Assessing the content specificity of interpretation biases in community adolescents with persistent and interfering pain

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Abstract

The tendency to select threatening over benign interpretations of ambiguous bodily sensations and cues characterises young people with chronic pain. However, previous studies disagree over whether these biases extend to nonbodily harm situations such as social evaluation. Understanding the content of these biases is crucial to the development of pain management strategies seeking to modify such biases. Two hundred forty-three young people aged 16 to 19 years completed an expanded version of the Adolescent Interpretation of Bodily Threat task. Using a factor-analytic approach, we removed items that did not consistently associate with bodily harm or social evaluation. Next, we examined whether the variance underlying negative and benign interpretations of bodily harm and social evaluation situations were best represented as a common factor (ie, one-factor model), 2 distinct factors (ie, 2-factor model), or one common and 2 distinct factors (ie, 2-factor bifactor model) in all adolescents. We then compared youth with and without persistent and impairing pain on factor scores derived from the best-fitting model. Although negative interpretations of bodily harm and social evaluation situations emerged as distinct factors, benign interpretations across situations were best captured by a common factor and 2 situation-specific factors (ie, bifactor model). Group comparisons showed that young people with moderate-to-high pain interference were more likely to endorse negative interpretations across all situations, and less likely to manifest a general benign interpretational style, than youth without interfering pain, although some of these group differences were explained by co-occurring anxiety and depressive symptoms. Replication of these findings is needed.

Keywords: Information processing, Youth, Community, Interpretation bias, Bodily threat

1. Introduction

Chronic pain that disrupts physical and socio-emotional functioning is common in youth. Studying biopsychosocial factors in community samples informs a range of pain experiences among those who do not make it to clinic.

Information-processing models suggest that biased cognitive factors contribute to pain chronicity. A central tenet of these models is that the tendency to categorise innocuous bodily cues and sensations as being threatening (rather than benign) is associated with greater fear and avoidance of pain and disability, than recovery. Indeed, a tendency to endorse negative over benign interpretations of ambiguous cues and scenarios around bodily harm (encompassing pain outcomes such as injury and poor health such as illness) differentiates adults with and without chronic pain, and explains variability in pain-relevant outcomes.

Community youth reporting intense, frequent, and disabling pain also endorsed negative interpretations of ambiguous situations around potential bodily harm more and benign interpretations of these situations less than those with lower pain levels. Adolescent patients with chronic pain were less likely to endorse benign interpretations of ambiguous situations around bodily harm than those with no history of pain. Both studies explored whether biased interpretations extended to nonbodily harm situations such as potential social threat situations, consistent with predictions of some models that an enmeshing of pain, illness, and self-schema (representations) would occur. Differences across studies emerged: in community adolescents, those with more persistent pain reported biases in selecting more negative but fewer benign interpretations of potential social threat but no such differences characterised the clinical sample. Thus, although these studies suggest a role for biased interpretations in explaining pain outcomes in youth, they differ over whether these biases generalise to situations beyond bodily harm.

Here, we sought to clarify the content specificity of biased interpretations in a large community sample of youth with varying pain persistence and interference levels. We expanded the Adolescent Interpretations of Bodily Threat (AIBT) task from previous studies by including more situations around potential injury and illness within the bodily harm category and more situations around potential interpersonal rejection and...
achievement-based failure within the social evaluation category. To determine the items that best measured the constructs of bodily harm and social evaluation and to best reflect the nature of interpretational style across situations across adolescents, different models were compared. Scores from the best-fitting model were used to test our hypotheses that greater endorsement of negative (over benign) interpretations of bodily harm situations would characterise community adolescents with persistent/impairing pain than those with no pain history. No hypotheses were made about whether pain-linked biases would characterise social situations. Given robust associations between anxiety and depressive symptoms and biased interpretations of various ambiguous situations, we investigated whether pain group differences in negative and benign interpretations emerged independently of these symptom effects. Studying biased interpretations in pain in late adolescence is important because interpretational style becomes increasingly linked to behavioural outcomes across youth. Yet, should biased interpretations be associated with pain disability, intervening to alter these in adolescents could be easier than in adults, when biases are hypothesised to have become habitual.

2. Methods

2.1. Sample

Participants were 243 community adolescents aged 16 to 19 years (M = 17.26 years; SD = 5.4 months) from 5 secondary schools in London. Twenty schools across different areas of London were contacted with information about the study, of which 5 responded positively about assessing their pupils during lesson time. Depending on the school, some or all of the pupils meeting our inclusion criteria (being aged 16-18 years) were given information sheets about a study of cognitive factors involved in young people’s pain experiences. Thus, our sample was a convenience sample. A large proportion of those approached (90%) consented to participate. Participants who struggled with reading and understanding task instructions completed the tasks but were excluded at the data analysis stage (n = 2), leaving 241 in the final sample. Ethnic composition of this sample was as follows: 39.1% were black; 35% were white, and the remaining participants were identified as being of Asian (13.2%), Arab (0.4%), mixed (7.4%), or “other” (1.6%) ethnic descent. English was spoken as a first language by 87% of participants. Those who did not list English as a first language were nonetheless fluent and able to understand task instructions. Annual family income ranged from under £19,999 (9.9% of the sample) to above £100,000 (5.3% of the sample) with 12.3% of the sample between £40,000 and £59,999, and 5.8% between £60,000 and £99,999. However, 62.2% participants did not complete this question.

To determine pain group, all participants reported on current pain symptoms using items from a questionnaire used in a previous study. Participants were asked “Have you been feeling any pains for longer than 3 months? [yes/no].” “How often have you felt aches or pains in the last 3 months?” (Every day/Most days/On about one day each week/On about 2 or 3 days each week/On about one day each month/On less than one day each month), and “How much has pain interfered with you doing activities that other people your age do, in the last 3 months?” (0-10 numeric rating scale where 0 = I don’t miss out on any activities and 10 = I miss out on all activities). Based on their responses to these questions, and an adapted grouping method we reported in a previous study of pain in a community youth sample, participants were allocated to one of 3 groups. Adolescents with no or low pain symptoms (n = 116) were defined as those who responded “no” to the item “Have you been feeling any pains for longer than 3 months?” and who reported experiencing pain less than once a week in response to the item “How often have you felt aches or pains in the last 3 months?” Adolescents with pain but with no or low interference to daily life (n = 66) were defined as those who responded “yes” to the item “Have you been feeling any pains for longer than 3 months?” but who gave a rating of between 1 and 4 (out of 10) when asked “How much has pain interfered with you doing activities that other people your age do, in the last 3 months?” Finally, adolescents with pain and with moderate to high levels of interference (n = 28) were defined as those who also responded “yes” to the item “Have you been feeling any pains for longer than 3 months?” but who gave a rating of between 5 and 10 (out of 10) when asked “How much has pain interfered with you doing activities that other people your age do, in the last 3 months?” We selected “5” as a cutoff score because previous studies have shown that a score of at least 4 to 5 on a scale of 10 reflects moderate levels of pain experience.

2.2. Interpretation bias task

This study used an expanded version of the Adolescent Interpretation Bodily Threat (ABT) taskd to assess young people’s tendencies to select threatening and benign explanations and outcomes of ambiguous bodily harm and social evaluation situations. In the original version of the task, participants are instructed to read 8 ambiguous vignettes about bodily harm and 8 ambiguous vignettes around social evaluation. The situations described in each vignette are considered ambiguous because it is unclear whether a threatening or benign outcome (or explanation) will occur. The resolution of the ambiguity of the scenario occurs in the final word; for this, participants are presented with each ending in turn across different trials and asked to rate the likelihood of each ending on a scale from 1 to 5. An example of a bodily harm scenario with the 2 different endings is: “You lie on the couch. Your body is cold. It is snowing outside. Your legs feel wet. It is ...blood/water.” The situation is resolved in a threatening direction by the final word being “blood” but resolved in a benign direction by the word “water.” Higher likelihood ratings for “blood” reflect relatively greater endorsement of a threatening interpretation while higher ratings for “water” index tendencies for selecting benign interpretations.

In the present version of the ABT task, we expanded the repertoire of situations in each of these categories to include 16 items. We ensured that 8 of the situations within the bodily harm category described immediate bodily harm (eg, potential injury) and the other 8 described longer-term bodily harm (eg, potential illness). Within the 16 items of social evaluation, we ensured that 8 items described potential interpersonal rejection and 8 described potential achievement-based failure. An example of a longer-term bodily harm scenario is: “You lie on the couch. Your body is feeling heavy. You would like to close your eyes. You are...” followed by “sick” and “relaxed.” An example of an interpersonal rejection scenario is “Your best friend invites you to go out with their new friends from the drama club. You hesitate at first but then agree to come along. At the end of the evening you think that the other people thought that you were... lovely/dull” and an example of an achievement-based failure is “You are struggling...”
a little with science and finding the topics much harder. On the mid-term exam you... passed/failed.”

Six of the items from the bodily harm subscale were taken from the original items of the AIBT but with changes to make them self-referential; 2 items from the original AIBT were not included because one was thought by the authors to be too similar and therefore repetitive in content to another item and for the other item, it was difficult to generate a self-referential version. Four of the 8 original AIBT social evaluation items were used in the new expanded version. All new scenarios (10 for the bodily harm and 12 for the social evaluation) were selected from items used in cognitive bias modification training, where multiple training sessions meant a huge selection of training scenarios to select from. We selected those items that were compatible with the categories of bodily harm and social evaluation, where the situation was self-referential, and where a threatening and benign outcome/explanation was deemed likely by the researchers. Minor modifications to the descriptions were made to ensure that all scenarios were similar in length and language difficulty.

In addition to adding more items, we also amended the response format. Unlike the AIBT, which asks participants to consider the degree to which a particular interpretation “popped into your mind” and “how much you believed” in the particular interpretation, here, we only asked participants to report the degree to which each negative and benign interpretation was likely to explain the situation. This was to be commensurate with other interpretation bias tasks in young people and to be considerate of time burden. Because there were 16 situations for each of the 2 domains of bodily harm and social evaluation, with 2 response options for each (ie, benign and negative), participants responded to 64 items. These were presented on a desktop computer and programmed using E-prime software (Psychology Software Tools, Inc) to appear in the same random order across participants. Likelihood ratings for each negative and benign word ending were made on a 5-point scale.

2.3. Procedure

Ethical approval for this study was obtained from the King’s College London Research Ethics Committee (HR-16/17-4035). All testing was conducted during class time at school under group-testing conditions. At least 2 experimenters were present to ensure that participants did not discuss completion of tasks and questionnaires during the session. Because all participants were older than 16 years, they provided informed consent rather than their parents/guardians. Participants were instructed to complete a demographic form containing information about their date of birth, gender identity, ethnicity group, their first language and, if known, their parental educational levels and family income. Two hundred two of the participants then completed a task measuring attention control, which is reported in a different study. This was then followed by the measure of interpretation bias. After completion of the experimental tasks, all participants completed items about pain experiences and the Revised Child Anxiety and Depression Scale. Participants were then thanked for their time and emailed a £5 gift voucher, together with a brief summary of the findings around 2 weeks after data collection.

2.4. Statistical analysis

2.4.1. Step 1: model fitting to select subscale items

To determine which of the 16 items should be included in each of the final AIBT subscales (negative interpretations of bodily harm, benign interpretations of bodily harm, negative interpretations of social evaluation, and benign interpretations of social evaluation), confirmatory factor analysis (CFA) was conducted using Mplus v7.1119 in 2 stages (Supplementary Table 1, available as supplemental digital content at http://links.lww.com/PAIN/A890). Because the 16 items for bodily harm were drawn from 8 items for immediate bodily injury situations (items 1-8, stage 1a, Supplementary Table 1, available as supplemental digital content at http://links.lww.com/PAIN/A890) and 8 items for long-term illness situations (items 9-16, stage 1a, Supplementary Table 1, available as supplemental digital content at http://links.lww.com/PAIN/A890), we first determined which of the 8 items in each subset did not cohere with the other items, ie, contribute variance to a single latent factor. Similarly, because the 16 items for social evaluation comprised 8 items for social rejection (items 1-8, stage 1a, Supplementary Table 1, available as supplemental digital content at http://links.lww.com/PAIN/A890) and 8 items for performance failure (items 9-16, stage 1a, Supplementary Table 1, available as supplemental digital content at http://links.lww.com/PAIN/A890), again, we determined for each subset, which of the 8 items were discrepant. Because this was done separately for negative and benign ratings for bodily harm and social evaluation situations, this resulted in 8 sets of CFA being conducted (stage 1a, Supplementary Table 1, available as supplemental digital content at http://links.lww.com/PAIN/A890). In each CFA, items that had negative loadings or had factor loadings below 0.4 on a single latent factor were removed, and the analysis repeated iteratively until all factor loadings were positive and above 0.4 without any deterioration in model-fit indices.

Next, to gain an index of their coherence, all the selected items (following multiple iterations) for each category of bodily harm and social evaluation were again submitted to a one-factor CFA, separately for negative and benign interpretations (stage 1b, Supplementary Table 1, available as supplemental digital content at http://links.lww.com/PAIN/A890), items were removed iteratively again until all items included loaded positively and above 0.4 (stage 1c, Supplementary Table 1, available as supplemental digital content at http://links.lww.com/PAIN/A890). Goodness of fit statistics (comparative fit index [CFI], Tucker–Lewis index [TLI], and root mean-squared error of approximation [RMSEA]) were computed for each CFA, including for the “full” model with all initial items and the final models with discrepant items removed. Comparative fit index values greater than or equal to 0.90 and TLI values greater than or equal to 0.95 suggested a good model fit.7,10 Root mean-squared error of approximation values closer to 0 reflect better fit, with those less than 0.08 suggesting a good model fit. The 2 item selection stages resulted in the 4 final subscales but with a different number of items in each.

2.4.2. Step 2: model fitting to compare 3 factor structures

Next, to determine the factor structure that best represented the underlying factors contributing to the interpretations of bodily harm and social evaluation situations across all young people, CFA was used to compare 3 separate models for negative and benign ratings of the retained items from step 1. Three CFA models were considered (Figs. 1A–C): (1) one-factor; (2) 2 (correlated) factors, and (3) 2-factor bifactor (one general and 2 specific factors), with covariances between all factors fixed to zero in line with bifactor model assumptions.1 Because prior theoretical models implicate a general cognitive style that influences appraisals across different kinds of situations (eg, the hopelessness theory of depression) with empirical findings of associations between interpretations of different types of
situations, we compared models that enabled common variance across negative (and benign) interpretations of bodily harm and social evaluation. However, to the extent that correlations between these constructs were minimal, these models enabled weak or nonsignificant associations to be estimated. We used mean- and variance-adjusted weighted least squares estimation (WLSMV) for all models, as recommended for ordinal data with 5 or fewer response categories. Comparative fit index, TLI, and RMSEA were again used to assess model fit. Comparative fit index change was also used to compare models, where a value superior to 0.01 was recommended as indicative of better fit. In addition, as the 2 (correlated) factors and two-factor bifactor models were nested, the DIFFTEST command for corrected $\chi^2$ difference tests was used to formally compare model fit.

2.4.3. Step 3: pain group comparisons
Factor scores and the associated determinacy index of each factor from the 2 best-fitting models (ie, for negative and benign

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**Figure 1.** (A) One-factor model. (B) Two (correlated) factors model. (C) Two-factor bifactor (one general and 2 specific factors).
factor models) were generated and analysed in relation to the 3 pain groups using mixed-model analyses of variance (ANOVA). Factor determinacy scores aimed to evaluate the internal consistency of the factors and reflect the quality of the generated factor scores through calculating, for each factor, the correlation coefficient between the estimated factor score and the obtained/true factor score. Factor determinacy scores range from 0 to 1 with values closer to 1 indicating better measurement of the factor. Mixed ANOVAs in SPSS were conducted with pain group as the between subject factor and factors from the best-fitting model as the within-subject factors for benign and negative factor scores separately. However, assumptions for mixed ANOVAs were first assessed. The distributions of each factor for each pain group were approximately normally distributed; there was equality of variance for the distribution of these factors across groups; and finally, as the sphericity assumption using the Mauchly test was violated, we applied the Greenhouse-Geisser correction to interpret the statistical significance of the main and interaction terms.

Given robust data showing linkages between anxiety and depressive symptoms and biased interpretational style across diverse range of situations, and also consistent with prior studies, we investigated correlations between anxiety and depression symptom scores from the Revised Children’s Anxiety and Depression Scale and our specific and general factor scores. If symptoms of anxiety and depression correlated significantly with factor scores, we subsequently investigated whether any pain group differences occurred after controlling for these symptom scores.

3. Results

There were no differences between pain groups in terms of age F (2,191) = 1.40, P = 0.25, gender identity χ² (2) = 3.24, P = 0.20, ethnicity χ² (10) = 14.21, P = 0.16, school attended χ² (8) = 13.68, P = 0.09, or native language χ² (2) = 1.16, P = 0.56 (Table 1). As expected, there were significant differences between all 3 groups on average levels of pain over the last 4 weeks, F(2,162) = 19.97, P < 0.001; last 3 months, F(2,162) = 23.56, P < 0.001; the intensity of the most amount of pain experienced, F(2,162) = 19.21, P < 0.001; and pain effects on missing school F(2,162) = 6.96, P = 0.001 (pairwise comparisons, all Ps < 0.07).

3.1. Model fitting to select subscale items

Fit statistics of the 8 CFAs for stage 1a of item selection are presented in Table 2 for the full models with all 8 items included and following the removal of items that had negative loadings or loadings less than 0.40. Next, in stage 1b of item selection, these remaining items were collapsed for each main category (ie, bodily harm and social evaluation) in separate single factors representing negative and benign interpretations—with more items removed (stage 1c). The final CFA models for negative interpretations of bodily harm comprised 9 items (CFI = 0.95, TLI = 0.93, RMSEA = 0.05) and for social evaluation, 12 items (CFI = 0.88, TLI = 0.86, RMSEA = 0.07). For the benign interpretations of bodily harm, 6 items remained (CFI = 0.83, TLI = 0.75, RMSEA = 0.10), whereas for benign interpretations of social evaluation, 11 items remained (CFI = 0.91, TLI = 0.90, RMSEA = 0.08). These final items are presented in Supplementary Methods (available as supplemental digital content at http://links.lww.com/PAIN/A890). Of note, 4 of the 6 items from the original AIBT bodily harm subscale were included in each of the negative and benign subscales of the new measure after item selection. All 4 of the social evaluation items from the original AIBT were retained in the final negative and benign subscales of the new measure. These items are marked with an asterisk in Supplementary Methods (available as supplemental digital content at http://links.lww.com/PAIN/A890). Factor loadings for the final items are presented in Supplementary Table 1 (available as supplemental digital content at http://links.lww.com/PAIN/A890); of note, in the final models, factor loadings of some items became <0.40; however, as their removal led to a worsening in model fit, they were retained. To gain an indication of the reliability of these factor loadings, we repeated CFAs using the final items for each subscale in 2 random halves of the sample; factor loadings were largely over or very close to 0.40 (all >0.37).

3.2. Step 2: model fitting to compare 3 factor structures

Using the final items, 3 models were considered separately for the negative and benign subscales (Table 3). For the negative subscale, the best-fitting model was the 2-factor model (Fig. 1B), with a correlation between bodily harm and social evaluation factors; and for the benign subscales, the best-fitting model was the 2-factor bifactor model (Fig. 1C) with one general and 2 specific factors. Compared to a correlated 2-factor solution for benign items, the bifactor model significantly improved fit for χ² (17) = 29.83, P = 0.028. Although the general factor refers to an individual’s tendency to endorse benign interpretations across all situations, the specific factors for bodily harm vs social evaluation situations refer to situation-specific interpretations. Factor scores generated from the best-fitting negative and benign models had the following determinacy scores: for the two-factor model of negative interpretations, factor determinacy was 0.88 for the specific factor of bodily harm and 0.90 for the specific factor of social evaluation. For the bifactor model of benign interpretations, factor determinacy was of 0.82 for the general factor, of 0.80 for the specific factor 1 (ie, bodily harm), and of 0.83 for the specific factor 2 (ie, social evaluation).

3.3. Step 3: pain group comparisons

For negative interpretations, a 2 × 2 mixed ANOVA with pain group as a between-subject factor and factor (bodily harm and social evaluation) as a within-subject factor revealed a main effect of pain group F(2, 207) = 3.81, P < 0.05. Post hoc tests with Bonferroni correction showed that those with moderate-to-high-interfering chronic pain endorsed more negative interpretations than those with no pain but did not differ from those with low-interfering pain. Given that both anxiety and depression symptoms correlated significantly with these specific factors: r(237)bodily harm–anxiety = 0.27, P < 0.001 and r(237)bodily harm–depression = 0.26, P < 0.001, analyses were repeated including anxiety and depressive symptoms as covariates. There was no longer a main effect of chronic pain group nor an effect of anxiety. Instead, only a significant effect of depression symptoms emerged F(1, 207) = 7.43, P < 0.01.

For benign interpretations, a 3 × 2 mixed ANOVA, again with pain group as a between-subject factor and factor (general, bodily harm, social evaluation) as a within-subject factor revealed a significant main effect of pain group F(2, 207) = 3.89, P < 0.05, which was further subsumed under a significant 2-way interaction F(4, 414) = 4.58, P < 0.05. To unpack this, we analysed group differences for the general factor and the 2 specific factors of bodily harm and social evaluation. This revealed only group differences for the general factor, F(2, 210) = 11.08, P < 0.001 such that significant group differences emerged between
adolescents with no or low pain symptoms and adolescents with low-interfering pain ($t(180) = 4.21, P < 0.001$), and adolescents with no or low pain symptoms and those with moderate-to-high interfering pain ($t(142) = 3.48, P < 0.01$), but not between low and moderate-to-high interfering groups ($t(92) = 0.33, P = 0.75$). Adolescents with no or low pain symptoms had higher scores than the 2 other pain groups, suggesting they had a more benign interpretational style across all situations. Because there were significant correlations between anxiety and depression symptoms and the benign general factor ($r(237)_{\text{general-anxiety}} = -0.16, P < 0.05$ and $r(237)_{\text{general-depression}} = -0.36, P < 0.05$), we repeated our post hoc pain group differences on the general benign factor score while controlling for anxiety and depression symptoms. This did not alter the significant main effect of pain group ($F(2, 209) = 4.54, P < 0.05$).

### 4. Discussion

This study investigated the content specificity of biased interpretations among community-based adolescents with...
could be a trait-like protective factor, potentially inherited.\textsuperscript{11,12} 

Overarching common factor too. This could reflect a general self-schema. By contrast, the tendency to endorse benign experiences that are internalised and “stored” separately across direct or indirect exposure to particular injury/health and social threat situations emerged as distinct situation-specific factors. Such findings suggested that although negative interpretations of bodily harm and social evaluation situations represented 2 situation-specific factors, for benign interpretations, these were influenced by both a general interpretational style factor and situation-specific factors representing unique variance to distinctive bodily vs social situations. Using resulting factor scores, adolescents with moderate-to-high levels of pain interference showed greater endorsement of negative interpretations across bodily threat and social evaluation situations than low-interfering adolescents and those with no or low pain symptoms. Adolescents with no or low pain symptoms also had a more general benign interpretational style than adolescents reporting low and moderate-to-high pain interference levels. Although endorsement of negative interpretations across factors seemed to be explained by co-occurring depressive symptoms, pain-group differences on benign interpretations emerged independently of these symptoms.

Our initial set of findings spoke to the factor structure of interpretational style across all adolescents. Across all young people, negative interpretations of bodily harm and social evaluation emerged as distinct situation-specific factors. Such distinct factors capturing situation-specific variance could reflect direct or indirect exposure to particular injury/health and social experiences that are internalised and “stored” separately across self-schema. By contrast, the tendency to endorse benign interpretations of diverse situations is also explained by an overarching common factor too. This could reflect a general inferential style that influences responses to all ambiguous situations around bodily and social threat. Such a common factor could be a trait-like protective factor, potentially inherited.\textsuperscript{11,12} However, the tendencies to draw benign interpretations of bodily harm and social threat situations are also each influenced by exposure to experiences around injury and health and specific social experiences. Future research should aim to replicate these factor structures, particularly for benign interpretations, not least because the Tucker–Lewis Index (TLI) of the best-fitting 2-factor bifactor model was still <0.95. Beyond this, studies should determine the stability of these factors, and whether they correlate with actual measures of general inferential style and situation-specific experiences.

Regardless of the identity of these general and distinct factors that influence negative and benign interpretations, our findings add to growing data on biased interpretational styles in young people with pain. Although prior studies converge on an association between the experience of pain in youth and displaying biased interpretations, they disagree somewhat on the content of biases. One study reported that community adolescents with frequent, persistent, and disabling pain displayed a preferential tendency to endorse negative interpretations of both bodily harm and social evaluation situations,\textsuperscript{9} whereas a second study of youth with chronic pain found a reduced tendency to draw benign interpretations of bodily harm situations only.\textsuperscript{4} Our findings, also among community youth, suggest pain-linked biases that extend beyond bodily harm situations, to social evaluation situations, particularly in the endorsement of negative explanations and outcomes. A generally reduced tendency to draw benign interpretations across all situations also characterised youth in our grouped sample with persistent pain. Interestingly, the degree to which situation-specific factors influence benign interpretations of bodily harm vs social situations did not vary by pain group (low vs moderate-to-severely impairing pain). Also, of importance, although pain-linked differences on negative interpretations were largely explained by confounding anxiety and depression symptoms, the effects of pain group on the general factor of benign interpretations were independent of mood and anxiety symptoms. Together, data across these 3 studies suggest that a negative interpretational style is associated with more impairing pain experiences (possibly because of co-occurring mood and anxiety symptoms), but that these interpretations become more focused on bodily harm in health care-seeking patients.\textsuperscript{4}

These data imply that the role of biased interpretations should be examined further. Although recent information-processing models propose that negative cognitive biases, notably the tendency to attend towards bodily sensations and interpret these as threatening, drive fear and avoidance of pain and in turn affect disability, there is not yet empirical evidence for these associations. Therefore, it is not clear yet whether biased interpretations maintain pain-associated fear, anxiety/depression, and avoidance, or if they confer vulnerability to the chronicity and disability

| Table 3 | Model-fitting results from comparison of the one-factor model; 2 (correlated) factors model; and 2-factor bifactor model with one general and 2 specific factors. |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         | Negative items: 11 items immediate bodily injury and long-term illness & 12 items social rejection and performance failure | Benign items: 6 items immediate bodily injury and long-term illness & 11 items social rejection and performance failure |
| One-factor model (full) | CFI = 0.706 | CFI = 0.678 |
| Two-factor model (full) | CFI = 0.928 | CFI = 0.926 |
| Two-factor bifactor model (full) | CFI = 0.947 | CFI = 0.949 |

CFI, comparative fit index; RMSEA, root mean-squared error of approximation; TLI, Tucker–Lewis index.
of pain among young people.14 Alternatively, negative interpretations could reflect the impact of pain experiences on anxiety and depression, and related cognitions. To disentangle these possibilities, longitudinal studies of biased interpretations, pain history and outcomes, and co-occurring anxiety and mood symptoms are needed at different time-points. Such studies could also investigate the degree to which threat interpretations influence responsiveness to pain management or rehabilitation efforts. More particularly, given that threat cognitions are hypothesised to influence natural recovery outcomes, it may be that they also influence responses towards management efforts that involve approaching pain situations, such as physiotherapy. Finally, it is important to address whether these biases are amenable to change with resultant reductions in pain-associated fear and avoidance, anxiety/depression, and disability. This has implications for treatment, and in youth, for prevention. Specifically, identifying cognitive-behavioural strategies that can effectively target biases could be implemented within treatment plans and/or early interventions to reduce pain and other correlated affective outcomes such as mood and anxiety symptoms.

Our findings support use of a novel tool for measuring interpretations to a variety of situations. We expanded our previous measure by including items around immediate bodily injury and longer-term illness, as well as social rejection and performance failure situations and then using a further step of model-fitting to remove items of poor coherence or fit. Of note, to the extent that items from the original AIBT were included here, these items were retained after stages of item selection, suggesting item coherence in the subscales used in previous studies. Because biased interpretations also characterise other psychiatric conditions in youth,22 this tool could be used more widely. However, future research would first be required to investigate the psychometric properties, notably the test–retest reliability and validity in both general population samples and within each specific population of youth to which it is administered. Although this study used factor analytic techniques to select items that best reflected negative and benign bodily harm and social evaluation interpretations, item selection should be replicated in independent community and clinical samples.

Our findings are limited. First, demographic characteristics of this sample constrain the generalizability of our findings. Only young people aged 16 to 19 years were assessed. Because rates of some chronic pain conditions may increase across adolescence,19 and because cognitive emotion regulation abilities such as appraisals show protracted maturation across this period,18 different associations between pain, disability, and biased interpretations may characterise other ages within adolescence and even in late childhood and early adulthood. Similarly, our sample was largely female; although we had some male participants, we were inadequately powered to examine interactions between gender and pain group on these different factors of interpretational style. Future studies should explore any moderation of the association between biased interpretations of bodily harm and social situations by age or gender by recruiting larger samples with wider age ranges and more equal distribution of male and female participants. Second, pain group and associated functional interference were determined on a few questions; standardised questionnaires of pain-linked interference for young people could be incorporated into future research studies to more precisely define pain groups within community samples. There are also questions around the ecological validity of the situations described in the AIBT. It is unclear whether interpretations measured using such self-reported responses to hypothetical situations generalise to the appraisals made in daily life. One way of addressing is to ask young people to keep diaries of real-life bodily harm and social evaluation situations and ask them to generate interpretations of these, which are then subsequently coded. Self-generating interpretations in a group with varying pain levels could test whether the response options of negative and benign interpretations given in the present task match real-life interpretations. Using more ecologically valid interpretations could also unmask pain group differences that are independent of correlated depression symptoms. In the current task, there was a mismatch in the nature of the “benign” interpretation between bodily harm and social evaluation situations, such that a “benign” interpretation of a social situation was usually a positive resolution, whereas a “benign” interpretation of a bodily harm situation was usually a more neutral resolution. This mismatch may arise from intrinsic differences between the motivational values of these situations. Because social situations are rewarding (particularly for youth), neutral resolutions of ambiguous situations could be considered mildly negative, in turn attenuating pain-group differences. By contrast, although the absence of pain/injury/illness is valued, any positive resolution of ambiguity could be perceived as unrealistic. Finally, we only assessed voluntary indices of interpretational style that relied on self-report and therefore subject to demand characteristics. Task-based measures using response times or other efforts to measure earlier, more involuntary aspects of ambiguity resolution such as the lexical decision task or the scrambled sentences24 could reduce any potential demand effects in future studies.

In conclusion, using an adapted version of the AIBT task, we investigated the factor structure of negative and benign interpretations of ambiguous situations around bodily harm and social evaluation. Then, using factor scores, we compared adolescents from the community with and without persistent pain. Adolescents with persistent pain endorsed more negative interpretations of ambiguous bodily harm and social evaluation situations and had a reduced overall tendency to draw benign interpretations of these situations. Replication efforts are needed in independent community samples with younger (adolescent) participants as well as health care-seeking patients.

Conflict of interest statement
The authors have no conflicts of interest to declare.

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Appendix A. Supplemental digital content
Supplemental digital content associated with this article can be found online at http://links.lww.com/PAIN/A890.

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