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The Interoceptive Sensitivity and Attention Questionnaire (ISAQ): Evaluating aspects of self-reported interoception in patients with persistent somatic symptoms, stress-related syndromes and healthy controls

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Abstract

Objective: To validate the Interoceptive Sensitivity and Attention Questionnaire (ISAQ), a 17-item self-report measure assessing sensitivity and attention to interoceptive signals.

Methods: In study 1, exploratory and confirmatory factor analysis was performed in a student convenience sample (n=1868). In study 2, ISAQ data of a healthy sample (n=144) and various patient groups experiencing stress-related syndromes [overstrain; n=63; burnout; n=37; panic disorder (PD; n=60)] and/or persistent somatic symptoms in daily life [irritable bowel syndrome (IBS; n=38); fibromyalgia and/or chronic fatigue syndrome (FM/CFS; n=151); medically unexplained dyspnea (MUD; n=29)] were compared.

Results: Three subscales were revealed: (F1) sensitivity to neutral bodily sensations, (F2) attention to unpleasant bodily sensations, and (F3) difficulty disengaging from unpleasant bodily sensations. Overall, patients with FM/CFS and patients with MUD scored significantly higher on F1 (p=.009 resp. p=.027) and F2 (p=.002 resp. p<.001) than healthy controls. Patients with PD had higher scores on subscales F2 (p<.001) and F3 (p<.001) compared with healthy controls, as well as higher scores on F2 compared with all other patient groups (p-value PD vs. MUD=.008, all other p-values <.001).

Conclusions: Interoceptive sensibility – the self-reported aspect of interoception – is not a homogeneous or unitary construct. The subscales of the ISAQ differentiate healthy controls from patients with persistent somatic and/or stress-related complaints in daily life and distinguish different patient groups. The ISAQ can be used as a concise, reliable, and clinically relevant research tool to further disentangle adaptive and maladaptive aspects of interoceptive ability.

Key words: interoception; symptom perception; attention; panic; functional physical symptoms

ISAQ = Interoceptive Sensitivity and Attention Questionnaire; IBS=irritable bowel syndrome; FM=fibromyalgia; CFS=chronic fatigue syndrome; MUD=medically unexplained dyspnea; PD=panic disorder; IA=interoceptive accuracy; IS=interoceptive sensibility; IAw=interoceptive awareness; ISe=self-reported interoceptive sensitivity; IAt=self-reported interoceptive attention; BPQ=Body Perception Questionnaire; BAQ=Body Awareness Questionnaire; MAIA=Multidimensional Assessment of Interoceptive Awareness; PANAS= Positive and Negative Affect Schedule; STAI= State-Trait Anxiety Inventory; ASI=Anxiety Sensitivity Index; CLQ= Claustrophobia Questionnaire; PCS=Pain Catastrophizing Scale; PTQ= Perseverative Thinking Questionnaire; PSWQ=Penn State Worry Questionnaire; CFA=confirmatory factor analysis; WLSMV=weighted least square mean and variance; RMSEA= root mean square error approximation; CFI= comparative fit index; EFA= exploratory factor analysis; CDC=Centers for Disease Control and Prevention; ACR= American College of Rheumatology; M.I.N.I=Mini-International Neuropsychiatric Interview; ANOVA=analyses of variance; RDoC=Research Domain Criteria initiative

Introduction

Interoception refers to the multidimensional perception of the internal state of one's own body (1). It is defined as "a process by which the nervous system senses, interprets, and integrates signals originating from within the body, providing a moment-by-moment mapping of the body's internal landscape across conscious and unconscious levels" (2). Different dimensions of interoceptive ability have been proposed by Garfinkel et al. (3): (a) interoceptive accuracy (IA; objective ability to accurately detect interoceptive signals, measured as behavioural performance on an interoceptive task), (b) interoceptive sensibility (IS; dispositional tendency to have confidence in the perception and identification of internal bodily signals, measured by questionnaires), and (c) interoceptive awareness (IAw, capacity to evaluate one's ability in the objective task; metacognitive awareness of interoceptive accuracy, reflecting the correspondence between objective and subjective measures). It is claimed that these three dimensions can be clearly differentiated (3,4) and rely on partly distinct neural networks (5).

In this paper, we propose a measure assessing IS conceptualized as the individual's belief in his or her interoceptive ability and the degree to which one feels engaged by interoceptive signals. It should be clearly differentiated from objective performance on tasks assessing IA. For example, Villani and colleagues (6) showed that non-invasive stimulation of the auricular branch of the vagus nerve improved participants' *belief* in their interoceptive ability (IS), but their confidence was unrelated to their actual accuracy. Other researchers have reported a discrepancy between IA and IS (4,7). Unfortunately, these concepts are often used interchangeably in research.

In fact, IS is an overarching term that may in itself comprise of different facets of self-report. For example, Ginzburg et al. (8) refer to interoceptive sensitivity (ISe) as the tendency to identify/notice subtle bodily reactions/changes to internal and environmental conditions.

These *self-reported beliefs regarding one's perceptual acuity* should be distinguished from *self-reported beliefs regarding one's attention to interoceptive signals* (IAt;9,10). Ginzburg et al. (8) showed that only attentional monitoring (self-reported tendency to actively scan the body in order to detect cues indicating physical condition) was associated with high hypochondriac tendency and anxiety, and not interoceptive sensitivity. By the use of constructs such as interoceptive sensitivity (ISe) and interoceptive attention (IAt), we acknowledge that interoceptive sensibility (IS) subsumes distinct self-report components.

In addition, it remains an open question whether and how the emotional significance of an interoceptive sensation interacts with its sensory processing. The latter may be an important issue when considering the relationship between interoception and symptom perception. Perceived internal sensations typically turn into self-reported bodily symptoms when they become endowed with negative affective value and become part of a meaning network associated with potential threat to the integrity of the body. Symptoms can be considered as an intuitive integration of sensory-perceptual and affective-motivational information from the body and (context-dependent, automatic) predictions emerging from pre-existing meaning networks (11).

Interestingly, symptom over-reporting has been typically found in persons with high trait negativity (12-16), a prominent characteristic present in patients with functional somatic syndromes (e.g. fibromyalgia, chronic fatigue, irritable bowel syndrome,…). Research in these patient groups suggests that their symptom reports are more strongly impacted by the affective-motivational component and less by sensory-perceptual aspects of the interoceptive sensation, which may also explain that symptom over-reporting is associated with less accurate interoception (16-18).

In sum, it seems important to distinguish between the sensory-perceptual and affective elements of an interoceptive stimulus. The first can be described using neutral

"sensory" wordings describing a "bodily *sensation*" (interoception), whereas the latter typically uses wordings implying an "unpleasant" aspect of a "bodily *symptom*" (symptom perception), while both are often intermingled in interoception questionnaires. For example, the Body Awareness subscale of the Body Perception Questionnaire (BPQ;19) contains items on bodily sensations/signals (e.g., goose bumps, urge to urinate) and symptoms (e.g. muscle pain, stomach pain). Other examples that do not clearly distinguish both aspects are the Body Awareness Questionnaire (BAQ;20), Body Vigilance Scale (21), and the Multidimensional Assessment of Interoceptive Awareness (MAIA;22,23).

With the present self-report instrument, we want to assess the validity of the distinction between descriptive terms that refer to a sensory aspect in a neutral way (e.g. fast/deep breathing) and terms that include some kind of negative affective appraisal (i.e. breathlessness). Experimental studies have shown that both aspects can reliably be distinguished during breathlessness inductions (24,25). In addition, in many questionnaires only a limited number of interoceptive response channels are assessed. This questionnaire includes items referring to a broad range of bodily systems such as a) thermoregulatory, b) mouth and throat, c) respiratory, d) gastrointestinal, e) energy level, d) cardiovascular, e) postural and muscles, and f) cerebral areas.

The present questionnaire builds upon recent multidimensional theoretical models of interoception and symptom perception (2,3,9,11,26,27) in order to better characterize the differential contributions of a large array of interoceptive stimuli. In a first study, we focused on the psychometric structure in a healthy sample, whereas in a second study we investigated whether and how distinct psychopathological groups differed on the factors assessed by the ISAQ.

Study 1

In Study 1, we aimed to validate the ISAQ, a new questionnaire measuring sensitivity and attention to neutral and unpleasant bodily sensations across various response channels. In particular, we explored the factor structure of the questionnaire, its temporal stability, as well as its convergent and divergent validity in a healthy sample.

Methods

Participants and procedure

Data were collected during 5 collective sessions among first-year psychology students (*n*=1868; 81.8% women, age=18.49 years, *SD*=2.09) in return for course credit. The battery of questionnaires was completed online after signed informed consent at the start of each academic year. Data used in the present study were from the collective testing sessions of 2012 (*n*=390), 2013 (*n*=313), 2014 (*n*=371), 2017 (*n*=437), and 2018 (*n*=357). To examine test-retest reliability, a subsample of 343 respondents from the collective testing session of 2012 (81.92% women; age=18.37 years, *SD*=1.22) completed the ISAQ for a second time 6 weeks after the first measurement. All group testing sessions were approved by the Social and Societal Ethics Committee of the University of Leuven (ML8678, S55996, G-2014 10 052, G-2017 09 942, G-2018 08 1322).

Measures

Interoceptive Sensitivity and Attention Questionnaire

Sensitivity and attention to interoceptive stimuli were measured with 19 statements which covered a broad range of modalities (cardiovascular, respiratory, gastrointestinal, cerebral, energy level, posture and muscles, and thermoregulation) in both neutral and unpleasant bodily sensations. The items were rated on a 5-point Likert-type scale that ranged from 1 (‘strongly disagree’) to 5 (‘strongly agree’). Previous analyses using a preliminary version in

a healthy sample revealed two subscales: a 10-item *sensitivity to neutral bodily sensations*, referring to responsiveness to sensory information from within the body, and a 9-item *attention to unpleasant bodily sensations* which reflected increased focus on and difficulty disengaging from the somatic information of negative valence (28; see Supplementary Materials 1 for more information about the development of the Interoceptive Sensitivity and Attention Questionnaire).

Body Awareness Questionnaire (BAQ;20). This questionnaire measures self-reported attentiveness to non-emotive bodily processes. Participants respond to 18 statements on a scale from 1 ('not at all true about me') to 7 ('very true about me').

Body Perception Questionnaire (BPQ;19). This is a self-report measure of body awareness and autonomic reactivity and in this study a subset of items from the awareness subscale was used. Participants responded to 12 statements about both neutral and unpleasant bodily sensations using a 5-point scale (e.g., tension in arms and legs, dry mouth, stomach and gut pain) on a 5-point scale (1=never; 2=sometimes; 3=often; 4=very often; 5=always).

Multidimensional Assessment of Interoceptive Awareness (MAIA;22). This 32-item questionnaire was designed to study multiple dimensions of interoception on a 6-point scale ranging from 0 ('never') to 5 ('always'). For the purpose of this study, we focused on the following subscales: Noticing (awareness of uncomfortable, comfortable, and neutral bodily sensations), Not-Distracting (tendency not to ignore or distract oneself from sensations of pain or discomfort), and Attention regulation (Ability to sustain and control attention to body sensations.

Positive and Negative Affect Schedule (PANAS Dutch version;29). This questionnaire assesses to what extent 10 positive and 10 negative adjectives apply to participants' feelings in general on a 5-point Likert scale ranging from 1 ('not at all') to 5 ('very much').

State-Trait Anxiety Inventory (STAI;30). This questionnaire measures trait anxiety and consists of 20 items, which are scored on a 4-point scale ranging from 1 ('not at all') to 4 ('almost always').

Anxiety Sensitivity Index-3 (ASI;31). This 18-item questionnaire measures the fear of sensations of anxious arousal based on beliefs about their possible negative consequences on a 5-item scale ranging from 0 ('very little') to 4 ('very much').

Claustrophobia Questionnaire (CLQ Dutch version;32). Fear of suffocation was measured using the suffocation subscale of the CLQ. This scale describes 14 situations that may induce suffocation fears and respondents rate how fearful they would feel in each of the situations on a 5-point scale ranging from 0 ('not at all fearful') to 4 ('extremely fearful').

Pain Catastrophizing Scale (PCS Dutch version;33). The PCS assesses cognitions about potentially harmful noxious stimuli and contains 3 subscales: rumination, magnification, and hopelessness. Thirteen statements about those cognitions are rated on a 5-point scale ranging from 0 ('not at all') to 4 ('always').

Perseverative Thinking Questionnaire (PTQ; 34). This 15-item scale measures repetitive negative thinking that is independent of a specific content. Responses are provided on a scale ranging from 0 ('never') to 4 ('almost always').

Penn State Worry Questionnaire (PSWQ Dutch version; 35). This questionnaire measures the tendency, intensity, and uncontrollability of worry. Responses to 16 statements are provided on a 5-point scale ranging from 1 (‘not at all typical) to 5 (‘very typical’).

Data analysis

First, confirmatory factor analysis (CFA) was performed on the data from 3 collective sessions (2012-2014, *n*=1074) to evaluate the fit of the proposed two-factor model that emerged from the preliminary study. The model was estimated with the robust mean- and variance-adjusted weighted least squares (WLSMV) procedure which is based on the tetrachoric correlation matrix. As such correlations can be biased by low cell frequencies (36), rarely used response categories were collapsed to reach the frequencies of minimum 5% per cell. This was the case for response 1 (‘strongly disagree’) for items 3, 5, 6, 8, 12, 14, 16, 17 and response 5 (‘strongly agree’) for items 2, 4, 9, 11, 13, 15. Those responses were collapsed with response 2 (‘disagree’) and 4 (‘agree), respectively. The model fit was evaluated with descriptive fit measures, such as the root mean square error approximation (RMSEA) and the comparative fit index (CFI). RMSEA values close to .06 (37) and CFI values close to .90 (38) were treated as the indices of a good model fit. This 2-factor solution showed a poor model fit.

Second, exploratory factor analysis (EFA) was conducted on the same dataset to explore the underlying factor structure. The parallel analysis method (39,40) and the scree plot were used to determine the number of factors to retain. The EFA model was estimated with a WLSMV procedure and GEOMIN oblique factor rotation. Items with a primary factor loading >.32 were retained (41). This new factor structure was then tested in a CFA performed on a new

dataset using the data from 2 collective sessions (2017-2018, *n*=814). The model fit was evaluated as described above.

To examine the temporal stability of the subscales, the scores of the participants who completed the ISAQ twice were correlated. The convergent and divergent validity of the subscales was examined by evaluating the pattern of correlations between each subscale and additional measures assessing conceptually relevant constructs: perception of neutral bodily processes (BAQ, BPQ, MAIA), anxiety and anxiety-related bodily focus (NA, PA, STAI, ASI, CLQ, PCS), and repetitive negative thinking (PTQ, PSWQ). The dataset did not contain missing data for questionnaires. Not all validation questionnaires were included in all collective sessions. The number of respondents that completed the validation questionnaires is mentioned in the tables. Analyses were performed using STATA 15 and Mplus 8.2 (42).

Results

The CFA (*n*=1,074) to determine the model fit of the originally assumed 2-factor model included the following factors: sensitivity to neutral bodily sensations and attention to unpleasant bodily symptoms. The results indicated the poor model fit (CFI=.812;RMSEA=.070; 90% CI[.066, .074]). Therefore, we performed EFA on the same dataset (*n*=1,074). The scree plot (Figure 1) and the parallel analysis both suggested a 3-factor solution with eigenvalues of 3.07, 2.08, and 1.53 exceeding the eigenvalues of the random data, which were 1.24, 1.20, and 1.16, respectively. Two items were removed from the original 19-item set due to low factor loadings (<.32). These were the neutral item "I notice specific physical responses to changes in the weather" and the unpleasant item "When I feel exhausted, I am unable to turn my attention away from this". Table 1 shows factor loadings of the 17-item, 3-factor solution that emerged. Next, a CFA was conducted on a new

dataset (*n*=814) to test the 3-factor model that emerged from the EFA. The model fit was very good (CFI=.951;RMSEA=.042; 90% CI[.036, .049]). Standardized factor loadings are depicted in Figure 2.

The original Dutch version was translated into English using forward-and-back translation procedures. The questionnaire was translated from Dutch to English by two independent professional translators. Those translations were translated back into English by two native Dutch speakers familiar with interoception research. The backtranslations and the original questionnaire were compared, and a final English version of the questionnaire was agreed upon by the authors. The final versions of the 17-item ISAQ in Dutch and in English are presented in the Supplementary Materials 2.

The internal consistency (α) coefficients for the scales are presented in Table 1. The test-retest reliability coefficients for the scales over a 6-week period on a subsample of respondents (*n*=343) were as follows: F1 Sensitivity, $r(341)=.63$, $p<.001$; F2 Attention, $r(341)=.54$, $p<.001$; and F3 Difficulty disengaging, $r(341)=.47$, $p<.001$.

Table 2 presents the correlations of the three ISAQ subscales with other self-report measures.

Results of the factor analyses suggest a 3-factor structure as best solution, representing sensitivity of neutral bodily sensations (Factor 1), attention to unpleasant bodily sensations (Factor 2), and difficulty disengaging from unpleasant bodily sensations (Factor 3). This is partially in line with the previous findings regarding the factor structure. Factor 1 in the current analyses consists of 9 out of 10 items that were initially included in the F1 subscale and represents the same construct. The initially assumed factor representing attention to unpleasant bodily sensations split into 2 factors in the current analyses: attention to

unpleasant bodily sensations (F2) and difficulty disengaging from unpleasant bodily sensations (F3), further specifying the potentially maladaptive aspect of interoceptive focus. Although the reliability of two of the scales was acceptable, the reliability of Factor 3 was poor. One of the possible causes could be low number of items together with the items being reversed. Convergent validity of the ISAQ Sensitivity (Factor 1) scale was supported by medium to large (r >.50) correlations with questionnaires measuring the perception of the neutral bodily sensations, such as BAQ and MAIA Noticing scale. Divergent validity for this factor was established by very small correlations with measures of anxiety-related body focus. Factor 2 showed small to medium correlations with measures of anxiety-related bodily focus, such as ASI-3, PCS and fear of suffocation as well as with measures of repetitive negative thinking–PTQ and PSWQ. Finally, factor 3 correlated with the MAIA Non-Distracting scale, which measures the tendency not to ignore or distract oneself from sensations of pain or discomfort.

In sum, the ISAQ can be considered a valid and reliable multidimensional instrument to assess interoceptive sensitivity and attention to neutral and unpleasant bodily sensations.

Study 2

In study 2 we investigated (a) whether different patient groups with stress-related syndromes and/or persistent somatic symptoms in daily life differed from healthy controls on ISAQ scores and on which factors, and (b) whether there are differences between diagnostic patient groups. We expected patients to differ from healthy controls on F2 (attention to unpleasant sensations) and on F3 (attentional disengagement). We had no specific expectations as regards to differences among the patient groups.

Methods

Participants and procedure

Participants in the current study were drawn from six studies, previously published or in preparation, in which patients experiencing persistent somatic symptoms and/or stress-related conditions completed the ISAQ during the recruitment phase (18,43-51). Data collection took place between 2013 and 2019. A description of the separate samples and studies can be found in the Supplementary Materials 3. In total, ISAQ scores of 37 patients diagnosed with burn-out (56.8% women, $mean_{age}$=43.3years, SD_{age}= 9.2), 151 patients with fibromyalgia and/or chronic fatigue syndrome (FM/CFS;87.5% women, $mean_{age}$=42.3years, SD_{age}=10.8), 38 patients with irritable bowel syndrome (IBS;86.8% women, $mean_{age}$=39.5years, SD_{age}=2.0), 29 patients with medically unexplained dyspnea (MUD;100% women, $mean_{age}$=38.0years, SD_{age}=9.1), 63 patients with overstrain (66.7% women, $mean_{age}$=38.9years, SD_{age}=11.9), 60 patients with panic disorder (PD;55.0% women, $mean_{age}$=33.7years, SD_{age}=11.6) and 144 healthy controls (HC;86.8% women, $mean_{age}$=41.0years, SD_{age}=11.0) were compared. Burn-out and overstrain patients were diagnosed according to the multidisciplinary guidelines for overstrain and burn-out for first line professionals of the Netherlands Society of Occupational Medicine (52-55). Patients with FM/CFS were diagnosed using the CDC criteria for CFS (Centers for Disease Control and Prevention;56) and/or ACR criteria for fibromyalgia (American College of Rheumatology;57). Patients with IBS were diagnosed using the Rome IV criteria (58). Patients were classified as having MUD after a systematic medical work-up procedure, which excluded physiological causes for the multiple somatic complaints, and after a systematic interview, namely the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition Axis I Disorders, which excluded psychiatric disorders other than somatization disorder or somatoform disorder. Patients with panic disorder were diagnosed according to DSM-IV criteria via the Mini-International Neuropsychiatric Interview (M.I.N.I); 59,60).

Measures

All participants gave informed consent and completed the 19-item version of the ISAQ. For the current analyses, 17 items from the original 19-item version were used. The internal consistency of the scales across the patient groups is presented in Table 3.

Data analyses

Overall, the datasets contained a small amount of missing data, with 514 participants (98.3%) responding to all 17 items, 6 participants (0.01%) responding to 16 items, and 3 participants (0.006%) responding to 15 items. The missing data were handled by adjusted calculation of scores for 11 participants (the mean of the answered items x the number of items in the scale).

To examine the differences in interoceptive dimensions between the groups, one-way analyses of variance (ANOVA) were used. When significant differences were found, post-hoc pairwise testing of means was performed using Tukey correction. In case of heterogeneity in variances between the groups, Brown-Forsythe *F*-ratios and *p*-values are reported. Statistical analyses were performed with SPSS.

Results

Group differences are presented in Table 4. Patients with FM/CFS and patients with MUD scored highest on the neutral sensations subscale (F1), with scores being significantly higher than those of patients with overstrain (p=.027 and p=.026, respectively) and healthy controls (p=.009 and p=.027, respectively) who had the lowest F1 scores. F1 scores of patients with burnout, IBS, and PD lay in between, with no significant differences with the other groups. Patients with PD had higher scores on the attention to unpleasant sensations (F2) subscales

than all other groups ($p_{PD\ vs.\ MUD}$=.008, all other *p*s<.001). Healthy controls had lower F2 scores compared to patients with FM/CFS (*p*=.002), patients with MUD (*p*<.001), overstrained patients (*p*<.001) and patients with PD (*p*<.001). Patients with PD also had the highest scores on the difficulty disengaging from unpleasant sensations subscale, with scores being significantly higher than those of patients with FM/CFS (*p*<.001), patients with IBS (*p*=.012) and healthy controls (*p*<.001).

General discussion

In two studies, we documented the development, reliability, and validity of a questionnaire that relies on recent theoretical models of interoception and symptom perception. We propose a useful tool for research allowing to distinguish different aspects of self-reported interoception in healthy persons and in patient groups.

Specifically, the studies reported above showed that the ISAQ can assess three distinct components of self-reported interoception: a) a tendency to identify/notice neutral internal bodily signals (F1), b) attentional focus to unpleasant bodily sensations (F2), and c) difficulties in disengagement from unpleasant bodily sensations (F3), with F1 and F2 showing adequate psychometric properties in this study.

The current findings show that the distinction between these aspects of interoception is clinically meaningful, since the different factors differentiate between and within patients with persistent somatic and/or stress-related symptoms in daily life versus healthy controls.

For F1, patients with CFS/FM and patients with MUD were the only patient groups with higher self-reported beliefs regarding their perceptual acuity compared with healthy controls. This is a noteworthy finding, since symptom over-reporting and lower interoceptive accuracy (IA) are often found in these specific patient groups (16-18). This adds to the assumption that belief in one's own interoceptive ability does not necessarily predict actual

interoceptive accuracy. The origins of body perception traits remain relatively unexplored and merit further investigation. In addition, these traits may play a mediating or moderating role in the relationship between IA and symptom reporting.

Another intriguing finding is that patients with PD have higher self-reported attention to unpleasant interoceptive sensations compared with healthy controls and other patient groups, with no difference in their self-reported beliefs on perceptual acuity. These findings are in line with Ginzburg et al. (8) and Murphy et al. (10), who showed that self-reported interoceptive attention was associated with increasing anxiety. It has been suggested that individuals who are prone to anxiety show a heightened discrepancy between observed and expected bodily states (61,62). In a next step, it would be interesting to compare ISAQ results with objective measures of interoceptive attention (63) and interoceptive accuracy.

Heightened interoceptive sensitivity and attention can be both adaptive and maladaptive for perceived health (22,23). Clinically, an increased attentional focus on physical sensations has commonly been associated with anxiety, hypervigilance, and somatization (9,61). However, mindfulness-based approaches show that interoceptive attention can also have a very different character–mindful rather than anxiety driven–and show preliminary positive effects in treatment studies (64,65). Given the current results that patients overall score higher on F2 compared with healthy controls, in particular patients with PD, research on the use of interoceptive attention towards neutral sensations instead of unpleasant sensations may have important clinical added value. More specifically, interoceptive differentiation training has been suggested to remedy poor interoceptive accuracy in several pathological conditions (11,27,28). The ISAQ may possibly detect the effects of such training.

Future research with the ISAQ may–in line with the Research Domain Criteria (RDoC) initiative (66)–add to identifying transdiagnostically relevant underlying

mechanisms across the stress/anxiety spectrum as well as pinpoint the specificity of abnormalities and its treatment components in a given disorder. For example, to what extent is state or trait anxiety an important characteristic as a source of differentiation; or how are specific concerns and catastrophic thoughts playing a role; what is the impact of attentional direction on scores on the ISAQ?

A strength of the current studies is that we used large enough samples to identify subgroups of participants. Another strength is that we have included different interoceptive response channels in the questionnaire and that we differentiated between the neutral/sensory and negative/affective aspects of interoceptive stimuli. Given the (weak) positive association found between F1 and positive affect (PA), we acknowledge that some items may not have been perceived as completely neutral in valence. Nevertheless, there is a clear differentiation observed from the unpleasant/negative valence of the items in F2 and F3. The latter factors are characterized by NA and subjective aspects of attention. It will be worthwhile to delineate the effects of these parameters in future research. A limitation is that the ISAQ was developed and validated in a student convenience sample. However, the internal structure that was found appeared relevant to distinguish clinical populations. Future studies in more diverse samples are needed to replicate and extend the construct validity and generalizability of the findings.

In sum, the ISAQ is a concise, reliable and easily interpretable measure to capture the self-reported tendency to notice and pay attention to neutral and unpleasant bodily sensations. The reported findings verify that the ISAQ can differentiate between patients and healthy controls, as well as within patient groups. The new questionnaire is clinically relevant and can be used as an additional tool in future research on adaptive and maladaptive body awareness.

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Figure legends

Figure 1. Scree plot with observed eigenvalues and mean eigenvalues from parallel analysis.

Figure 2. Standardized factor loadings from a three-factor model. ISAQ=Interoceptive Sensitivity and Attention Questionnaire. Loadings in bold are significant at $p<.001$.

Table 1. Factor structure of the Interoceptive Sensitivity and Attention Questionnaire obtained with oblique rotation (*n*=1074) and internal consistency of the scales.

	F1	F2	F3
Factor 1: Sensitivity to neutral bodily sensations (α=.67)			
13. When there is a considerable increase or decrease in my physical activity, I can predict exactly how this change will affect my energy levels.	.67		
17. During physical activity I can always tell when my heart rate accelerates.	.52		
15. I am always aware of changes in my posture.	.47		
5. I am aware of changes in my activity level throughout the day.	.47		
3. During physical activity I can immediately tell when I am taking deeper breaths than usual.	.45		
1. I am quick to notice changes in my body temperature.	.45		
8. I easily recognize changes in my muscles following physical activity.	.42		
9. As soon as I wake up in the morning, I know how much energy I am going to have during the day.	.35		
11. I quickly notice changes in my blood pressure without having to measure this explicitly.	.33		
Factor 2: Attention to unpleasant bodily sensations (α=.73)			
16. When I'm short of breath, I focus my attention on this.		.81	
10. When I have difficulty breathing, I focus on that.		.80	
6. When my chest hurts, I tend to focus my attention on this.		.56	
14. When I feel dizzy, I often focus on this.		.51	
Factor 3: Difficulty disengaging from unpleasant bodily sensations (α=.56)			
4. I tend to hardly notice stomach aches until they truly demand my attention.*			.57
7. When my stomach feels bloated, I usually don't focus on this.*			.51
2. When my throat hurts, I can easily ignore this.*			.49
12. I suppress headaches when they occur.*			.49

* reversely coded items; Loadings below .32 not shown.

Table 2. Correlations between the factors of the Interoceptive Sensitivity and Attention Questionnaire scales, Sensitivity to neutral bodily sensations (F1), Attention to unpleasant bodily sensations (F2), Difficulty disengaging from unpleasant bodily sensations (F3), and other self-report measures.

	n	**Cron-bach's alpha study sample**	**F1 Sensitivity to neutral bodily sensations**	**F2 Attention to un-pleasant bodily sensations**	**F3 Difficulty disengaging from unpleasant bodily sensations**
Measures of somatic awareness					
BAQ	1184	.82	.52***	.10***	.02
BPQ	357	.86	.28***	.17**	.04
MAIA F1 Noticing	357	.63	.52***	.32***	-.02
MAIA F2 Not-Distracting	357	.68	.11*	.10	.52***
MAIA F4 Attention Regulation	357	.84	.39***	.12*	-.16**
Measures of anxiety/anxiety-related body focus					
PANAS NA	1778	.88	.05*	.22***	.15***
PANAS PA	1778	.82	.13***	-.08***	-.11***
STAI	1812	.92	.03	.20***	.15***
ASI-3	1809	.87	.11***	.29***	.12***
Fear of suffocation	768	.93	.05	.31***	.20***
PCS	1339	.91	.08**	.30***	.22***
Measures of repetitive negative thinking					
PTQ	288	.94	.03	.32***	.09
PSWQ	1426	.92	.05	.27***	.19***

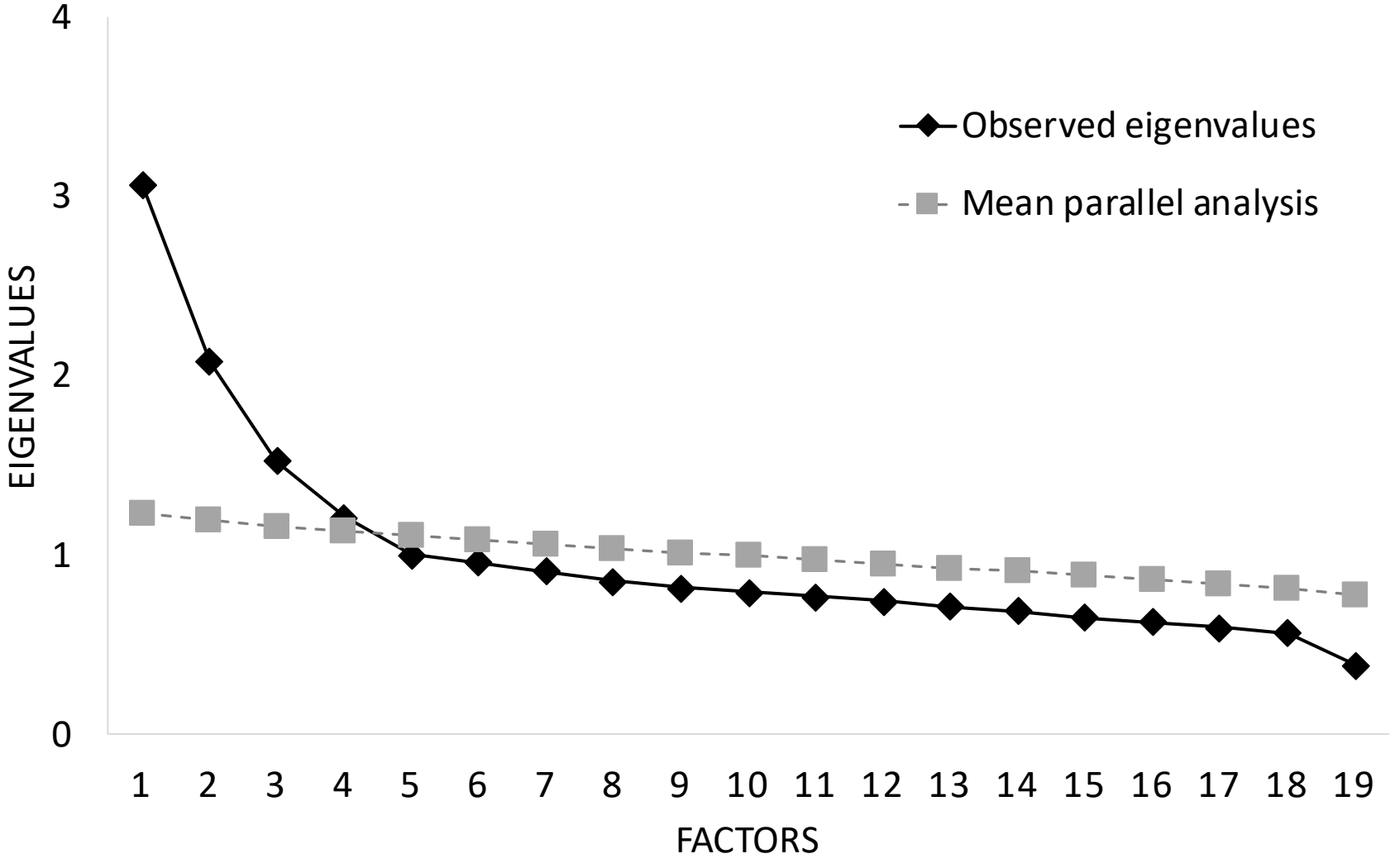
Note. *p<.05, **p<.01, ***p<.001.

Table 3. Internal consistency (Cronbach's alpha) of the three scales of the ISAQ across the patient groups.

	Items	HC	Overstrain	Burnout	PD	FM/CFS	IBS	MUD
ISAQ F1	9	.80	.83	.86	.68	.73	.72	.74
ISAQ F2	4	.73	.73	.82	.74	.78	.82	.92
ISAQ F3	4	.59	.68	.52	.61	.49	.68	.66

Table 4. Means and standard deviations of the different groups on the three ISAQ factors: F1 Sensitivity to neutral bodily sensations, F2 Attention to unpleasant bodily sensations, and F3 Difficulty disengaging from unpleasant bodily sensations. Means with different superscripts in the same row are significantly different.

	HC (*n*=144)		Overstrain (*n*=63)		Burnout (*n*=37)		PD (*n*=60)		FM/CFS (*n*=151)		IBS (*n*=38)		MUD (*n*=29)				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	df	p
ISAQ F1	27.85^{a}	5.73	27.46^{a}	6.45	29.05^{ab}	6.65	29.68^{ab}	4.91	30.14^{b}	5.42	28.03^{ab}	4.73	31.49^{b}	5.65	4.08	6,516	0.001
ISAQ F2	11.17^{c}	3.01	13.56^{a}	3.19	12.73^{ac}	3.25	17.00^{b}	2.28	12.62^{a}	3.18	12.00^{ac}	3.26	14.48^{a}	4.34	24.41	6,221	<0.001
ISAQ F3	11.70^{a}	2.69	12.27^{ab}	3.29	12.59^{ab}	2.98	13.60^{b}	2.68	11.40^{a}	2.64	11.58^{a}	3.32	12.66^{ab}	3.20	5.29	6,516	<0.001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Observed eigenvalues
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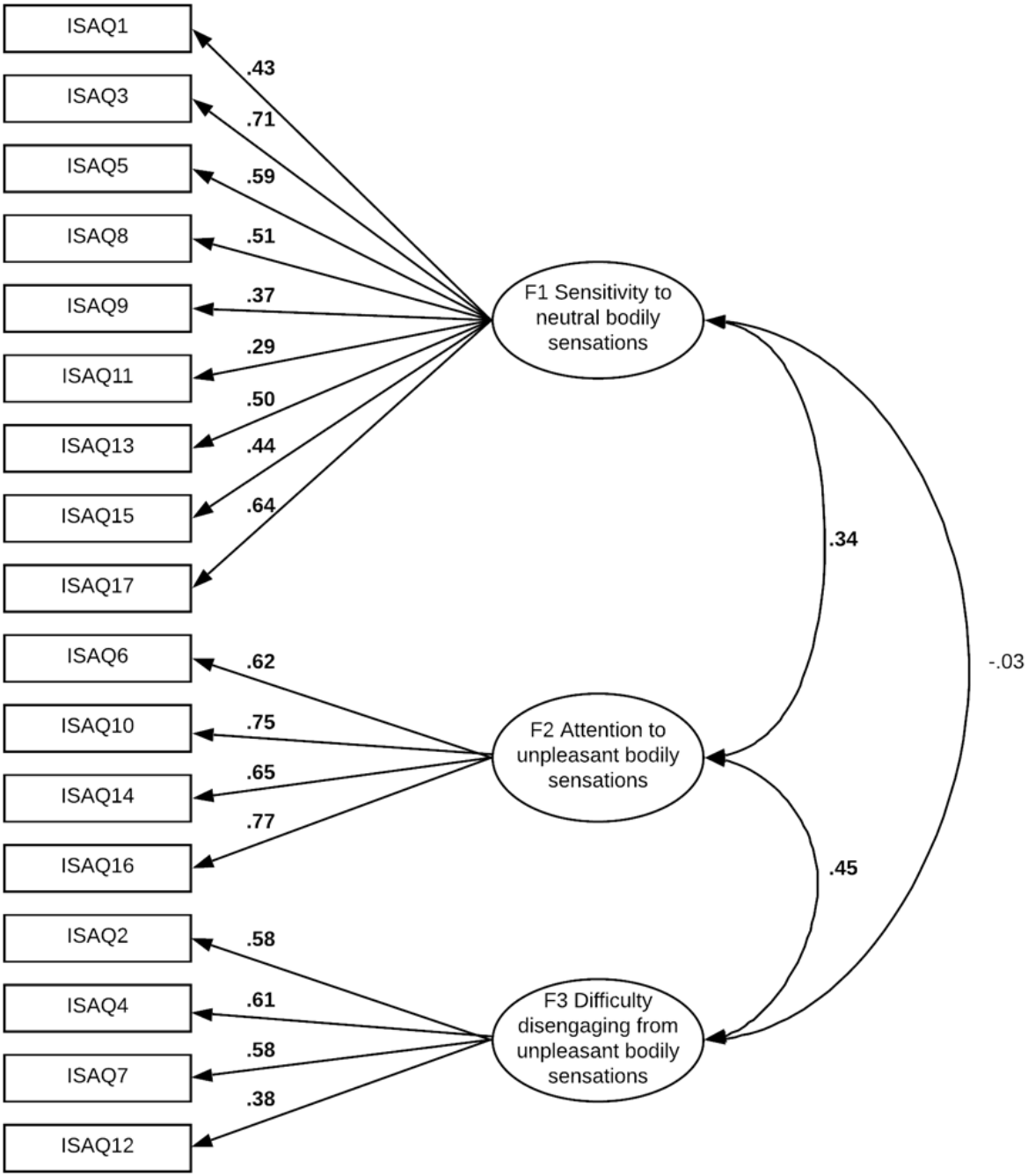
ISAQ1
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ISAQ8
ISAQ9
ISAQ11
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F1 Sensitivity to neutral bodily sensations
F2 Attention to unpleasant bodily sensations
F3 Difficulty disengaging from unpleasant bodily sensations
.34
.45
-.03

Supplementary Materials 1

Development of the Interoceptive Sensitivity and Attention Questionnaire (ISAQ)

In this supplementary materials we describe the development of the Interoceptive Sensitivity and Attention Questionnaire, which was previously presented during the following conference:

Van den Bergh O, Bogaerts K, Walentynowicz M, Van Diest I. The Interoceptive Awareness Questionnaire: Unraveling the distinction between awareness of neutral and negative bodily sensations. Paper presented at: Annual Meeting of the International Society for the Advancement of Respiratory Psychophysiology (ISARP); 28-30 September, 2012;Orlando, FL.

Method

Participants and procedure

Data for questionnaire development were collected during 3 consecutive group testing sessions (2009-2011) among all first-year psychology students (n=1356; 82.5% women[1]) in return for course credit. Participants completed the initial item pool (27 items) in a paper-pencil format. All group testing sessions were approved by the Social and Societal Ethics Committee of the University of Leuven (ML8678, S55996, G-2014 10 052, G-2017 09 942, G-2018 08 1322).

Materials

ISAQ initial pool

An initial item pool consisted of 27 items which aimed to cover a broad range of modalities, including cardiovascular, respiratory, gastrointestinal, energy level, mouth

[1] Age was not measured in those collective sessions. However, based on the collective sessions from other years at this university, the average age could be expected as 18.5 years.

and throat, thermoregulatory, postural and cerebral modalities, in both neutral and unpleasant sensations. Many items were based on the existing body awareness questionnaires, including the Body Awareness Questionnaire (1) and the Mindful Attention Awareness Scale (2). The items were rated on the 5-point Likert-type scale that ranged from 1 ('strongly disagree') to 5 ('strongly agree').

Data analysis & results

Missing cases were excluded listwise, resulting in a final sample of n=1279. Principal component analysis (PCA) with oblique rotation (oblimin) was performed on the responses to 27 items to investigate the factorial structure of the ISAQ. The values of the Kaiser-Meyer-Olkin coefficient (.80) and Bartlett's test of sphericity, $\chi 2(351) = 4638.68$, $p < .001$ verified the appropriate sampling adequacy for the analysis. The scree test suggested two separate factors. Items with factor loadings < .35 and items which loaded in an opposite direction were excluded, yielding a 19-item scale with 2 factors. The first factor consisted of 10 items reflecting responsiveness to sensory information from within the body, which was interpreted as *sensitivity to neutral bodily sensations*. The second factor consisted of 9 items which reflected increased focus on and difficulty disengaging from the somatic information of negative valence, which was interpreted as *attention to unpleasant bodily sensations*. Factor loadings for each item are displayed in Supplementary Table 1.

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1. Shields SA, Mallory ME, Simon A. The Body Awareness Questionnaire: Reliability and validity. J Pers Assess 1989;53:802–815.
2. Brown KW, Ryan RM. The benefits of being present: Mindfulness and its role in psychological well-being. J Pers Soc Psychol 2003;84:822–848.

Supplementary Table 1. Factor structure of the ISAQ obtained with oblique rotation (*n*=1279). Individual item factor loadings, eigenvalues, and Cronbach's alpha for the two selected factors.

	Factor loadings	
Item	Factor 1	Factor 2
During physical activity I can always tell when my heart rate accelerates.	.62	
When there is a considerable increase or decrease in my physical activity, I can predict exactly how this change will affect my energy levels.	.61	
I am aware of changes in my activity level throughout the day.	.53	
During physical activity I can immediately tell when I am taking deeper breaths than usual.	.50	
I easily recognize changes in my muscles following physical activity.	.49	
I quickly notice changes in my blood pressure without having to measure this explicitly.	.49	
I am quick to notice changes in my body temperature.	.44	
As soon as I wake up in the morning, I know how much energy I am going to have during the day.	.42	
I am always aware of changes in my posture.	.39	
I notice specific physical responses to changes in the weather.	.39	
When my throat hurts, I can easily ignore this.		.58
I tend to hardly notice stomach aches until they truly demand my attention.		.58
When my stomach feels bloated, I usually do not focus on this.		.56
When my chest hurts, I tend to focus my attention on this.		.52
I suppress headaches when they occur.		.51
When I feel dizzy, I often focus on this.		.47
When I have difficulty breathing, I focus on that.		.47
When I am short of breath, I focus my attention on this.		.42
When I feel exhausted, I am unable to turn my attention away from this.		.38
Eigenvalues	3.96	2.20
Alpha	.69	.66

Supplementary Materials 2

Interoceptive Sensitivity and Attention Questionnaire – Dutch version

Bogaerts, K., Walentynowicz, M., Van Den Houte, M., Constantinou, E., & Van den Bergh, O.

Geef aan in welke mate je het eens bent met onderstaande uitspraken door één van de volgende antwoordalternatieven aan te duiden: 1 = helemaal oneens, 2 = oneens, 3 = noch eens noch oneens, 4 = eens, 5 = helemaal eens.

1 helemaal oneens	**2** oneens	**3** noch eens noch oneens	**4** eens	**5** helemaal eens

		1	2	3	4	5
1.	Ik ben snel in het waarnemen van veranderingen in mijn lichaamstemperatuur.					
2.	Wanneer ik keelpijn heb, kan ik dat gemakkelijk negeren.					
3.	Tijdens het uitvoeren van een fysieke inspanning weet ik onmiddellijk wanneer ik dieper adem dan normaal.					
4.	Ik heb de neiging buikpijn niet echt op te merken totdat deze werkelijk mijn aandacht opeist.					
5.	Ik ben me bewust van veranderingen in mijn activiteitsniveau doorheen de dag.					
6.	Wanneer ik pijn heb aan mijn borst, ben ik geneigd mijn aandacht daarop te richten.					
7.	Wanneer ik een opgeblazen gevoel heb in mijn maag, focus ik me daar gewoonlijk niet op.					
8.	Ik herken gemakkelijk de veranderingen in mijn spieren na het uitvoeren van een lichamelijke activiteit.					
9.	Zodra ik ’s morgens wakker word, weet ik hoeveel energie ik ga hebben tijdens de dag.					
10.	Wanneer ik moeilijker kan ademen, focus ik me hier op.					
11.	Ik merk veranderingen in mijn bloeddruk snel op zonder dit expliciet te hoeven meten.					
12.	Ik onderdruk hoofdpijn wanneer het zich voordoet.					
13.	Wanneer mijn lichaamsbeweging aanzienlijk verhoogt of verlaagt, kan ik zeer precies voorspellen hoe die verandering een effect zal hebben op mijn energieniveau.					
14.	Wanneer ik me duizelig voel, richt ik er vaak mijn aandacht op.					
15.	Ik ben er me altijd bewust van wanneer ik van lichaamshouding ben veranderd.					
16.	Wanneer ik ademnood heb, eist dat mijn volledige aandacht op.					
17.	Tijdens het uitvoeren van een fysieke inspanning kan ik altijd aangeven wanneer mijn hartslag versnelt.					

Interoceptive Sensitivity and Attention Questionnaire – English version

Bogaerts, K., Walentynowicz, M., Van Den Houte, M., Constantinou, E., & Van den Bergh, O.

Please indicate the extent to which you agree or disagree with the following statements by selecting one of the following options: 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree.

1 strongly disagree	**2** disagree	**3** neither agree nor disagree	**4** agree	**5** strongly agree

		1	2	3	4	5
1.	I am quick to notice changes in my body temperature.					
2.	When my throat hurts, I can easily ignore this.					
3.	During physical activity I can immediately tell when I am taking deeper breaths than usual.					
4.	I tend to hardly notice stomach aches until they truly demand my attention.					
5.	I am aware of changes in my activity level throughout the day.					
6.	When my chest hurts, I tend to focus my attention on this.					
7.	When my stomach feels bloated, I usually don't focus on this.					
8.	I easily recognize changes in my muscles following physical activity.					
9.	As soon as I wake up in the morning, I know how much energy I am going to have during the day.					
10.	When I have difficulty breathing, I focus on that.					
11.	I quickly notice changes in my blood pressure without having to measure this explicitly.					
12.	I suppress headaches when they occur.					
13.	When there is a considerable increase or decrease in my physical activity, I can predict exactly how this change will affect my energy levels.					
14.	When I feel dizzy, I often focus on this.					
15.	I am always aware of changes in my posture.					
16.	When I'm short of breath, I focus my attention on this.					
17.	During physical activity I can always tell when my heart rate accelerates.					

Scoring instructions:

F1 Sensitivity to neutral bodily sensations: sum items 1, 3, 5, 8, 9, 11, 13, 15, 17

F2 Attention to unpleasant bodily sensations: sum items 6, 10, 14, 16

F3 Difficulty disengaging from unpleasant bodily sensations: sum items 2*, 4*, 7*, 12*
* items marked with an asterisk should be reverse scored before summing

Supplementary Materials 3

The description of the datasets used in Study 2

Dataset 1.

Outpatients at Tumi Therapeutics, a multidisciplinary diagnostic and treatment center that specializes in stress-related symptoms and syndromes (Heusden-Zolder, Belgium), were diagnosed with panic disorder (*n*=30), overstrain (*n*=32) and fibromyalgia and/or chronic fatigue syndrome (FM/CFS; *n*=24), and participated in a study investigating a self-observation tool on the dynamic relationship between self-reported psychological distress and somatic symptoms (1). The ISAQ was filled out during the intake procedure by 26 panic disorder patients (M_{age}=30.81, SD_{age}=1.72; 58% women; diagnosed according to DSM-IV criteria via the Mini-International Neuropsychiatric Interview (M.I.N.I); (2,3), 31 overstrained patients (M_{age}=37.84, SD_{age}=2.44, 68% women; diagnosed according to the multidisciplinary guidelines for overstrain and burn-out for first line professionals of the Netherlands Society of Occupational Medicine (4-7) and 21 CFS/FM patients [(M_{age}=38.55, SD_{age}=3.07, 67% women; diagnosed using the CDC criteria (Centers for Disease Control and Prevention; 8) and/or ACR criteria (American College of Rheumatology; 9)]. Organic diseases were excluded on the basis of doctor's reports, physical examination, and medical tests.

Dataset 2.

Outpatients at Tumi Therapeutics, a multidisciplinary diagnostic and treatment center that specializes in stress-related symptoms and syndromes (Heusden-Zolder, Belgium), were diagnosed with FM/CFS (*n*=38), overstrain (*n*=35), panic disorder (*n*=37) and burn-out (*n*=48), and participated in a study investigating functionality of the physiological stress

response system. There was no overlap with patients included in Dataset 1. Additionally, thirty healthy controls were recruited and matched on gender and age using a frequency sampling method, so that the distributions of age and gender were similar in the patient and the healthy control sample (10,11). The ISAQ was filled out during the intake procedure by 35 FM/CFS patients (M_{age} = 42.14, SD_{age} = 1.65, 94% women; diagnosed using the CDC criteria (8) and/or ACR criteria (9), 32 overstrained patients (M_{age}=39.91, SD_{age}=1.78, 66% women; diagnosed according to the multidisciplinary guidelines for overstrain and burn-out for first line professionals of the Netherlands Society of Occupational Medicine (4-7), 34 panic disorder patients (M_{age}=35.94, SD_{age}=2.24, 53% women; diagnosed according to DSM-IV criteria (2,3) and 30 healthy controls (M_{age}=40.23, SD_{age}=1.76, 70% women). Organic diseases were excluded on the basis of doctor's reports, physical examination, and medical tests.

Dataset 3.

Patients diagnosed with fibromyalgia and/or chronic fatigue disorder (*n*=81) and matched healthy controls (*n*=41) participated in a project investigating symptom perception processes. Eighty FM/CFS patients (M_{age}=42.24, SD_{age}=10.62, 88% women) and 41 healthy controls (M_{age}=42.37, SD_{age}=11.38, 88% women) completed the ISAQ questionnaire. Participant recruitment and methods are described in detail elsewhere (12-14).

Dataset 4.

Female patients diagnosed with fibromyalgia (*n*=16; ACR criteria, 9), irritable bowel syndrome (*n*=7; Rome IV criteria, 15) or both (*n*=6) and matched (age, BMI and SES) healthy women (*n*=25) participated in a study investigating neural responses to emotionally loaded pictures (16). One IBS patient did not fill out the questionnaire. The final sample

consisted of 16 FM and 12 IBS patients (M_{age}=44.57, SD_{age}=2.08, 100% women) and 25 healthy controls (M_{age}=44.80, SD_{age}=2.26, 100% women). Organic diseases were excluded on the basis of doctor's reports, physical examination, and medical tests.

Dataset 5.

Patients with irritable bowel syndrome (n=26; M_{age}=39.08, SD_{age}=12.09, 81% women) and matched healthy controls (n=24; M_{age}=39.29, SD_{age}=12.11, 79% women) completed the questionnaires during intake. Participant recruitment and methods are described in detail elsewhere (17).

Dataset 6.

Patients with medically unexplained dyspnea (n=29; M_{age}=28.00, SD_{age}=9.07, 100% women) and age-matched healthy controls (n=24; M_{age}=37.42, SD_{age}=9.84, 100% women) completed the questionnaires during intake. Participant recruitment and methods are described in detail elsewhere (18,19).

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