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Attentional bias to pain and social threat in pediatric patients with functional abdominal pain and pain-free youth before and after performance evaluation

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Abstract

This study investigated attentional biases for pain and social threat versus neutral stimuli in 54 youth with functional abdominal pain (FAP) and 53 healthy control subjects (ages 10 to 16 years). We assessed attentional bias using a visual probe detection task (PDT) that presented pain and social threat words in comparison to neutral words at conscious (1250 ms) and preconscious (20 ms) presentation rates. We administered the PDT before and after random assignment of participants to a laboratory stressor—failure versus success feedback regarding their performance on a challenging computer game. All analyses controlled for trait anxiety. At the conscious rate of stimulus presentation, FAP patients exhibited preferential attention toward pain compared with neutral stimuli and compared with the control group. FAP patients maintained preferential attention toward conscious pain stimuli after performance feedback in both failure and success conditions. At the preconscious rate of stimulus presentation, FAP patients' attention was neutral at baseline but increased significantly toward pain stimuli after performance feedback in both failure and success conditions. FAP patients' somatic symptoms increased in both failure and success conditions; control youth's somatic symptoms only increased after failure. Regarding social threat, neither FAP nor control youth exhibited attentional bias toward social threat compared with neutral stimuli at baseline, but both FAP and control youth in the failure condition significantly increased attention away from social threat after failure feedback. Results suggest that FAP patients preferentially attend to pain stimuli in conscious awareness. Moreover, performance evaluation may activate their preconscious attention to pain stimuli.

Keywords

Attention; Attentional bias; Pain; Functional abdominal pain; Anxiety; Probe detection task; Social threat

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Appendix A. Supplementary data Supplementary data associated with this article can be found, in the online version, at doi: 10.1016/j.pain.2011.01.029.

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

1. Introduction

Although attention to acute pain may trigger adaptive behavior that promotes well-being, the constant attentional demands associated with chronic pain may foster excessive fear and avoidance behavior that increases distress and disability [8]. This possibility has been examined in studies investigating selective attention toward pain-related information as a potential mechanism maintaining chronic pain [23,27]. Results of these studies suggest that selective attention to pain-related stimuli by chronic pain patients varies as a function of individual difference variables such as anxiety sensitivity [1] and stimulus features such as whether the stimulus is available in preconscious or conscious awareness [14]. In the only pediatric study to date, Boyer et al. [3] found that children with recurrent abdominal pain of various etiologies had an attentional bias to pain words in preconscious awareness compared with neutral words. However, given the heterogeneity of the pain sample and the absence of a nonpain control group, it is possible that this finding represents an adaptive response to unconscious pain threat that characterizes all children.

The present study examined attentional bias to pain in pediatric patients with persistent, medically unexplained functional abdominal pain (FAP) compared with children without pain. Our prior work linked school-day stress to increased reports of pain and somatic symptoms by patients with FAP [32], suggesting that their attention to pain may increase under conditions of acute minor stress typical of the school environment. We evaluated this possibility in the present study by assessing changes in attention to pain-related stimuli after exposure to a laboratory task that simulated a school stressor.

Using the computer-administered dot probe detection task [17,28], we assessed attention allocation by means of participants' response latencies to a visual probe that replaced pain-related versus neutral words. After baseline administration of the probe detection task, we randomly assigned participants to failure versus success feedback on a challenging computer problem-solving game; after completing the game, they repeated the probe detection task. We expected that attention to pain stimuli would significantly increase in FAP patients randomized to the stress condition—failure feedback—compared with FAP patients assigned to the success feedback condition and to control youth in both feedback conditions. Because stress increases physiological arousal and somatic sensations that may be particularly salient for FAP patients, we also assessed somatic symptoms and predicted that FAP patients in the failure condition would report significant increases in somatic symptoms.

Following Boyer et al. [3], we evaluated whether attentional bias by FAP patients was specific to pain-related threat by assessing participants' attention to social as well as pain-related threat words. We presented all word stimuli at both preconscious and conscious presentation rates to examine early and later stages of attention allocation [10,12,21]. Finally, because trait anxiety may influence attention to threat [3,28,29] and FAP is associated with anxiety [7], we included anxiety as a covariate in our analyses.

2. Methods

2.1. Participants

2.1.1. FAP group (N = 54)—The patient sample was drawn from youth between the ages of 10 and 16 years (mean = 12.42; standard deviation [SD] = 1.82) referred consecutively to a pediatric gastroenterology clinic for evaluation of abdominal pain. Caregivers of youth whose medical evaluation revealed no evidence of organic disease were contacted by telephone and invited to participate. Additional eligibility criteria obtained by parent report included at least 3 episodes of abdominal pain during the previous 3 months and no chronic

illness, disability, or reading disorder. Sixty-three percent of participants were female. The sample was 91% Caucasian, 5% African American, 3% Asian American, and 2% from other ethnic backgrounds. Based on caregiver report at the time of the child's medical evaluation, 64% of patients had experienced recurrent episodes of abdominal pain for more than 1 year. Caregivers who participated in the study included mothers (84.4%), fathers (14.1%), and 1 aunt (1.6%). The mean occupational status of parents, based on the 9-point Hollingshead occupational scores [11], was 5.10 (SD = 1.24).

2.1.2. Control group (N = 53)—Caregivers of participants in a public school survey of children's health were contacted by phone to assess eligibility for the present study. To ensure that the youth were not pain patients, they had to meet the following criteria: (1) Youth self-report surveys, completed at school several weeks prior to recruitment for this study, indicated no more than 2 episodes of abdominal pain in the past 2 weeks and their score on the Children's Somatization Inventory [31] was below the sample median for their gender (the purpose of this eligibility criterion for the control sample was to exclude children with high levels of various types of pain and nonspecific somatic symptoms that are common in children with functional abdominal pain and to reduce the likelihood that the control sample would include children with any type of chronic pain, eg, headache, chest pain). (2) Their caregivers' report, at the time of recruitment for the present study, indicated that they had experienced no moderate or severe pain of any kind in the previous 3 months and had experienced mild pain (including stomachaches, headaches, or other pain) no more than once per month. Youth with a chronic illness, disability, or reading disorder were excluded. Participants ranged in age from 10 to 16 years (mean = 12.53, SD = 2.02); 41% percent were female. The sample was 97% Caucasian and 3% African American. Participating caregivers included mothers (73.4%), fathers (14.1%), and nonparent caregivers (eg, grandparents; 3.2%). The mean occupational status of parents [11] was 4.78 (SD = 1.03).

2.2. Experimental stress manipulation (computer game)

Participants completed a cognitive problem-solving task that allows experimental manipulation of success and failure feedback [5,6]. The game entails the use of clues to identify the correct stimulus dimension (color, shape, or center symbol) for a series of figures presented on a computer screen. After each trial, the computer informs the participant whether his/her answer was "correct" or "incorrect." In this study, participants in each group (FAP, control) were randomly assigned to either the success or failure feedback condition. In both conditions, participants completed 4 practice trials with the aid of the research assistant. Participants repeated each practice trial with additional help if they were unable to independently reach the correct answer. This procedure ensured that participants in both conditions experienced success on the 4 practice trials. On the subsequent 3 test problems, computer feedback to participants in the success and failure conditions indicated that their responses were correct and incorrect, respectively.

2.3. Dot probe detection task

2.3.1. Word selection procedure—Participants' attentional orienting to threatening information was measured using a dot probe detection task similar to those used widely in research with adults and children [29]. Stimuli included words related to pain threat (eg, pain, hurt, bleed), words related to social threat (eg, ugly, dumb, stupid), and neutral words (eg, lamp, coat, floor). We generated an initial pool of over 450 words that were rated by youth for their emotional valence, by teachers for their reading level, and by psychology graduate students for their relevance to the proposed categories of pain threat, social threat, and neutral. To assess the threat value of words, 431 public school youth between the ages of 8 and 15 years were asked to rate the emotional valence of words in the initial pool from

3 (very bad) to 3 (very good), with 0 = not good and not bad. A word was considered for the pain or social threat category if its average rating was between -3 and -1.5 , and in the neutral category if its average rating was between -1 and $+1$. To confirm that the words reflected their intended threat categories, 20 graduate students naïve to the purpose of the study categorized the words as pain threat, social threat, or neutral. Words were divided across the graduate students, such that each word was evaluated by a total of 5 students. Words were considered for the dot probe detection task only if a minimum of 4 raters agreed on the category (80% agreement). To ensure that these words could be read and understood by participants, a third- and a fourth-grade teacher were asked to judge whether the words were readable and comprehensible by children finishing third grade. Only words that were judged to be readable and comprehensible to this age group by both teachers were included in the dot probe detection task.

Twenty pain threat words, 20 social threat words, and 80 neutral words that met the above criteria for emotional valence, category relevance, and readability were selected for stimuli in the dot probe detection task. An analysis of variance (ANOVA) indicated that the valence scores for threat and neutral word categories were significantly different from each other, $F(2, 77) = 545.35$, $P < .001$. A Scheffe's test indicated that the mean valence ratings for pain threat words (mean = -2.04 , SD = 0.36) and social threat words (mean = -2.04 , SD = 0.27) were not significantly different from each other, but were significantly different from the neutral word valence ratings (mean = 0.30 , SD = 0.32). In addition, an ANOVA comparing the length of pain threat words (mean = 5.40 letters, SD = 1.98) and social threat words (mean = 5.25 , SD = 1.33) revealed no significant differences, $F(2, 77) = 0.35$, not significant. The list of words is included in the Appendix.

Each threat word was paired with a neutral word according to its number of letters. In addition to the 40 threat-neutral word pairs, 20 length-matched neutral-neutral word pairs were included as filler trials in the dot probe detection task to control for response biases that might result from the expectation of threat words on each trial. In total, the task presented 60 distinct pairs of words to each participant.

2.3.2. Conscious and preconscious presentation rates of words—Consistent with previous pediatric research [3], word pairs in the conscious trials appeared on the screen for 1250 ms, and pairs in the preconscious trials appeared for 20 ms. To prevent preconsciously presented words from leaving a faded image after disappearing, identical strings of consonant letters (eg, FWRTP and FWRTP) replaced the upper and lower preconsciously presented words. The letter strings were composed of an equal number of letters as the words that they replaced. To match the total exposure time of conscious word pairs, letter strings appeared for 1230 ms after preconscious word pairs.

2.3.3. Procedure for the dot probe detection task—The procedure for the dot probe detection task was similar to that used Boyer et al. [3], although the word stimuli differed. Word pairs were presented on a 15-inch monitor of a Dell computer. The experiment was controlled and timed with E-Prime software [24]. The order of presentation for the 60 word pairs was randomly generated by the computer for each participant. Each threat-neutral word pair was presented at a conscious presentation rate (1250 ms) and a preconscious presentation rate (20 ms). To control for order effects and prevent consecutive presentations of the same word pair at different presentation rates, their order was counter-balanced across the first and second halves of the experiment. Specifically, a pair that was presented at the conscious rate during the first half of the experiment was presented at the preconscious rate during the second half of the experiment, and a pair that was presented at the preconscious rate during the first half was presented at the conscious rate during the second half. In total,

each participant completed 120 distinct trials. After participants completed the first half of the experiment, they were given a 1-minute break during which they could rest their eyes.

During each trial of the experiment, a white addition symbol (+) appeared as a fixation mark in the center of the screen for 1 second. After the fixation mark, one of the 60 word pairs appeared on the screen at either a conscious or preconscious exposure rate. All characters appeared in white Courier font on a black background, one above the other in the center of the screen, separated by 3 centimeters. The position of the threat word in the upper or lower position was balanced across pain threat-neutral and social threat-neutral word pairs. After the word pairs, the dot probe, a period (.), appeared in the same position as one of the words in the word pair, replacing upper and lower words with equal frequency across trials. Participants were instructed to press a corresponding key as quickly and accurately as possible to indicate the position of the dot. Participants were instructed to press the c key when the dot appeared in the upper position and the m key when the dot appeared in the lower position. The keys were labeled UP and DOWN, on the keyboard, respectively. In addition, pictures of arrows were placed on the bottom border of the computer monitor in line with the c and m keys. The left arrow pointed upward as a reminder that the c key indicated the upper position, and the right arrow pointed downward as a reminder that the m key indicated the lower position. These instructions, labels, and arrow illustrations were reversed for half of participants to control for hand dominance.

2.4. Measures

2.4.1. Attentional Bias Index (ABI) scores—The computer recorded the rate and accuracy of participants' responses for each trial. Recorded latencies to threat-neutral word pair trials served as the measure of selective attention. Continuous attentional bias scores were created by collapsing scores for the dot probe position by threat word position [16]. For each participant, mean response latency data from each trial were entered into the equation below to compute a continuous ABI score. This ABI score reflects the magnitude of the attentional bias across all positions of the threat word and dot probe. Bias was operationalized as the response latency to detect the dot probe when it appeared in the same position as the threat word subtracted from the latency to detect the dot probe when it appeared in the opposite position on the screen as the threat word.

$$\text{ABI score} = 1/2 [(UP/LT - UP/UT) + (LP/UT - LP/LT)]$$

In this equation, U = upper screen position, L = lower screen position, P = probe, and T = threat word. Thus, UP/LT is equal to the mean reaction time when the dot probe is in the upper position and the threat word is in the lower position. In this equation, positive scores reflect an attentional bias toward threat, negative scores reflect a bias away from threat (ie, avoidance of threat words), and a score of 0 reflects no bias toward or away from threat. Separate bias index scores for physical and social threat words at both presentation rates (conscious and preconscious) were computed for each participant, resulting in a total of 4 ABI scores for each child: (1) conscious attentional bias for physical threat words, (2) conscious attentional bias for social threat words, (3) preconscious attentional bias for physical threat words, and (4) preconscious attentional bias for social threat words.

2.4.2. Lexical decision task—After the dot probe detection task, a lexical decision task [3] was administered to test whether participants could report reading word pairs presented at the preconscious rate. E-Prime software [24] was used to present the task, which was introduced to participants as the “word game.” Similar to the preconscious presentation of word pairs in the dot probe detection task, an addition sign (+) appeared on the computer screen for 1 second as a fixation point, followed by 2 words, one above the other, for 20 ms.

Half of the trials presented real words (eg, house, driveway), and the remaining trials presented nonsense words (ie, pronounceable words with no meaning, eg, blorky, snidbell). Length-matched, identical strings of consonant letters replaced these words for 1230 ms. After the letter strings, a question mark (?) prompted participants to indicate whether a real word or a nonsense word was presented. A 50% overall accuracy rate would indicate that participants were guessing and/or unable to read the words and identify them as real or nonsense.

Participants completed the lexical decision task in a similar manner to the dot probe detection task, except that no practice trials were administered and participants were informed that half the words would be real and half would be nonsense words. The c key was labeled YES to indicate that real words were presented, and the m key was labeled NO to indicate that real words were not presented. The keys' meaning and labels were reversed for half of participants to control for hand dominance. The computer recorded response accuracy. Three pain threat word pairs, 3 social threat word pairs, and 9 filler word pairs were included in the task. The computer presented 18 different trials in random order for each participant.

2.4.3. Symptom/emotion report (SER) [34]—The SER is a state measure of emotional and somatic symptoms. Subscales assess negative affect (NA; eg, sad), positive affect (PA; eg, happy), gastrointestinal (GI) symptoms (eg, stomach upset) and non-GI somatic symptoms (eg, sweaty hands, dizziness). We added to the latter subscale several somatic symptoms that might be associated with playing the computer game (eg, blurry eyes, cramped fingers, stiff neck). Items appeared on the computer screen above a 5-point rating scale ranging from 1 = not at all to 5 = a whole lot. The experimenter read the stem, “How much do you feel [symptom/emotion] right now?” and entered participants' verbal ratings into the computer. Ratings of items were recoded to a 0 to 4 scale and averaged to create 4 indices: NA (4 items), PA (6 items), GI symptoms (3 items), and non-GI somatic symptoms (13 items). Scores on each index could range from 0 to 4. PA and NA were included to assess whether the failure feedback condition of the computer game was indeed more stressful than the success feedback condition. In this study, the Cronbach alpha coefficients for the PA, GI, and non-GI somatic symptoms were adequate (all α s $\geq .83$) in administrations before and after the computer game. The NA scale had low alpha coefficients before and after the computer game (α s = .48 and .43, respectively).

2.4.4. The Multidimensional Anxiety Scale for Children (MASC) [19]—The MASC consists of 39 items that assess anxiety symptoms, such as “My heart races or skips beats,” “I worry about other people laughing at me,” and “I try to stay near my mom or dad.” Participants rated how often each anxiety-arousing statement was true for them on a 4-point rating scale ranging from 0 = never true about me to 3 = often true about me. Scores were summed, with higher scores reflecting higher levels of anxiety. The MASC has excellent internal reliability and adequate test-retest reliability [19,20]. In our sample, Cronbach alpha coefficient for the total scale score was .91.

2.4.5. Demographic information—Parents provided demographic information about participants and their families, including participants' ethnicity and parents' education and occupation(s). Parents' level of education and occupational status were used to derive the families' socioeconomic status using the Hollingshead index [11].

2.5. Procedure

The protocol was approved by the Vanderbilt University Institutional Review Board. Upon the family's arrival at the laboratory, an experimenter who was unaware of participants'

group status reviewed the study procedures and obtained informed assent and consent from participants and parents, respectively. Parents went to a separate room to complete the demographic information form, and returned at the end of their child's study session.

Participants sat at a computer desk in a chair set 60 cm from the computer screen. The heights of the computer monitor and chair were adjusted so that participants' eyes were level with the center of the monitor and their elbows bent at right angles when their hands rested on the keyboard. A halogen lamp was dimmed to a low brightness to enhance viewing of the computer screen.

The experimenter provided instructions for the dot probe detection task, and participants completed 6 instructional trials followed by 12 practice trials with opportunities to ask questions. Next, they completed the dot probe detection task independently. After the dot probe detection task, participants received instructions and completed 4 practice trials of the computer game. After these practice trials, participants completed the first SER. They then completed 3 trials of the computer game with success versus failure manipulated, followed by the second SER. Finally, participants completed the dot probe detection task for a second time and then completed the lexical decision task. Families were de-briefed regarding the manipulation of success/failure feedback and were given \$50 compensation for their participation. The MASC was administered after the dot probe detection task to avoid priming participants for threat items that appeared in the dot probe detection task [15].

3. Results

3.1. Statistical analyses

To test whether the failure feedback condition on the computer game was experienced as distressing, we evaluated changes in NA and PA from baseline to post-game using repeated-measures ANOVAs with group (FAP versus control), sex, and feedback condition (ie, success versus failure) as the between-group factors, and time (baseline versus post-game) as the within-group factor. To examine changes in attention and physical symptom reports from baseline to post-game, we used repeated-measures ANCOVA with group (FAP versus control), sex, and feedback condition (ie, success versus failure) as between-group factors, time (baseline versus post-game) as a within-group factor, and trait anxiety as a covariate. Dependent variables were the ABI, GI symptoms, and non-GI somatic symptoms. Analyses of attentional bias were conducted separately for conscious and preconscious exposure conditions of pain threat and social threat words. In the cases of statistically reliable higher-order interactions, we used *t*-tests to decompose the interactions to identify the simple effects/group differences that contributed to the interaction. The *t*-tests were performed on the covariance-adjusted estimated means generated by each ANCOVA (ie, scores were adjusted for MASC scores). Positive ABI scores reflect an attentional bias toward threat, negative scores reflect a bias away from threat (ie, avoidance of threat words), and a score of 0 reflects no bias toward or away from threat. Two-tailed alpha was set at $P < .05$. Effect sizes are reported as Cohen's *d*. All analyses were conducted in SPSS 15.0.

3.2. Validation of the preconscious presentation rate

Mean response accuracy on the lexical decision task was calculated for each participant and compared with the expected range of scores for the task following the procedures of Boyer [3]. Participants' accuracy was slightly lower than chance, indicating that they were not able to read words presented at 20 ms.

3.3. Manipulation check for laboratory stressor (computer game)

3.3.1. Negative affect (NA)—ANOVA with NA as the repeated measure yielded a significant time $\times$ game feedback interaction, $F(120) = 9.71$, $P < .01$. As expected, participants in the failure feedback condition showed a significant increase in NA from baseline to post-game (means = 1.34 and 1.51, respectively, $t(58) = -4.40$, $P < .001$, $d = .41$), whereas participants in the success feedback condition showed no change in NA from baseline to post-game (means = 1.39 and 1.38, $t(68) = .26$, not significant).

3.3.2. Positive affect (PA)—ANOVA with PA as the repeated measure yielded a significant main effect for group, $F(120) = 7.54$, $P < .01$, $d = .5$, indicating that FAP patients reported lower PA (mean = 3.03) averaged across both time points compared with youth in the control group (mean = 3.40). A significant time $\times$ game feedback interaction, $F(120) = 26.63$, $P < .001$, showed that PA decreased significantly from baseline (mean = -3.29) to post-game (mean = 3.01) in the failure condition (paired $t(58) = 5.87$, $P < .001$, $d = 1.45$) but remained the same from baseline (mean = 3.25) to post-game (mean = 3.29) in the success condition, $t(69) = -1.06$, not significant. There were no other significant main effects or interactions for NA or PA.

3.4. Attentional bias

3.4.1. Pain threat—For the conscious exposure to pain threat versus neutral words, repeated measures ANCOVAs with MASC total scores as a covariate and ABI for pain threat as the dependent variable yielded a significant between-subjects main effect for group, $F(1, 101) = 5.20$, $P < .05$, $d = 1.42$, indicating that FAP patients showed significantly greater attention toward pain threat words (mean = 19.96, SD = 20.58) compared with control youth (mean = .40, SD = 7.27). FAP patients' ABI scores also differed significantly from neutral, $t(53) = 7.13$, $P < .001$, $d = 1.94$, indicating a conscious attentional bias toward pain threat. Control participants' ABI scores did not differ significantly from neutral, indicating absence of a conscious attentional bias to pain threat. Tests of time effects were not significant, indicating that differences in attentional biases to conscious pain threat in FAP patients relative to control youth were stable across time, and did not differ as a function of success or failure feedback on the problem-solving task. The MASC was not a significant covariate, indicating that trait anxiety was not significantly associated with attentional bias to consciously perceived threat stimuli.

In the preconscious exposure to pain threat versus neutral words, a significant interaction effect emerged for time $\times$ group, $F(1, 95) = 13.46$, $P < .001$ (Fig. 1). Across success and failure feedback conditions, FAP patients significantly increased their preconscious attention to pain threat from baseline (mean = -10.92) to post-game (mean = 29.70), paired $t(53) = -2.70$, $P < .01$, $d = 2.06$; thus, their preconscious attention to pain threat increased after a challenging computer game, regardless of success or failure feedback on that game. At post-game, FAP patients' attention to pain threat words presented at a preconscious rate was significantly greater than that of control youth, $t(70) = -8.21$, $P < .001$, $d = 1.73$, and significantly greater than their attention to neutral words, $t(51) = 7.23$, $P < .001$, $d = 2.01$, indicating an attentional bias to pain threat. In contrast, for control youth, preconscious attention to pain threat decreased from baseline (mean = 10.55) to post-game (mean = -7.04), paired $t(51) = 8.53$, $P < .001$, $d = 1.18$ and did not differ significantly from attention to neutral words at baseline or post-game. The MASC was not a significant covariate.

A significant time $\times$ sex interaction, $F(1, 95) = 5.86$, $P < .02$, also was found for preconscious exposure to pain threat words. The t -tests revealed that this interaction effect was due to a significant increase in boys' preconscious attention to pain threat from baseline (mean = -2.13) to post-game (mean = 25.81), $t(48) = -3.95$, $P < .001$, $d = .99$, whereas girls'

preconscious attention to pain threat did not change significantly across time (means = 1.55 versus -1.56, $t(54) = 0.94$, $P = .35$). Comparison of boys' post-game attention to pain versus neutral words indicated that in both success and failure feedback conditions, boys had a significant attentional bias toward pain threat words presented at a preconscious level, $t(48) = 5.47$, $P < .001$, $d = 1.56$. The MASC was not a significant covariate.

3.4.2. Social threat—In the conscious exposure to social threat versus neutral words, repeated measures ANCOVA yielded a significant time $\times$ feedback (ie, success versus failure) interaction, $F(1, 97) = 5.96$, $P < .02$. For both FAP and control groups in the failure condition, attention away from social threat increased significantly from baseline (mean = 6.91) to post-game (mean = -21.64), paired $t(52) = 2.08$, $P < .05$, $d = 1.45$, and differed significantly from neutral after failure feedback, $t(54) = -2.04$, $P < .05$, $d = 3.4$. Thus, both FAP patients and control youth showed an attentional bias away from social threat after failure. In contrast, in the success condition, participants' attention toward social threat increased significantly from baseline (mean = -17.44) to post-game (mean = 15.02), $t(61) = 2.04$, $P < .05$, $d = .28$. The effect size for this finding was small, and participants' post-game attention to social threat did not differ significantly from neutral in the success condition. Tests of between-subjects effects were not significant.

In the preconscious exposure to social threat versus neutral words, no significant between-subjects or time effects emerged. MASC scores were not a significant covariate in the analyses for either conscious or preconscious exposure to social threat.

3.5. GI and other somatic symptoms

3.5.1. GI symptoms—ANCOVA with MASC as a covariate and GI symptoms as the repeated measure yielded a significant main effect for group, $F(1, 109) = 6.31$, $P < .02$, $d = 2.0$, with FAP patients reporting significantly higher levels of GI symptoms compared with control youth (means = 1.40 versus 1.09). The MASC was a significant covariate, $F(1, 109) = 5.73$, $P < .02$, with higher MASC scores associated with higher levels of GI symptoms ($r = .75$, $P < .01$). No additional main or interaction effects were observed for GI symptoms.

3.5.2. Non-GI somatic symptoms—ANCOVA with MASC as a covariate and non-GI somatic symptoms as the repeated measure yielded a significant time $\times$ group $\times$ feedback interaction, $F(1, 109) = 4.44$, $P < .05$ (Fig. 2). FAP patients in both success and failure feedback conditions reported significant increases in non-GI somatic symptoms from baseline to post-game (success: paired $t(30) = -13.91$, $P < .001$, $d = .19$; failure: paired $t(28) = -10.34$, $P < .001$, $d = .65$). Control youth's scores on non-GI somatic symptoms also increased significantly in the failure condition, paired $t(24) = -8.00$, $P < .001$, $d = .86$, but decreased significantly in the success condition, paired $t(32) = 5.07$, $P < .001$, $d = .16$. The MASC was a significant between-subjects covariate, $P < .005$, with higher MASC scores associated with higher levels of non-GI somatic symptoms ($r = .35$, $P < .001$).

4. Discussion

Using the dot probe detection task, we examined attentional processing of pain-related information among pediatric patients with functional abdominal pain (FAP) compared with pain-free youth. At the conscious rate of stimulus presentation, patients with FAP exhibited preferential attention toward pain stimuli compared with neutral stimuli and exhibited significantly greater attention to pain stimuli as compared with control youth. Repeated administration of the task after a challenging computer game indicated that preferential attention to consciously perceived pain threat stimuli was stable in patients with FAP. Our analyses controlled for trait anxiety and revealed that preferential attention to pain stimuli in

conscious awareness occurred over and above anxiety that is common in the FAP population. Taken together, these findings suggest that pediatric patients with FAP selectively attend toward pain-related information that appears in conscious awareness. Thus, this study joins a growing body of research [25,36] showing that clinical populations exhibit threat-related attentional biases specific to the content of their clinical disorder.

Unique to this study, we examined the effect of acute stress (manipulation of failure versus success feedback on a computer game) on attentional processing of pain stimuli. As expected, FAP patients in the failure feedback condition significantly increased their attention to pain stimuli. This increased attention to pain after failure occurred at the preconscious rate of stimulus presentation. Control youth, in contrast, exhibited no change in preconscious attentional focus after failure feedback. Interestingly, FAP patients in the success feedback condition also significantly increased their preconscious attention to pain stimuli. Perhaps performance challenges, regardless of failure or success, elicit automatic preconscious attention toward pain-related information in patients with FAP. This would be consistent with the notion, advanced by Eccleston and Crombez [8], that chronic pain patients become vigilant to a broad range of potential signals of pain. Given that abdominal pain episodes often occur at school [32], it is possible that performance challenges such as those associated with school become signals of pain threat that elicit the preconscious attention of some FAP patients and may contribute to school avoidance.

It also is possible that performance demands in both the success and the failure conditions elicited state anxiety in FAP patients. Recent work by Pacheco-Unguetti et al. [22] linked state anxiety with overfunctioning of the early, automatic stages of attentional processing. Thus, it is notable that significant increases in FAP patients' attention to pain after game performance occurred when stimuli were presented at the preconscious rate, which is thought to capture automatic processing [36]. Also of note, FAP patients' non-GI somatic symptoms increased along with their increased preconscious attention to pain stimuli, perhaps reflecting increases in physiological arousal associated with playing a challenging computer game. That is, patients with FAP may detect the physiological arousal of stress at a preconscious level that subsequently appears in conscious awareness as somatic symptoms. Future research should explore whether attentional processes contribute to the link between stress and somatic symptoms observed here as well as in other studies of FAP patients [30,32].

In contrast to patients with FAP, youth in the control group exhibited no attentional bias to pain threat words presented at preconscious or conscious rates either at baseline or when the task was repeated after success or failure feedback. However, the intensity of stimulus threat is known to affect attentional bias [35], and higher levels of pain-related stimulus intensity than that used in this study may elicit preferential attention in youth without FAP.

Regarding social threat stimuli, patients with FAP and control youth exhibited similar patterns of attention. At baseline, their attention to social threat did not differ from their attention to neutral stimuli. In the failure feedback condition, both patients with FAP and control youth exhibited significant increases in attention away from consciously presented social threat stimuli. The effect size for this finding was quite large. Strategic avoidance of social threat after performance failure may be adaptive in both clinical and nonclinical populations if it protects youth at a time when they are particularly vulnerable to criticism.

Strengths of this study include participant exposure to stimuli at preconscious and conscious presentation rates that captured different levels of automaticity of attention, assessment of attention to both pain and social threat, and control for the contribution of trait anxiety to participants' responses. Effect sizes were robust, increasing confidence in the findings. The

extent to which attentional biases to lexical stimuli correspond to attentional biases toward real-world stimuli needs further study [2]. Whether the current findings about attentional biases in a tertiary care patient sample generalize to youth with FAP in the general population also needs to be explored [36]. Finally, replication of these results in other pediatric pain populations is needed.

Recent studies suggest that attention training can alter attentional biases and reduce clinical anxiety [4,9,18,26,37]. No studies to date have used attention training in an effort to alleviate the suffering of pain patients. However, experimental [33] and clinical [13] interventions that reduce parents' solicitous attention to the symptom complaints of their children with FAP have produced decreases in symptom complaints, perhaps by reducing their children's attention toward pain-related information.

Future research should investigate the potential role of attentional bias toward pain in the development and maintenance of pediatric pain syndromes. In particular, our findings suggest the possibility that school-related performance challenges may trigger preconscious attention to stimuli associated with pain in the absence of nociception. Preferential attention to pain-related information may fuel an exaggerated perception of health-related vulnerability that fosters fear and avoidance of activities, impairing youth's development of age-appropriate competencies. Impaired competencies may contribute to stress and physiological arousal that may, in turn, capture patients' attention in an escalating cycle of perceived threat and increased pain. This process may be particularly insidious in functional pain disorders such as FAP that lack objective biomarkers and, therefore, are associated with diagnostic uncertainty that fosters vigilance to pain-related information by patients and their parents.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1. Group $\times$ time interaction for Attentional Bias Index (ABI) scores to pain threat words presented at a preconscious rate.

Fig. 2. Time $\times$ group $\times$ feedback condition (success, failure) interaction for nongastrointestinal somatic symptom scores on the symptom/emotion report (SER).