth may have met criteria for more than 1 disorder at the time of the

Table 3

Correlations between theorized antecedents and clinical outcomes (pain and mental health) in youth with chronic pain.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Pain intensity (baseline)	—												
2. Pain interference (baseline)	0.43**	—											
3. CPSS-5 (baseline)	0.32**	0.38**	—										
4. RCADS depression (baseline)	0.20*	0.49**	0.66**	—									
5. RCADS anxiety (baseline)	0.16	0.49**	0.62**	0.69**	—								
6. PCS-C (baseline)	0.25**	0.43**	0.47**	0.43**	0.46**	—							
7. CASI (baseline)	0.17	0.46**	0.56**	0.56**	0.77**	0.57**	—						
8. FOPQ-C (baseline)	0.27**	0.47**	0.59**	0.52**	0.58**	0.70**	0.61**	—					
9. Pain intensity (follow-up)	0.50**	0.15	0.20*	0.11	0.12	0.09	0.16	0.22*	—				
10. Pain interference (follow-up)	0.20*	0.44**	0.38**	0.40**	0.47**	0.31**	0.43**	0.37**	0.48**	—			
11. CPSS-5 (follow-up)	0.25**	0.24*	0.51**	0.38**	0.38**	0.29**	0.45**	0.31**	0.25**	0.38**	—		
12. RCADS depression (follow-up)	0.23*	0.41**	0.49**	0.69**	0.58**	0.31**	0.55**	0.31**	0.18	0.42**	0.67**	—	
13. RCADS anxiety (follow-up)	0.14	0.39**	0.53**	0.63**	0.83**	0.32**	0.68**	0.37**	0.15	0.46**	0.62**	0.76**	—

*$P < 0.05$, **$P < 0.01$, two-tailed test.
CASI, Childhood Anxiety Sensitivity Index; CPSS-5, Child PTSD Symptom Scale; FOPQ-C, Fear of Pain Questionnaire — Child Report; PCS-C, Pain Catastrophizing Scale—Child Version; RCADS, Revised Child Anxiety and Depression Scale.

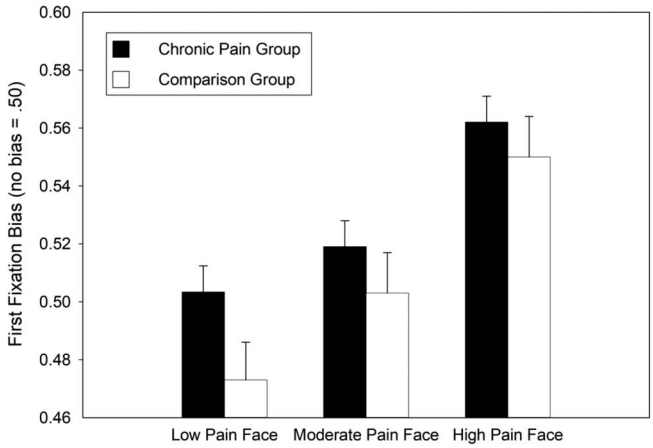

Figure 3. First fixation bias for each level of pain facial expressiveness (low, moderate, and high) for youth with chronic pain and youth without chronic pain.

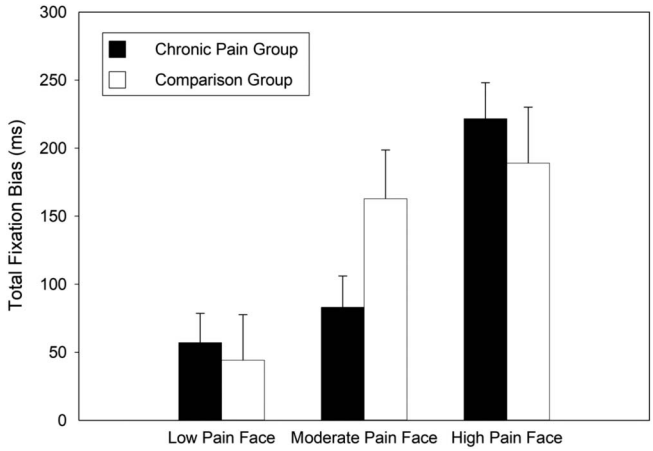

Figure 4. Total fixation bias for each level of pain facial expressiveness (low, moderate, and high) for youth with chronic pain and youth without chronic pain.

interview and may thus be represented in multiple diagnostic categories.

3.3. Descriptive statistics for key variables

Descriptive statistics for the key variables of interest are shown in **Table 2**. Youth with chronic pain had significantly higher scores than youth without chronic pain on the PCS-C (pain catastrophizing), the FOPQ-C (fear of pain), and the RCADS depression subscale, $t(175) = 5.06$, $P < 0.001$, $d = 0.38$; $t(168) = 6.08$, $P < 0.001$, $d = 0.47$; $t(169) = 4.22$, $P < 0.001$, $d = 0.32$, respectively. The 2 groups did not differ significantly in age, $t(171) = 1.52$, $P = 0.129$, $d = 0.12$, or their scores on the CASI (anxiety sensitivity), $t(175) = 1.11$, $P = 0.268$, $d = 0.08$, RCADS total anxiety scale, $t(168) = 1.65$, $P = 0.102$, $d = 0.13$, or the CPSS-5 (PTSD symptoms), $t(167) = 1.69$, $P = 0.093$, $d = 0.13$.

3.4. Clinical outcomes in youth with chronic pain

For youth with chronic pain, the mean pain intensity level was 5.40 of 10 (SD = 1.83) at baseline and 5.25 of 10 (SD = 2.07) at follow-up. The pain interference T-score was 54.12 (SD = 8.96) at baseline and 52.51 (SD = 9.73) at follow-up. The mean PTSD symptoms score was 14.23 (SD = 13.27) on the CPSS-5, with 14.4% of youth having scores 31 or higher, indicative of clinically significant PTSD symptoms.[23] With respect to mean anxiety and depressive symptoms, youth with chronic pain had scores on the RCADS total anxiety scale ($M = 46.79$, $SD = 12.00$) and the depression subscale ($M = 51.69$; $SD = 13.01$) that are below the clinical cutoffs reported by Chorpita et al.[10]

3.5. Correlations among theorized antecedents and clinical outcomes

As shown in **Table 3**, self-reported pain intensity and pain interference were both significantly correlated with measures assessing theorized antecedents of chronic pain and mental health symptoms at baseline and follow-up (all Ps < 0.05), with 2 exceptions: Pain intensity was not significantly correlated with anxiety sensitivity or anxiety symptoms. Remaining correlations among theorized antecedents and clinical outcomes were all statistically significant (all Ps < 0.05).

3.6. Between-group differences in attentional bias

Figure 3 shows the first fixation bias data for each group for each level of pain facial expression. In the ANOVA, there was a main effect of facial expression, $F(2, 174) = 20.95$, $P < 0.001$, partial $\eta^2 = 0.11$, indicating a first fixation bias for more intense pain facial expressions in both youth with and without chronic pain. There was no main effect of group, $F(1, 175) = 3.72$, $P = 0.055$, partial $\eta^2 = 0.02$, and no interaction between group and facial expression, $F(2, 174) = 0.42$, $P = 0.655$. Follow-up 1-sample t tests indicated that across both groups, the first fixation bias for high pain faces ($M = 0.56$; $SD = 0.10$) was significantly greater than chance (0.50), $t(176) = 7.94$, $P < 0.001$, $d = 0.60$. First fixation bias for moderate ($M = 0.51$; $SD = 0.10$) and low pain ($M = 0.49$; $SD = 0.10$) faces did not differ significantly from chance, $t(176) = 1.93$, $P = 0.055$, $d = 0.15$ and $t(176) = 0.77$, $P = 0.440$, $d = 0.06$, respectively.

Figure 4 shows the total fixation bias data for each group for each level of pain facial expression. In the ANOVA, there was a main effect of facial expression, $F(2, 174) = 20.76$, $P < 0.001$, partial $\eta^2 = 0.11$, such that the total fixation bias for pain faces increased with each level of pain expressiveness (ie, $M_{low\ pain} = 53.25$, $SD = 240.65$; $M_{moderate\ pain} = 106.44$, $SD = 259.52$; $M_{high\ pain} = 212.00$, $SD = 295.98$). Youth with and without chronic pain did not differ in their average total fixation bias, $F(1, 175) = 0.12$, $P = 0.735$, partial $\eta^2 < 0.01$. A significant interaction indicated that there were within-group differences in patterns of attending as a function of pain facial expression, $F(2, 174) = 3.13$, $P = 0.045$, partial $\eta^2 = 0.02$. Pairwise comparisons revealed that for youth with chronic pain, total fixation bias for high pain faces was significantly larger than total fixation bias for moderate pain faces, $t(124) = 5.02$, $P < 0.001$, $d = 0.45$, and low pain faces, $t(124) = 6.66$, $P < 0.001$, $d = 0.60$. Total fixation bias for low and moderate pain faces did not differ, $t(124) = 1.01$, $P = 0.316$, $d = 0.09$. For youth without chronic pain, total fixation bias for high pain faces was significantly larger than total fixation bias for low pain faces, $t(51) = 3.79$, $P < 0.001$, $d = 0.53$. Unlike the chronic pain group, total fixation bias for high and moderate pain faces did not differ, $t(51) = 0.61$, $P = 0.543$, $d = 0.09$, whereas total fixation bias for moderate and low pain faces did differ significantly, $t(51) = 2.97$, $P = 0.003$, $d = 0.42$. These results are consistent with those reported in Soltani et al.[65]

Table 4

Hierarchical linear regression examining contribution of theorized antecedents to first fixation bias for pain faces.

	Model statistics					Coefficients						
	R	R^2	R^2_Δ	F	*P*	*r*	sr	b	β	SE B	t	*P*
Step 1	0.08	0.01	0.01	0.34	0.678							
Constant								0.53		0.04	14.37	<0.001
Age						−0.00	−0.01	−1.52	−0.00	0.00	0.01	0.995
Sex						0.08	0.08	0.01	0.08	0.01	0.88	0.380
Step 2	0.16	0.03	0.02	0.59	0.705							
Constant								0.55		0.04	13.28	<0.001
Age						−0.00	−0.05	−0.00	−0.06	0.00	0.54	0.588
Sex						0.08	0.08	0.01	0.08	0.01	0.88	0.383
PC						−0.03	−0.11	−0.01	−0.17	0.01	1.21	0.230
AS						0.06	0.06	0.01	0.08	0.01	0.64	0.525
FP						0.07	0.10	0.01	0.15	0.01	1.08	0.284

R^2, model summary variance accounted for; R^2_Δ, change in variance accounted for at each step of model; *r*, zero-order correlation with criterion variable; sr, semipartial correlations; b, regression coefficient (unstandardized); β, standardized regression coefficient; AS, Childhood Anxiety Sensitivity Index total score (centered); FP, Fear of Pain Questionnaire — Child Report total score (centered); P, probability value for t statistic; PC, Pain Catastrophizing Scale — Child Version total score (centered); SE, standard error of regression coefficient; t, t statistic for regression coefficient.

3.7. Association between theorized antecedents and attentional bias (aim 1)

The results for the hierarchical linear regression analyses with theorized antecedents (pain catastrophizing, anxiety sensitivity, and fear of pain) predicting attentional bias are presented in **Table 4** (with first fixation bias as the outcome variable) and **Table 5** (with total fixation bias as the outcome variable). As shown in **Table 4**, after controlling for age and sex, the 3 theorized antecedents did not account for significant additional variance in first fixation bias (all *P*s $>$ 0.05). Similarly, as shown in **Table 5**, after controlling for age and sex, the 3 theorized antecedents did not account for significant additional variance in total fixation bias (all *P*s $>$ 0.05).

3.8. Relationship between attentional bias and clinical outcomes at baseline and 3-month follow-up (aim 2)

Zero-order correlations among attentional bias variables (first fixation bias and total fixation bias composite scores) and clinical outcomes (pain intensity, interference, anxiety, depression, and PTSS) are presented in **Table 6**. Partial correlations among attentional bias variables and 3-month clinical outcomes (controlling for baseline clinical outcome variables) are presented in **Table 7**. Three-month pain intensity was significantly negatively correlated with first fixation bias, $r = -0.29$, $P = 0.002$. None of the remaining attentional bias variables were significantly correlated with either pain-related outcomes or mental health symptoms at either baseline or at 3-month follow-up (*P*s $>$ 0.05).

4. Discussion

This eye-tracking study examined attentional bias for painful facial expressions in a clinical sample of youth with chronic pain and a comparison sample of youth without chronic pain and assessed the relationship of the bias to theorized antecedents and clinical outcomes. Youth exhibited first fixation bias and total fixation bias for pain facial expressions, regardless of chronic pain status. These results are consistent with theoretical models positing an attentional bias for pain that is characterized by hypervigilance.[1,3,30,58,76] The results are also consistent with cognitive-affective models of pain[21] and a recent meta-analysis of eye-tracking studies on attentional biases for pain stimuli, suggesting that attentional bias for pain is ubiquitous and indicative of an evolutionary predisposition rather than a function of pain status.[32]

Contrary to hypotheses and tenets of theoretical models of fear avoidance and mutual/shared vulnerability for chronic pain and mental health, key theorized antecedents—pain catastrophizing, anxiety sensitivity, and fear of pain—were not related to attentional bias in youth with chronic pain. These results contrast

Table 5

Hierarchical linear regression examining contribution of theorized antecedents to total fixation bias for pain faces.

	Model statistics					Coefficients						
	R	R^2	R^2_Δ	F	*P*	*r*	sr	b	β	SE B	t	*P*
Step 1	0.28	0.08	0.08	0.10	0.009							
Constant								0.40		110.53	0.00	0.997
Age						0.07	0.07	6.29	0.07	7.70	0.82	0.416
Sex						0.27	0.27	100.84	0.27	33.13	3.04	0.003
Step 2	0.28	0.08	0.00	1.97	0.088							
Constant								5.66		125.60	0.05	0.964
Age						0.07	0.06	5.89	0.07	8.79	0.67	0.504
Sex						0.27	0.27	102.17	0.28	33.64	3.04	0.003
PC						0.02	0.01	3.88	0.02	25.49	0.15	0.879
AS						0.04	−0.01	−3.44	−0.02	24.38	−0.14	0.888
FP						0.04	0.03	7.55	0.04	26.15	0.29	0.773

R^2, model summary variance accounted for; R^2_Δ, change in variance accounted for at each step of model; *r*, zero-order correlation with criterion variable; sr, semipartial correlations; b, regression coefficient (unstandardized); β, standardized regression coefficient; AS, Childhood Anxiety Sensitivity Index total score (centered); FP, Fear of Pain Questionnaire — Child Report total score (centered); P, probability value for t statistic; PC, Pain Catastrophizing Scale — Child Version total score (centered); SE, standard error of regression coefficient; t, t statistic for regression coefficient.

Table 6

Zero-order correlations among attentional bias and baseline outcomes in youth with chronic pain.

	Variable	1	2	3	4	5	6	7
1.	First fixation bias (composite)	—						
2.	Total fixation bias (composite)	0.34**	—					
3.	Pain interference (baseline)	0.05	−0.07	—				
4.	Pain intensity (baseline)	−0.05	0.04	0.43**	—			
5.	RCADS anxiety (baseline)	0.13	−0.07	0.49**	0.16	—		
6.	RCADS depression (baseline)	0.03	−0.07	0.49**	0.20*	0.69**	—	
7.	CPSS-5 (baseline)	0.02	0.06	0.38**	0.32**	0.62**	0.66**	—

*$P < 0.05$, **$P < 0.01$, two-tailed test.
CPSS-5, Child PTSD Symptom Scale; RCADS, Revised Child Anxiety and Depression Scale.

with previous research that has reported relationships between attentional bias for pain-related information and pain catastrophizing,[29,74] anxiety sensitivity,[2] and fear of pain.[2] However, most of these studies examined these relationships in adult samples, and in the studies with pediatric samples, the focus was on experimentally induced acute pain in healthy youth.[28,29,74] The current findings are consistent with a meta-analytic review on attentional bias for pain-related information in adults, which found no link between attentional bias and various antecedents and clinical outcomes.[17] Our findings also align with a recent review on cognitive biases in pain that highlighted the lack of evidence for a consistent relationship between attentional bias, key theorized antecedents, and pain outcomes.[70]

Contrary to hypotheses, most of the attentional bias variables were not correlated with clinical outcomes (pain and mental health symptoms) assessed at baseline or at 3-month follow-up. The single exception was the significant correlation found between first fixation bias and pain intensity at follow-up, such that higher first fixation bias for pain faces was associated with lower self-reported pain intensity at follow-up. Given the number of correlations examined and the absence of corroborating associations, it is possible that this result is artifactual. On the other hand, if replicated, this finding may suggest that early attentional engagement with feared stimuli is adaptive in reducing adverse outcomes over time, as suggested by Heathcote et al.[28] in their cross-sectional analysis of healthy youth.

There are several explanations that could account for the current findings. First, it is possible that the findings are reliable and point to a true lack of association between attentional bias for pain facial expressions and theorized antecedents and clinical outcomes in this sample. In their review, van Ryckeghem et al.[70] highlighted the paucity of evidence in support of cognitive biases for pain-related information influencing the development and progression of chronic pain. Our results also align with meta-analytic research that found a lack of consistent association between attentional bias for pain, related theorized antecedents, and clinical pain outcomes.[18] Despite the emphasis on biased attentional processing as a key factor in the development and maintenance of chronic pain in major theoretical models,[1,3,30,58,76] research that has reliably tied the presence of attentional biases for pain to real-world clinical outcomes in individuals with chronic pain is strikingly absent.

Much of the existing research on attentional biases for pain has focused on determining whether such a bias reliably exists and on clarifying the nature of the bias. An important question that remains underresearched is whether selective attention for pain-related information is reliably associated with the development of chronic pain.[38] As noted by Liossi,[38] if attentional biases for pain-related information can be modified and subsequently tied to improved pain-related outcomes, this would support an important causal role for attentional processes in the development and maintenance of chronic pain. However, the results of attention bias modification studies within the context of pain have yielded mixed results to date.[8,27,57,60] As noted by Sharpe,[59] more emphasis on clarifying the conceptualization and nature of attentional bias for pain-related information, particularly in youth, is required to refine and tailor attention bias modification protocols in a developmentally appropriate and effective manner.

The largely null findings in the current study may also relate to the heterogeneity and characteristics of the sample. The sample included youth with various chronic pain conditions and a range of mental health symptoms. Furthermore, youth attended a tertiary-

Table 7

Partial correlations among attentional bias and 3-month outcomes (youth with chronic pain).

	Variable	1	2	3	4	5	6	7
1.	First fixation bias (composite)	—						
2.	Total fixation bias (composite)	0.23**	—					
3.	Pain interference follow-up	0.07	-0.01	—				
4.	Pain intensity follow-up	−0.29**	−0.13	0.48**	—			
5.	RCADS anxiety follow-up	0.04	0.05	0.46**	0.15	—		
6.	RCADS depression follow-up	0.04	0.02	0.42**	0.18	0.76**	—	
7.	CPSS-5 follow-up	−0.05	−0.05	0.37**	0.25**	0.62**	0.67**	—

*$P < 0.05$, **$P < 0.01$, two-tailed test. Correlations between attentional bias variables and follow-up outcome variables are partial correlations controlling for the corresponding baseline outcome variable. Remaining correlations are zero-order correlations.
CPSS-5, Child PTSD Symptom Scale; RCADS, Revised Child Anxiety and Depression Scale.

level pain clinic for a primary presenting complaint of chronic pain—not mental health concerns. Indeed, on average, the level of mental health symptoms endorsed by youth with chronic pain in our study did not surpass clinical cutoffs indicative of clinically significant symptoms[10] and was lower than those reported in previous research in pediatric chronic pain.[12,19,49] Thus, mental health symptoms experienced by youth may not have been sufficiently elevated to be meaningfully associated with attentional bias. Future research would benefit from an examination of associations between attentional bias and outcomes in youth with chronic pain who endorse clinically elevated mental health concerns.

Finally, an important consideration in the interpretation of the current findings relates to the methodology used. Although eye-tracking offers advantages over other commonly used measures of attentional bias (eg, the dot-probe task), it assesses attentional processing at only 1 point in time, typically in an experimental research setting, using symbolic representations of pain.[69,70] The stimuli used in our study were images of youth depicting painful facial expressions as captured during an acute experimental pain task. These images may have lacked personal relevance to the youth in our study because they did not relate to their personal chronic pain experience and may thus have contributed to our null findings.[20] Furthermore, it is possible that the facial stimuli used evoked an empathic response to others' pain as compared with attention when faced with one's own idiosyncratic pain experience. A paradigm shift in the way we conceptualize and assess attentional biases is needed to better take into account contextual, personal, motivational, emotional, and sensory factors.[69,70] This includes taking into account one's own lived pain experience,[48] leveraging methodologies such as ecological momentary assessment and augmented reality, and using actual and impending pain signals and somatosensory cues in the assessment of attentional bias.[6,55,68] Such paradigms allow for the dynamic investigation of attention in a more ecologically valid way and with more relevance to the actual experience of an individual with chronic pain. Another important future direction is to consider the dynamic interplay and interaction of other cognitive mechanisms, including attentional, interpretation, and memory biases, given the paucity of such research to date.[16,70] Expanding the scope of research to integrate more complex models to investigate these relationships and paradigm shifts in how we assess attentional bias will be necessary to further our understanding of the theoretical and clinical utility of attentional biases in pediatric chronic pain. Finally, given the variety of pain complaints endorsed by youth in our sample, methodological refinements may benefit from comparing attentional bias across different pain conditions (eg, headache vs musculoskeletal vs functional abdominal) and tailoring stimuli selection based on specific pain complaints.

Limitations of the current investigation can be used to inform additional future research. First, the sample comprised primarily middle-class white youth, which limits the generalizability of the findings. Second, the facial stimuli included painful and neutral facial expressions, but not other negative expressions (eg, fear and sadness) precluding a determination of whether the bias observed was pain-specific or indicative of a more general bias for images with negative emotional valence. Third, the facial expressions used in this study consisted of images of healthy youth experiencing an experimental pain task, which impacted the ecological validity and personal relevance of the stimuli.[20] Fourth, mental health symptoms reported by youth with chronic pain were significantly lower than those of clinically anxious and depressed youth and may not have been elevated enough to be associated with attentional bias.[10]

In conclusion, theoretical models of chronic pain development and maintenance, as well as the co-occurrence of chronic pain and internalizing mental health symptoms, posit a key role for attentional biases as underlying both conditions.[3,15,30,76] Despite the inclusion of attentional biases in theoretical models, empirical evidence regarding their presence and nature, particularly among youth with clinical pain problems, is equivocal. The current findings confirm the existence of an attentional bias for pain facial expressions in both youth with and without chronic pain using eye-tracking methodology; however, this attentional bias was not significantly associated with key clinical outcomes. We have outlined several explanations for the current findings. We also highlight important next steps in research aimed at enhancing the ecological validity and assessment of attentional bias as it relates to the pain experience. Future research using new and more comprehensive paradigms is needed to clarify the nature and clinical significance of attentional biases for pain.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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