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Original Research Article

Do Interoceptive Sensations Provoke Fearful Responses in Adolescents With Chronic Headache or Chronic Abdominal Pain? A Preliminary Experimental Study

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Abstract

Objective To determine whether fear can be triggered when experiencing interoceptive sensations locally proximal to the primary pain region. **Methods** Two groups of adolescents (11–18 years) with chronic headache ($n = 20$) or chronic abdominal pain (CAP; $n = 20$) completed three muscle tensing tasks to induce proximal versus distal sensations: (1) "frown" task (proximal for chronic headache; distal for CAP), (2) "tighten stomach" task (proximal for CAP; distal for chronic headache), and (3) safe comparison task (clench fist). Fear and avoidance were assessed via self-report. **Results** Adolescents with CAP reported greater fear and avoidance after the proximal compared with the distal task, while adolescents with chronic headache did not. Both groups reported similar levels of fear and avoidance in the frown and safe comparison task. **Conclusions** Results suggest that the perception of proximal interoceptive sensations appears to activate the fear system in adolescents with CAP. Future research is warranted.

Key words: children and adolescents; chronic pain; fear of pain; interoceptive sensations; symptom provocation

Introduction

Children and adolescents[1] experiencing severe chronic pain face impairments in many aspects of their daily lives: they are unable to attend school on a regular basis, they restrict their leisure time activities, they do not meet up with their peers, they face extreme difficulty in accomplishing daily activities, and they suffer from emotional distress (Zernikow et al., 2012). According to the fear-avoidance Model, pain-related fear (Vlaeyen & Linton, 2000, 2012) can lead to this widespread functional disability (Simons, Kaczynski, Conroy, & Logan, 2012). Thus, daily activities that the adolescents expect to trigger pain are no longer performed. Avoidance behavior occurs in anticipation of pain rather than as a response to pain. This anticipatory anxiety is assumed to be acquired via associative learning, a mechanism by which diverse internal or external stimuli are learned as predictors of painful

1 In the present study, the focus is on children and adolescents aged 11–18 years, covering preadolescence to adolescence. Given that the mean age of the participants was 15.0 years (for those with chronic headache) and 14.2 years (for those with chronic abdominal pain), the term adolescents will be used throughout the article.

experiences and, hence, become a conditioned stimulus (CS). CSs can be of exteroceptive (e.g., auditory), proprioceptive (e.g., change in position), and interoceptive (i.e., body signals arising from the muscles, the skin, and the inner organs) nature (Gatzounis, Schrooten, Crombez, & Vlaeyen, 2012; Vlaeyen, 2015; Vlaeyen & Linton, 2012). Once the expectancy of a pain experience and its mental representation have been acquired, fear of pain and associated defensive behaviors (such as avoidance behaviors) will be activated as conditioned responses (CRs). Their function is to minimize future encounters with the pain experience (Vlaeyen, 2015).

In clinical situations, interoceptive CSs are assumed to be better predictors of pain than exteroceptive CSs owing to their functional proximity to the pain (De Peuter, Van Diest, Vansteenwegen, Van den Bergh, & Vlaeyen, 2011). However, research on the potential of internal stimuli to activate a conditioned fear response in individuals with chronic pain is lacking. From a functional perspective, it has been argued that the interoceptive CS must be proximal in location and in timing related to the unconditioned stimulus (i.e., pain; Bouton, Mineka, & Barlow, 2001). Interoceptive sensations that evolve from the same body region as the primary pain and are timely associated with pain episodes in that region are therefore assumed to more likely become conditioned stimuli and to elicit conditioned fear responses than interoceptive sensations more distal to the primary pain location (e.g., evolving from another body region; De Peuter et al., 2011). This assumption is in accordance with research focusing on panic disorder, which suggests that interoceptive sensations that occur proximal to the panic attack may be more likely to evoke anxious apprehension of panic attacks (Bouton et al., 2001). This proximity assumption, however, has not yet been systematically tested in chronic pain research.

The preliminary study presented here has the following objectives: We aim to investigate if the provocation of interoceptive sensations locally proximal to the primary pain region will be able to elicit greater self-reported fear and an avoidance tendency (hereafter referred to as avoidance) in adolescents with chronic headache and adolescents with chronic abdominal pain (CAP) than the provocation of sensations locally distal to the primary pain region. The two groups of adolescents were therefore asked to complete three tasks to induce interoceptive sensations: (1) the "frown" task, that is, tensing the corrugator supercilii muscle (proximal for chronic headache; distal for CAP), (2) the "tighten stomach" task, that is, tensing the abdominal muscles (proximal for CAP; distal for chronic headache), and (3) the safe comparison task, that is, clenching the fist (distal for both groups). In children with chronic headache, we expect greater fear and avoidance during the frown task compared with the tighten stomach task and the safe comparison task. In children with CAP, we expect greater fear and avoidance during the tighten stomach task compared with the frown and the safe comparison task.

Methods

Study Population

The study sample ($N = 40$) consisted of adolescents (aged 11–18 years) with recurrent and chronic pain disorder receiving either outpatient ($n = 3$) or inpatient ($n = 37$) intensive interdisciplinary pain treatment at the Children and Adolescent Hospital, Datteln. Eligible adolescents with chronic headache (chronic headache; $n = 20$, 80% female) were diagnosed according to ICD-10 criteria for chronic pain disorder as well as according to the criteria of the International Headache Society (IHS; Headache Classification Committee of the International Headache Society, 2013). Eligible adolescents with CAP ($n = 20$, 65% female) were diagnosed according to ICD-10 (Weltgesundheitsorganisation, Dilling, Mombour, & Schmidt, 2005). Excluded from the study were adolescents with comorbid headache and abdominal pain, head and abdomen as the primary pain location, unspecific primary pain, and insufficient German language skills. Detailed information on adolescents' specific pain diagnoses according to the IHS for adolescents with headache and Rome III for adolescents with CAP are presented in Table I.

The majority of participants in our sample was recruited during their participation in an inpatient interdisciplinary pain treatment program (Hechler et al., 2014). To diminish the therapeutic impact on the

Table I Pain Diagnoses of the Study Sample

Headache diagnoses[a]	*n*	%
Migraine without aura (IHS: 1.1)	4	20
Migraine with aura (IHS: 1.2)	1	5
Frequent episodic tension-type headache (IHS: 2.2)	3	15
Chronic tension-type headache (IHS: 2.3)	16	80
Chronic post-traumatic headache attributed to mild head injury (IHS: 5.2.2)	1	5
Medication-overuse headache (MOH) (IHS: 8.2)	5	25
Abdominal pain diagnoses		
Functional dyspepsia (ROME-III: H2a)[b]	4	20
Irritable Bowel Syndrome (ROME-III: H2b)[b]	2	10
Functional Abdominal Pain Syndrome (ROME-III: H2d1)[b]	11	55
Colitis ulcerosa (ICD-10: K51)[c]	1	5
Gastritis and duodenitis (ICD-10: K29)[c]	1	5
Chronic nephritic syndrome (N03.0)[c]	1	5

[a]According to International Headache Society (IHS) classification ICHD-II.
[b]According to ROME-III criteria for abdominal pain diagnosis.
[c]According to ICD-10 classification.

study results, adolescents were recruited during the first week of their treatment. Overall, $N = 43$ participants agreed to participate in the study. Three were excluded during the assessment owing to unspecified pain region ($n = 2$) or incomplete assessment ($n = 1$), resulting in a total sample size of $N = 40$ adolescents. The two study groups comprised $n = 20$ adolescents with chronic headache (16 girls, 4 boys; mean age: 15.0 years; $SD = 1.8$) and $n = 20$ adolescents with CAP (13 girls, 7 boys; mean age: 14.2 years; $SD = 2.0$). They did not differ in demographic characteristics and were equally impaired owing to chronic pain, as reflected in repeated absence from school, high pain intensity, and significant pain-related disability. They did also not differ in levels of fear of pain and anxiety sensitivity (all p's $> .05$) (Table II).

Tasks and Ratings

Tasks to Induce Interoceptive Sensations Locally Proximal to the Primary Pain Region

We aimed to induce a benign interoceptive sensation proximal to the primary pain region that is typically temporarily associated with (worsening of) pain episodes. To achieve this, we decided to implement tensing of muscles closely located to the primary pain region, specifically, the corrugator supercilii muscle (for headache) and the abdominal muscles (for CAP). Muscle tensing has been profoundly studied in pain research, for example, in the context of biofeedback studies (Sielski, Rief, & Glombiewski, 2016). Muscular sensitivity is also a significant research area in the field of interoception (Ceunen, Vlaeyen, & Van Diest, 2016). Tensing of the muscles is generally well perceived (Epstein, 1990) and easily performed. In a pilot study with 14 adolescents with chronic pain, the majority of participants (64%) reported that the onset of their pain episodes or worsening of the pain sensation is typically preceded by a feeling of tension. Hence, we aimed to induce interoceptive sensations proximal to the primary pain region by the two tasks targeting these areas: frowning and tightening the stomach.

Tighten Stomach Task.

Adolescents, in the present study, were trained to tense their abdominal muscle for 3 min (maximal duration). This task represents the locally proximal task for adolescents with CAP and the locally distal task for adolescents with chronic headache. It is assumed that tightening the stomach will trigger interoceptive sensations located in the abdomen. To ensure adherence to and successful completion of the task, participants were instructed on how to tense their abdominal muscles by a research assistant before participating in the actual experiment. Particular emphasis was placed on learning to tense only the focus muscle group without tensing additional muscles not targeted in this trial. This task was first demonstrated to the adolescents and then they were guided on how to perform this task themselves. The experiment began only after the adolescents indicated that they were able to tense their abdominal muscles correctly.

Frown Task.

The frown task was chosen as a task to trigger interoceptive sensations proximal to the head. The frown task requires the adolescents to voluntarily contract the corrugator supercilii muscle by instructing them to frown for 3 min (maximal duration). This task represents the locally proximal task for adolescents with headache and the locally distal task for adolescents with CAP. It is assumed that frowning will trigger interoceptive sensations located at the

Table II Sample Characteristics of the Two Study Groups

Variable	Category	Headache		CAP		Statistics	
		Mean (*SD*)	*n* (%)	Mean (*SD*)	*n* (%)	Parameter (*t*, Chi^2)	*p-value* (two-tailed)
Age		15.0 (1.8)		14.2 (2.0)		$t(38) = 1.38$	.18
Sex	Male		4 (20)		7 (35)	$Chi^2(1) = 1.13$	.29
	Female		16 (80)		13 (65)		
P-PDI[a]		33.0 (9.8)	20	35.5 (8.4)	20	$t(38) = -0.86$	.39
Pain intensity[b]		6.6 (1.6)	20	6.3 (2.3)	20	$t(38) = 0.45$	.66
Permanent pain[c]			12 (60)		14 (70)	$Chi^2(1) = 0.44$	.51
School absence[d]		7.4 (6.9)	13 (65)	10.5 (8.4)	15 (80)	$t(35) = -1.22$	.23
Fear of pain (GFOPQ-C)[e]		28.0 (11.6)	20	33.8 (10.0)	20	$t(38) = -1.69$	.10
Anxiety sensitivity (KASI)[f]		28.7 (5.6)	20	29.0 (5.1)	20	$t(38) = -0.15$	.88

Note. CAP = chronic abdominal pain.

[a]Pain-related disability: Pediatric Pain-related Disability Index (P-PDI) (range: 12–60) (Hübner et al., 2009).

[b]Pain intensity: mean pain intensity within the preceding 7 days (numerical rating scale 0–10).

[c]Permanent Pain: within the preceding 7 days (yes/no).

[d]School absence: parental reports of number of days missed at school within the preceding 4 weeks.

[e]Fear of pain: assessed via the German version of the Fear of Pain Questionnaire for Children (GFOPQ-C) (range: 0–59) (Flack et al., 2017).

[f]Anxiety sensitivity: assessed via the Children Anxiety Sensitivity Index (KASI) (range: 0–51) (Schneider, Adornetto, In-Albon, Federer, & Hensdiek, 2009).

forehead. Corresponding to the procedure for ensuring the correct performance of the tighten stomach task explained above, adolescents learned to contract the corrugator supercilii muscle by frowning. Again, once they indicated that they were able to carry out the task, the experiment was started.

Safe Comparison Task.

Adolescents were asked to clench both fists for 3 min (maximal duration). This task represents the safe comparison task.

The adolescents could terminate the tasks at any time. If they stopped any tensing task prematurely, participants were asked to indicate this immediately to the experimenter. The adolescents performed each of the two threatening tasks [frown (F), tighten stomach (TS)] only once. The sequence order of the two threatening tasks (F, TS) was varied randomly across participants. Each threatening task was followed by the safe comparison task (SCT), thus leading to two orders F – SCT – TS – SCT and TS – SCT – F – SCT.

Measures

Measures for Sample Characterization

Three measures were used to assess pain variables. First, children completed the German Pain Questionnaire (Deutscher Schmerzfragebogen für Kinder und Jugendliche, DSF-KJ; Schroeder et al., 2010), which assesses, among other variables, the child's mean pain intensity using an 11-point numerical rating scale. Second, pain-related disability was assessed by self-ratings on the Pediatric Pain Disability Index (P-PDI; Hübner et al., 2009). The P-PDI assesses pain-related disability in daily activities on 12 items rated on a 5-point scale (1 = *never* to 5 = *always*). Internal consistency was high (Cronbach's $\alpha = .865$) in an outpatient ($n = 163$) and inpatient sample ($n = 167$) of children and adolescents with chronic pain (Hübner et al., 2009). Third, parents reported school absence in number of days the child missed school owing to ongoing pain in the preceding 4 weeks.

In addition, children completed two questionnaires to assess disorder-specific anxiety symptoms: The German version of the Fear of Pain Questionnaire for Children (GFOPQ-C; Flack, Gerlach, Simons, Zernikow, & Hechler, 2017, accepted for publication) and the Anxiety Sensitivity Index (Kinder-Angstsensitivitätsindex, KASI; Adornetto et al., 2008). The GFOPQ-C is a 15-item self-report inventory to assess fear of pain on two subscales "fear of pain" (9 items; $\alpha = .89$; e.g., "When I feel pain, I am afraid that something terrible will happen.") and "avoidance" (six items; $\alpha = .76$; e.g., "I cannot go back to school until my pain is treated.") (Flack et al., 2017, accepted for publication). Items are rated on a 5-point Likert-type scale (0 = *strongly disagree* to 4 = *strongly agree*). The KASI is a self-report questionnaire containing 18 items, which describe reactions to bodily symptoms. On a 3-point scale (1 = *never*, 2 = *sometimes*, 3 = *often*), adolescents indicate for each item the extent to which they believe the experience of anxiety symptoms will result in negative consequences. Internal consistency was high ($\alpha = .79$) in a sample of $N = 1{,}538$ children and adolescents (Schneider, Adornetto, In-Albon, Federer, & Hensdiek, 2009). Descriptive data of the measures are presented in Table 2.

Measures During the Experiment

Self-Reported Fear. A visual analogue scale (VAS 0–100) was used to assess self-reported fear, with 0 indicating no fear and 100 indicating very strong fear.

Self-Reported Avoidance. Self-reported avoidance was assessed by rating the desire to leave the present situation on a VAS (0–100), with 0 indicating no desire to leave the situation and 100 indicating maximal desire to leave the situation, in accordance with previous studies in which this method has been frequently implemented (In-Albon, Kossowsky, & Schneider, 2010).

Duration of Task Performance. The length of time the adolescents were actively engaged in performing the different tasks was recorded in seconds. Different colored slides indicated the beginning of the tasks (see also Figure 1). If the participants stopped the task before the maximal duration of 3 min, they were instructed to verbally signal when they were done.

Self-reported Type of Pain. Even though the tasks were not chosen to induce pain, self-reported headache and abdominal pain was assessed on a 6-point Likert-scale ranging from 1 (*no pain*) to 6 (*unbearable pain*). For this self-report, participants reported on the disorder-specific pain that was caused by the task.

Procedure

The ethics committee of the Children and Adolescent Hospital, Datteln approved the study. Written informed consent was obtained from the adolescents and their caregivers. Adolescents were informed that they would undergo different tasks and that their reactions to these tasks would be assessed via self-report. Next, they completed questionnaires to characterize the sample regarding sociodemographic, pain, and emotional variables (see *Measures* for details). Immediately afterward the study procedure was explained to the adolescents. In an initial trial before the actual experiment, the research assistant explained each of the three tasks and the participant was then asked to perform each task following the presentation of different colored cues (Figure 1).

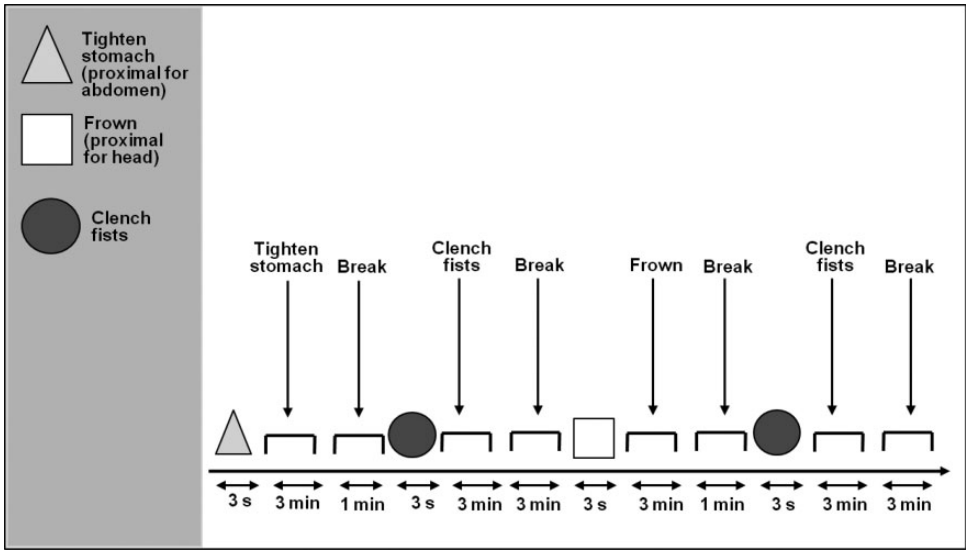

Figure 1 Schematic representation of an experimental block including the sequence of stimulus presentation (example).

The two threatening tasks (F, TS) and the safe comparison task (SCT) were subdivided into four parts (see Figure 1):

1. Threat or safe *anticipation* indicated by colored cue presented for 3 s,
2. Threat of safe *symptom provocation task* indicated by a slide with instruction to tense the respective muscle group (3 min maximal duration),
3. *Recovery* with 1 min duration,
4. *Ratings*: Adolescents were asked to rate fear, avoidance, and pain-intensity following each task (paper-pencil).

After completion of the ratings, the second task directly followed (see Tasks and Ratings for details). Total duration of the entire experimental session was approximately 45 min.

Data Analysis

The statistical analyses of the study consisted of the following steps: First, we compared the two safe comparison tasks (SCT; clench fists) separately for the two groups, using paired *t*-tests to determine whether they could be pooled for further analyses when no significant differences between repetitions were found. Second, to test the hypotheses that adolescents with chronic headache will display greater fear and avoidance (self-reported avoidance; duration of task performance) during the frown task, and those with CAP will display greater fear and avoidance during the tighten stomach task, three separate 2 (groups [chronic headache; CAP]) × 3 (tasks [clench fist; frown; tighten stomach]) repeated measures analyses of variance (rmANOVA) for fear and avoidance were computed. We additionally computed contrast effects for fear and avoidance across the three tasks to investigate differences in fear and avoidance between the three tasks.

As mentioned above, the three tasks were carefully chosen not to induce pain. Yet to analyze whether the tasks induced pain, we investigated whether the three tasks induced self-reported disorder-specific pain in the two groups. This was tested in a 2 (groups [adolescents with chronic headache; adolescents with CAP]) × 2 (types of self-reported pain [self-reported headache; self-reported abdominal pain]) × 3 (tasks) rmANOVA. Post hoc *t*-tests and contrast effects were computed to test group differences in self-reported headache and abdominal pain in the three tasks. We also investigated how many adolescents reported a significant increase in self-reported pain owing to the tasks by comparing self-reported pain ratings in the frown or tighten stomach task to self-reported pain in the safe comparison task. This was done by calculating the difference between self-reported pain in either the frown or the tighten stomach task and self-reported pain in the safe comparison task. As a minimally significant increase, we defined an increase of $>+1$ on our scale across the two difference scores ("frown − safe"; "tighten stomach − safe").

All analyses were performed using SPSS Version 22.0. When necessary, a Greenhouse-Geisser correction was used. A significance level of $p < .05$ was applied. In the contrast analyses, adjusted *p*-values were used according to the SPSS internal Bonferroni correction for multiple comparisons (Bland & Altman, 1995).

Results

For both groups (chronic headache, CAP), the paired *t*-test showed no differences ($ps > .05$) between the two repetitions of the safe comparison task. Therefore, they were pooled for all further analyses.

Self-Reported Fear

The 2 (groups [adolescents with chronic headache; adolescents with CAP]) × 3 (tasks [clench fist; frown; tighten stomach]) rmANOVA yielded a significant interaction effect (group × task) ($F(2,76) = 16.40$; $p < .001$, $\eta_p^2 = .30$).

As depicted in Figure 2 and Tables III and IV, contrast tests for the three tasks revealed that adolescents with chronic headache reported slightly higher fear in the frown task compared with the safe comparison task ($p = .05$), while fear reports did not differ between the frown and the tighten stomach task ($p > .05$). Fear reports of adolescents with CAP were higher in the tighten stomach task compared with the frown and the safe comparison task (both $p < .001$). Self-reported fear in the frown task did not differ from the safe comparison task ($p > .05$). In the group comparison, adolescents with chronic headache and adolescents with CAP reported similar fear in the frown and in the safe comparison task ($p > .05$), while adolescents with CAP reported greater fear in the tighten stomach task ($t(38) = -4.08$, $p < .001$).

Self-reported Avoidance

In the 2 (groups [adolescents with chronic headache; adolescents with CAP]) × 3 (tasks [clench fist; frown; tighten stomach]) rmANOVA, we found a significant interaction effect (group × task) ($F(2,76) = 4.40$; $p = .019$, $\eta_p^2 = .10$) for self-reported avoidance (Tables III and IV; Figure 3).

Contrast tests revealed that adolescents with chronic headache reported greater avoidance in the frown task compared with the safe comparison task ($p = .004$). Avoidance did not differ between the frown and the tighten stomach task ($p > .05$), and the latter was higher compared with the safe comparison task ($p = .018$). Adolescents with CAP reported greater avoidance in the tighten stomach task than in the frown ($p = .041$) and the safe comparison task ($p < .001$). Avoidance in the frown task was higher than in the safe comparison task ($p = .002$). Regarding the group comparison, post hoc tests revealed that adolescents with CAP reported greater avoidance compared with adolescents with chronic headache following the tighten stomach task ($t(38) = -3.53$, $p = .001$). No significant group differences emerged in the frown and safe comparison task ($p > .05$).

Duration of Task Performance

In the 2 (groups [chronic headache; CAP]) × 3 (tasks [clench fist; frown; tighten stomach]) rmANOVA, we found a significant effect of task ($F(2,76) = 30.54$; $p < .001$, $\eta_p^2 = .45$) for the duration of task performance. Contrast tests revealed that duration was shorter in the tighten stomach task ($p < .001$) and in the frown task ($p < .001$) as compared with the safe comparison task. No difference between the tighten stomach and the frown task was detected ($p > .05$). The main effect for group failed to reach statistical significance ($F(1,38) = 3.73$; $p = .061$, $\eta_p^2 = .09$; duration measured in seconds—CAP: $M = 101$, $SD = 48.74$; chronic headache: $M = 128.44$, $SD = 42.32$). Moreover, no interaction effect was found ($p > .05$) (Tables III and IV).

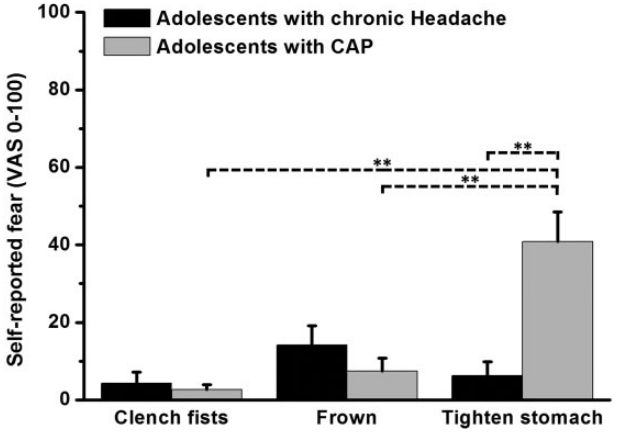

Figure 2 Self-reported fear compared between adolescents with headache and adolescents with chronic abdominal pain across the three tasks. *$p < .05$; **$p < .01$. Error bars indicate the standard error (*SE*).

Table III Results for the rmANOVAs for all Measures

Measures	ANOVA			
	F	*df*	*p*	η_p^2
Self-reported fear				
Group * Task	**16.40**	**2, 76**	***.000**	**0.30**
Task	**13.43**	**2, 76**	***.000**	**0.26**
Group	4.01	1, 38	.053	0.10
Self-reported tendency to avoid				
Group * Task	**4.40**	**2, 76**	***.019**	**0.10**
Task	**21.83**	**2, 76**	***.000**	**0.37**
Group	3.92	1, 38	.055	0.09
Duration of task performance				
Group * Task	1.835	2, 76	.171	0.05
Task	**30.54**	**2, 76**	***.000**	**0.45**
Group	3.73	1, 38	.061	0.09
Self-reported pain				
Group *Type-of-pain *Task	2.03	2, 76	.148	0.05
Task *Type-of-pain	**49.25**	**2, 76**	***.000**	**0.56**
Task *Group	0.66	2, 76	.482	0.02
Type-of-pain * Group	**60.72**	**1, 38**	***.000**	**0.62**
Task	**15.83**	**2, 76**	***.000**	**0.29**
Group	2.30	1, 38	.138	0.06
Pain	0.01	1, 38	.940	0.00

Note. Group = chronic headache, chronic abdominal pain; task = clench fist, frown, tighten stomach; self-reported type of pain = headache or abdominal pain.

*$p < .05$.

Boldface values indicate significant results.

Table IV Contrast Effects for the Three Tasks for Self-Reported Fear, Self-Reported Tendency to Avoid, Self-Reported Headache, Self-Reported Abdominal Pain and Duration of Task Performance

Measures	Group	Task	Statistics		
			M	*SD*	*p*[a]
Self-reported fear[b]	Chronic headache	Frown Clench fists	14.1 4.3	22.75 12.81	***.050**
		Tighten stomach Clench fists	6.3 4.3	16.05 12.81	1.000
		Frown Tighten stomach	14.1 6.3	22.75 16.05	.734
	CAP	Frown Clench fists	7.4 2.6	14.97 6.01	.680
		Tighten stomach Clench fists	40.9 2.6	34.27 6.01	***.000**
		Frown Tighten stomach	7.4 40.9	14.97 34.27	***.000**
Self-reported tendency to avoid[c]	Chronic headache	Frown Clench fists	37.1 14.2	36.70 19.35	***.004**
		Tighten stomach Clench fists	33.0 14.2	24.20 19.35	***.018**
		Frown Tighten stomach	37.1 33.0	36.70 24.20	1.000
	CAP	Frown Clench fists	41.6 17.5	29.04 20.60	***.002**
		Tighten stomach Clench fists	62.7 17.5	28.82 20.60	***.000**
		Frown Tighten stomach	41.6 62.7	29.04 28.72	***.041**
Self-reported headache[d]	Chronic headache	Frown Clench fists	3.3 2.3	1.37 1.24	***.002**
		Tighten stomach Clench fists	2.3 2.3	1.37 1.24	1.000
		Frown Tighten stomach	3.3 2.3	1.37 1.37	***.006**
	CAP	Frown Clench fists	2.5 1.3	1.28 0.61	***.001**
		Tighten stomach Clench fists	1.2 1.3	0.62 0.61	1.000
		Frown Tighten stomach	2.5 1.2	1.28 0.62	***.000**
Self-reported abdominal pain[e]	Chronic headache	Frown Clench fists	1.1 1.0	0.22 0.11	1.000
		Tighten stomach Clench fists	1.8 1.0	0.83 0.11	***.005**
		Frown Tighten stomach	1.1 1.8	0.22 0.83	***.009**
	CAP	Frown Clench fists	2.6 2.4	1.40 1.26	***.011**
		Tighten stomach Clench fists	3.8 2.4	1.32 1.26	***.000**
		Frown Tighten stomach	2.6 3.8	1.40 1.32	***.000**

Table IV. (continued)

Measures	Group	Task	Statistics		
			M	*SD*	*p*[a]
Duration of task performance[f]		Frown Clench fists	88.3 143.4	9.5 7.8	*.000
		Tighten stomach Clench fists	83.8 143.4	9.6 7.8	*.000
		Frown Tighten stomach	88.3 83.8	9.5 9.6	1.000

Note. CAP = chronic abdominal pain.
[a]Bonferroni corrected *p*-values.
[b]Self-reported fear: 0 = *no fear* to 100 = *high fear* (VAS 0–100).
[c]Self-reported tendency to avoid: 0 = *no urge to leave the situation* to 100 = *great urge to leave the situation* (VAS 0–100).
[d]Self-reported headache: 1 = *not unpleasant* to 6 = *intolerable* (6-point Likert scale 1–6).
[e]Self-reported abdominal pain: 1 = *not unpleasant* to 6 = *intolerable* (6-point Likert scale 1–6).
[f]Duration of task performance in seconds.
*$p < .05$.
Boldface values indicate significant results.

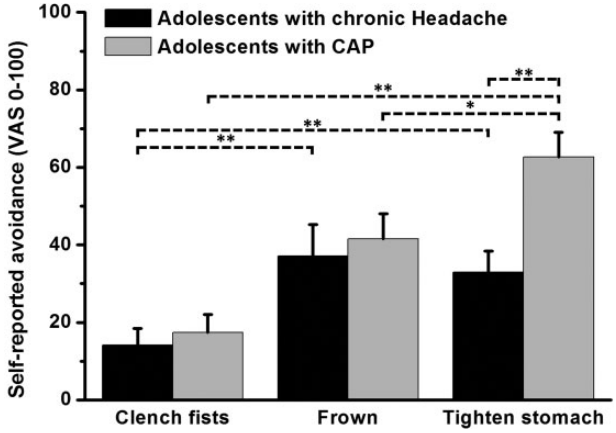

Figure 3 Self-reported tendency to avoid compared between adolescents with headache and adolescents with chronic abdominal pain across the three tasks. *$p < .05$; **$p < .01$. Error bars indicate the standard error (*SE*).

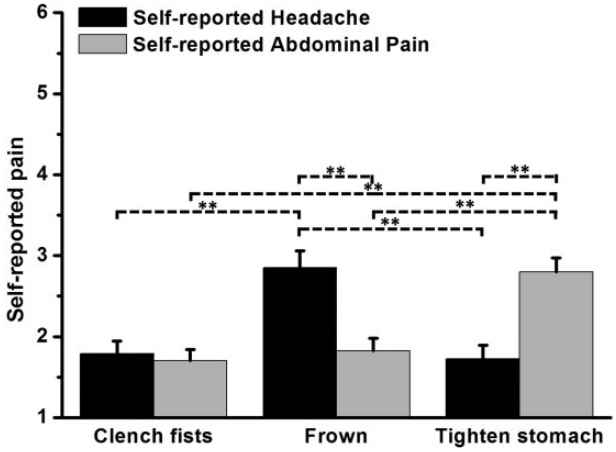

Figure 4 Self-reported headache and abdominal pain compared between adolescents with headache and adolescents with chronic abdominal pain for the three tasks. *$p < .05$; **$p < .01$. Error bars indicate the standard error (*SE*).

Self-Reported Headache and Abdominal Pain

The 2 (groups [adolescents with chronic headache; adolescents with CAP]) × 2 (self-reported types of pain [self-reported headache; self-reported abdominal pain]) × 3 (tasks) rmANOVA did not reach statistical significance ($F(2,76) = 2.03$; $p = .15$, $\eta_p^2 = .05$). We found a significant interaction effect for self-reported type of pain and task ($F(2,76) = 49.25$; $p < .001$, $\eta_p^2 = .56$) (see Figure 4 and Tables III and IV).

We compared self-reported headache and abdominal pain for each of the three tasks. Contrast tests for each task revealed that adolescents in both groups reported more headache than abdominal pain in the frown task ($p < .001$), and more abdominal pain than headache in the tighten stomach task ($p < .001$). Self-reported headache and abdominal pain did not differ in the safe comparison task ($p > .05$). We also investigated differences in self-reported headache and abdominal pain across the three tasks. This was done by separate contrast tests for self-reported headache and abdominal pain. Adolescents reported more headache in the frown task compared with the other two tasks (both $ps < .001$). In the tighten stomach and the safe comparison task, no significant differences for self-reported headache emerged ($p > .05$). Adolescents reported significantly more abdominal pain in the tighten stomach task than in the other two tasks (both $ps < .001$). Self-reported abdominal pain did not differ between the safe comparison task and the frown task ($p = .058$).

We also found a significant interaction effect for group and self-reported type of pain ($F(1,38) = 60.72$; $p < .001$, $\eta_p^2 = .62$). Separate ANOVAs for the two groups revealed that adolescents with chronic headache reported more headache than abdominal pain across all tasks ($F(1,38) = 30.96$; $p < .001$, $\eta_p^2 = .45$), while adolescents with CAP reported more abdominal

pain than headache across all tasks ($F(1,38) = 29.77$; $p < .001$, $\eta_p^2 = .44$).

We found a pain increase of $> +1$ on the 6-point rating scale in at least one of the two threat tasks in $n = 23$ adolescents ($n = 14$ adolescents with CAP and $n = 9$ adolescents with chronic headache). Seventeen adolescents ($n = 6$ adolescents with CAP; $n = 11$ adolescents with chronic headache) did not report an accentuated pain increase. Descriptive results for this latter sample regarding fear, avoidance, and duration of task performance are depicted in Supplementary Figures S1, S2, and S3.

Discussion

Summary of Main Findings

This preliminary study is one of the first experimental studies investigating fear and avoidance in adolescents with chronic pain disorders when confronted with proximal versus distal interoceptive sensations. Results showed that the provocation of proximal, rather than distal, interoceptive sensations elicited greater fear and avoidance in adolescents with CAP. In adolescents with chronic headache, proximal sensations did not elicit greater fear and avoidance than distal sensations. Compared with the safe comparison task, fear reports in adolescents with chronic headache were only slightly higher in the proximal task, while self-reported avoidance was significantly higher in the proximal task. Duration of task performance was significantly shorter in the two threat tasks (frown; tighten stomach) than in the safe comparison tasks across all adolescents. Even though the tasks were carefully chosen not to induce pain, self-reported headache in both groups was higher in the frown task compared with the other two tasks, as was self-reported abdominal pain in the tighten stomach task. Characteristically, both clinical groups reported greater disorder-specific pain (self-reported headache, abdominal pain) across all tasks.

Before carefully interpreting the present findings, the preliminary nature of the study needs to be addressed. Hence, we would like to draw attention to the following study limitations: A core criticism relates to the validity of our tasks (tighten stomach, frown). Even though previous research has shown that these two tasks induce interoceptive sensations at the respective region (Epstein, 1990), validity of the tasks should be comprehensively assessed in future studies, for example, via self-report assessing to which degree the task induced interoceptive sensations and whether these sensations typically show a temporal association to the occurrence of pain in each individual. The tasks were carefully designed not to induce pain. However, $n = 23$ adolescents reported a relevant increase in pain intensity (defined as $>+1$ increase on a 6-point Likert scale) in at least one of the two threat tasks. Reasons for the self-reported pain increase are discussed below. Although we controlled the sequence order, the tasks in the experimental study were not balanced. The present study consisted of only one trial for each threat task. To enhance reliability of our findings, future studies are warranted in which children and adolescents undergo a substantial number of trials. In our study, we assessed fear ratings by use of self-report. In future studies, fear of pain should ideally be assessed using a multimodal approach, including behavioral (escape/avoidance), emotional, physiological (reactivity), and cognitive (appraisal, hypervigilance) factors. Despite these limitations and the pilot character of the study, this is the first experimental study that showed that interoceptive sensations proximal to the primary pain location initiate fear, especially in adolescents with CAP.

Fear and Avoidance Following Proximal Interoceptive Sensations in Adolescents With CAP

Our results suggest that adolescents with CAP appear to experience fear and an urge to avoid experiencing sensations when confronted with locally proximal interoceptive sensations in the primary pain regions. Notably, they do not display a generally increased fear response. This was shown by low fear and avoidance levels for the frown and the safe comparison task generated by comparable muscle contraction tasks but at distal locations in relation to the primary pain site. Instead, they display a disorder-specific fear response only after interoceptive sensations proximal to their primary pain location. This is in line with results from clinical studies that investigate the effectiveness of interoceptive exposure to decrease fear responses in chronic pain patients (Craske et al., 2011; Dobe, Hechler, & Zernikow, 2009; Flink, Nicholas, Boersma, & Linton, 2009; Nicholas et al., 2013; Wald, Taylor, Chiri, & Sica, 2010). Craske et al. (2011), for example, used proximal interoceptive sensations as a symptom provocation technique in a randomized-controlled trial to decrease visceral anxiety in adults with irritable bowel syndrome. Symptom provocation tasks involved repeated exposure to visceral sensations (e.g., tightening the stomach to produce gut sensations). They found a steeper decline in visceral anxiety following the symptom provocation task compared with patients in an attention-control group (Craske et al., 2011). Of importance, symptom provocation tasks to elicit visceral sensations varied between participants ranging from tightening the stomach to eating feared/avoided foods. Fear reports for these individual tasks, however, were not reported. Our results may provide initial evidence that sensations locally proximal to the main pain site become

elicitors of anxious apprehension in individuals with CAP.

Fear and Avoidance Following Proximal Interoceptive Sensations in Adolescents With Chronic Headache

Contrary to our hypothesis, proximal sensations did not elicit greater fear and avoidance compared with distal sensations in adolescents with chronic headache. Fear and avoidance reports of adolescents with chronic headache were also similar to those reported by adolescents with CAP in the proximal task. Compared with the safe comparison task, fear reports and avoidance were higher in the frown task. Two explanations can be put forward for the detected response pattern in adolescents with chronic headache: First, results may suggest that adolescents with chronic headache may not be prone to fear responses. However, reports of fear of pain and anxiety sensitivity in the present study were similar for adolescents with chronic headache and adolescents with CAP. In addition, recent studies revealed that children and adolescents with headache report increased fear and anxiety compared with healthy children (Cappucci & Simons, 2015). Second, methodological issues, such as the choice of the frown task, may also account for the unexpected findings. The corrugator supercilii muscle is used in everyday communication processes and is also activated during different emotional states (Reicherts et al., 2012). Hence, frowning may have not elicited a proximal interoceptive sensation for adolescents with chronic headache, thus not activating a conditioned fear response. This is also related to the validity of the frown task, which certainly warrants investigation in future studies. The assumption that frowning may not constitute an adequate task can be tested when different tasks (e.g., tensing the neck) are compared for their potential to initiate fear and avoidance in adolescents with chronic headache. Another possible explanation is based on the pattern that adolescents with chronic headache report higher fear and avoidance in the proximal, compared with the safe, comparison task. This finding indicates responsivity of the fear system. However, the missing differentiation between the proximal and distal tasks (tighten stomach) may indicate a pattern of overgeneralization (Zaman, Vlaeyen, Van Oudenhove, Wiech, & Van Diest, 2015).

Applying the fear-avoidance model to our findings, our results may be interpreted as preliminary evidence for a conditioned fear response (fear of pain, defensive behavior) in children with CAP. This conditioned fear response might have evolved owing to interoceptive fear conditioning, that is, a learned association between proximal interoceptive sensations and pain. In children with headache, our results may suggest that the fear system of children with headache is responsive, and that these children may be prone to an increased generalization to nonthreatening sensations.

Self-Reported Pain Following Proximal Interoceptive Sensations in Adolescents With Chronic Headache and Adolescents With CAP

Even though the two experimental tasks (frown, tighten stomach) were carefully chosen not to induce pain, our results revealed that self-reported headache in both groups was higher in the frown task, and self-reported abdominal pain was higher in the tighten stomach task. Mean levels for both types of pain (assessed on a 6-point Likert scale) were moderate, with mean values around 3. At this point, we can only speculate about the factors that might have induced pain in the two groups: The methodological setup may be one factor. Adolescents were asked to tense their muscles for 3 min. Results showed that only $n = 6$ adolescents were able to maintain the muscle tension over this period. On average, adolescents tensed their muscles for 88 s ($SD = 59.8$) instead of 180 s in the frown task, and for 83 s ($SD = 64.5$) instead of 180 s in the tighten stomach task. The task duration, therefore, appears to be too long and should be decreased in future studies. We also did not assess muscle tension objectively in the present study. An objective EMG assessment should be included in future studies to quantify muscle tension and control for adherence to the task. Besides these methodological issues, our findings simply suggest that some adolescents with chronic pain experience pain when confronted with interoceptive sensations proximal to their main pain site, such as tensing their abdominal muscles. This might emerge because the adolescents overexerted when performing the muscle tensing task, owing to emotional (such as anticipatory anxiety) or attentional processes (increased attention allocation to the main pain region) (Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013) or an inability to differentiate between painful and nonpainful stimuli (Zaman et al., 2015). Or, taking a Bayesian perspective, our findings might suggest that children with chronic pain display a heightened expectation of pain, which results in a heightened pain perception because their mind infers pain as the most likely cause for the interoceptive sensation (tighten stomach; Hechler, Endres, & Thorwart, 2016). This hypothesis is in line with the interoceptive predictive coding model (Barrett & Simmons, 2015; Seth, 2013; Seth, Suzuki, & Critchley, 2011) and linked to the assumption of heightened interoceptive predictions in anxiety-prone individuals (Hechler et al., 2016; Paulus & Stein, 2006, 2010). These aspects need to be elucidated in future studies.

Future Directions

It is important to understand fear responses in children and adolescents with various chronic pain disorders and whether the mere anticipation and perception of interoceptive sensations locally proximal to the primary pain region (such as tensing the abdominal muscles) elicit anxious apprehension of pain. A research agenda could entail the following areas: (1) an investigation into the validity of different (nonaversive) interoceptive tasks that trigger interoceptive sensations locally proximal to the primary pain region, (2) an exploration of mechanisms underlying the increase in self-reported pain in some individuals following these tasks, (3) an assessment of potential differences in fear and avoidance following the interoceptive tasks between adolescents who experience a significant pain increase and those who do not, and (4) a replication of the disorder-specific fear and avoidance patterns in adolescents with different chronic pain disorders when confronted with interoceptive sensations proximal to the primary pain region. Fear of pain should ideally be assessed within a multimodal approach, including behavioral (escape/avoidance), emotional, physiological (reactivity), and cognitive (appraisal, hypervigilance) factors. This research might increase our knowledge on fear of pain in children and adolescents with chronic pain disorders and may eventually improve conception of interventions targeting this specific type of fear in this particular age-group.

Supplementary Data

Supplementary data can be found at: http://www.jpepsy.oxfordjournals.org/.

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