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Body awareness: differentiating between sensitivity to and monitoring of bodily signals

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Abstract Sensitivity to bodily signals is the tendency to be aware of bodily states and to identify subtle bodily reactions to internal and environmental conditions. Monitoring these signals is a top-down process, describing individuals' tendency to *actively* scan their bodies in order to detect cues for their physical condition. Two studies examined the relations between these constructs and their adaptivity among young adults. In Study 1, 180 young adults completed questionnaires assessing sensitivity, monitoring, and hypochondriac tendency. In Study 2, 205 students reported their levels of sensitivity, monitoring, pain catastrophizing, and trait anxiety. Although monitoring and sensitivity were correlated, when controlling for their shared variance, only monitoring was associated with high hypochondriac tendency and anxiety. In addition, the adaptivity of sensitivity to bodily signals was dependent on both level of monitoring of bodily signals and pain catastrophizing. That is, pain catastrophizing moderated the effect of sensitivity and monitoring on anxiety. These findings suggest that the adaptivity of sensitivity is determined by the mode of attention characterizing the individual engaged in this process.

Keywords Body awareness · Sensitivity · Monitoring · Pain catastrophizing

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Introduction

Body awareness is defined as the extent of *sensitivity* and *attentiveness* to internal signals and sensations (Shields et al., 1989). Although these two components are often used interchangeably (Bekker et al., 2002; 2008; Schmidt et al., 1997; Shields et al., 1989), a closer examination reveals lack of clarity regarding their definitions and operationalization. As a result, researchers debate whether these are similar and related concepts or whether they are distinct constructs that reflect different underlying processes.

Defining and measuring body awareness' components

At the core of the definition of body awareness, lays the concept of sensitivity. *Sensitivity* to bodily signals is defined as the tendency to be aware of, or sensitive to, bodily processes and states (Andersen, 2006; Craig, 2003; Miller et al., 1981; Shields et al., 1989; Spoor et al., 2005), to notice subtle bodily changes in response to internal and environmental conditions (Price & Thompson, 2007), and to differentiate between various sensations (Haugstad et al., 2006; Mehling et al., 2005). Sensitivity is sometimes measured as the accuracy of detecting organ-specific signals, such as heart rate (Pollatos et al., 2007a), body movements (Tsakiris et al., 2006) or changes in temperature (Johnston et al., 2012). Yet, sensitivity is often considered a subjective construct that is measured as the perceived sensitivity to somatic signals in general (Mehling et al., 2012; Miller et al., 1981; Shields et al., 1989). This approach is taken in the current study.

The definition of attentiveness to somatic signals is less clear. It is sometimes defined as the degree to which individuals are attentive to and focused on their bodily sensations, which enables them to identify physiological fluctuations (Bekker et al., 2002; 2008; Hansell et al., 1991). Attentiveness, in this sense, is somewhat similar to the construct of mindful observing (Baer et al., 2006; 2008). Although mindful observing refers to a wider range of experiences, including sensations, perceptions, thoughts and feelings (Baer et al., 2006), both mindful observing and attentiveness refer to a similar receptive state or process. More specifically, the two processes reflect open observing and witnessing of any current moment experiences. When attentiveness is defined in this manner, it is often used as a synonym to sensitivity, and is measured accordingly (Bekker et al., 2002, 2008; Shields et al., 1989). Indeed, a recent study demonstrate that when focusing attention to somatic sensations is conducted after a mindfulness meditation training, sensitivity to somatic signal is increased (Mirams et al., 2013). Thus, it seems that when attentiveness represents attentive observing of bodily signals, it is a complementary process to sensitivity, and as such is an integral part of the concept of body awareness.

Attentiveness to somatic signals, however, is also defined as the extent to which individuals actively scan their bodies in order to detect cues and changes in their current physical condition (Hansell et al., 1991; Schmidt et al., 1997). This deliberate, though not always controllable tendency reflects a top-down process, in which some individuals tend to think about their internal processes more often than others and to directly search for internal sensations as information on their current state. This tendency is captured by questions such as "How much do you think about how your body feels" (Hansell et al., 1991), or "On average, how much time do you spend each day 'scanning' your body for sensations" (Schmidt et al., 1997). This tendency is sometimes referred to as attentiveness (Hansell et al., 1991), monitoring (Hansell et al., 1991) or vigilance (Schmidt et al., 1997). Since it describes the extent to which individuals are engaged in active monitoring of their bodies, it seems that *monitoring* of somatic signals is a more accurate term than attentiveness.[1]

Thus, while attentive observing seems to be closely related to sensitivity to these signals and, as such, is an integral part of body awareness, the status of monitoring is less clear. More specifically, it is unclear whether monitoring of somatic signals is also associated with sensitivity, and whether it could also be considered as a component of body awareness, or whether monitoring and sensitivity denote two distinct unrelated constructs. This ambiguity may be attributed to the lack of understanding of the basic mechanisms that underlie sensitivity to and monitoring of bodily signals, and the relations between them. This lack of clear understanding is further reflected in research findings concerning their adaptivity as implicated by their relation to well-being.

The adaptivity of sensitivity to bodily signals and monitoring of these signals

Hansell et al. (1991) suggest that monitoring of bodily signals may be associated with somatosensory amplification, i.e., the tendency to be preoccupied with bodily sensations, intensify them, and interpret them as symptoms of illness (Barsky & Wyshak, 1990). That is, according to this interpretation, the tendency to actively monitor the body amplifies the amount of bodily sensations, which might be understood as pathological markers (Fergus & Valentiner, 2010; Keough et al., 2011; Rief & Barsky, 2005). This process leads to preoccupation with somatic sensations, which in turn amplifies anxiety level (Brown, 2004; Cioffi, 1991; Looper & Kirmayer, 2002; Schmidt & Trakowski, 1999). Indeed, a close examination of studies which assessed the tendency to monitor for bodily signals, especially when monitoring was assessed by the amount of time spent in scanning the body for sensations which may reflect signs and symptoms of illness, supports this perspective. More specifically, a high level of monitoring of bodily signals was shown to be related to increased levels of disease phobia (Fergus & Valentiner, 2010), anxiety (Schmidt et al., 1997), anxiety sensitivity (Olatunji et al., 2007; Vujanovic et al., 2007), and hypochondriasis (Schmidt & Trakowski, 1999; Schmidt et al., 1997). The tendency to monitor bodily signals was also shown to be associated with frequent utilization of medical services among older adults and anxiety disorder patients (Hansell et al., 1991; Olatunji et al., 2007). Although frequent health services utilization among older adults with health deterioration may denote an engagement in health promoting activities, among younger adults it is likely to be associated with health anxiety.

There are, however, conflicting views regarding the nature and adaptivity of sensitivity to bodily signals. According to one perspective, high sensitivity to somatic signals, similar to monitoring of these signals, signifies distress and disruption in affect regulation. More specifically, it is argued that high sensitivity to somatic signals is associated with hyper-arousal, intensified psychophysiological reactivity to emotional stimuli and anxiety (Domschke et al., 2010; Koroboki et al., 2010; Pollatos et al., 2007b). Some suggest that, similar to monitoring, increased sensitivity to somatic signals plays an essential role in the pathogenesis of anxiety, through the process of somatosensory amplification (Domschke et al., 2010).

[1] The term *monitoring of somatic signals* should not be confused with the term *sensory monitoring*, which is used in the pain literature. The latter denotes a strategy to cope with pain by focusing attention on its sensory aspects in order to distract attention away from the emotional aspects (Roelofs et al., 2004).

Others suggest a reversed causal direction, according to which habitually heightened psychophysiological reactivity, due to frequent arousal and anxiety, facilitates sensitivity to somatic signals (Pollatos et al., 2007c). This view was supported by studies documenting higher cardiovascular reactivity and essential hypertension among highly sensitive individuals, as compared to individuals with lower sensitivity to somatic signals (Koroboki et al., 2010; Pollatos et al., 2007b). It was also evident in studies that showed that highly sensitive individuals tend to react intensely to emotional stimuli, as was measured by a variety of measurements such as self-reports, records of event-related potentials and monitored heart rate (Herbert et al., 2007; Pollatos et al., 2007a, b, 2007d). Furthermore, there are indications that high sensitivity to internal signals is related to indicators of somatosensory amplification (Bekker et al., 2002; Spoor et al., 2005), as well as to anxiety (Pollatos et al., 2007a, 2009; Stewart et al., 2001), eating disorders (Spoor et al., 2005), interpersonal problems (Bekker et al., 2008) and impaired quality of life (Oh et al., 2010).

An alternative view, however, suggests that sensitivity to somatic signals is a salutogenic factor (Craig, 2010; Damasio, 2003; Damasio et al., 2000), rather than a signal of distress. This perspective views the level of sensitivity to somatic signals as deriving from the individual's sense of 'embodied self', that is, the extent to which his or her self integrates both the mind and body (Mehling et al., 2009). According to this view, individuals differ in the level of integration between their sense of their body and their sense of self (Tessari et al., 2010; Tsakiris, 2010). Individuals whose sense of body is integrated in their sense of self tend to perceive their bodies as reliable informants of their emotional and somatic conditions. Their persistent reliance on these signals, in turn, further enhances and elaborates this sensitivity. Individuals whose sense of self does not include their sense of body, on the other hand, often tend to ignore or alienate these somatic signals. This process of estrangement may result in attenuation of their sensitivity to these signals.

This capacity, attributed to the activity of the human insula (Craig, 2002; Critchley et al., 2004), was suggested to result from an evolutionary pressure to achieve integration of bodily, environmental and neural systems for the purpose of optimizing homeostatic efficiency (Craig, 2002; 2010). Thus, according to this view, the sensitivity to subtle somatic signals is an adaptive quality, which serves the individual's maintenance and well-being (Craig, 2010).

There are studies that support this view, showing that the sensitivity to somatic signals promotes the management of, and adjustment to, chronic disease (for extensive review, see Mehling et al., 2009). This quality was also shown to be positively associated with various indications of well-being, such as increased bodily satisfaction and responsiveness (Daubenmier, 2005; Dittmann & Freedman, 2009), and inversely associated with indicators of distress and anxiety such as somatosensory amplification (Aronson et al., 2001; Mailloux & Brener, 2002), somatization (Bogaerts et al., 2008), eating disorders (Gustafsson et al., 2010), depression (Ouwens et al., 2009) and self-injury (Ross et al., 2009). Finally, a study that assessed subjects' sensitivity to bodily signals according to their accuracy in a heat discrimination task, found that a higher level of accuracy is associated with a lower level of perceived pain (Johnston et al., 2012).

Closer examination of the way that sensitivity was measured in the various studies suggests that the reported conflicting finding with regard to the adaptivity of sensitivity to bodily signals cannot be explained by the method of assessment. Most of the studies that assessed sensitivity to bodily signals as the level of accuracy in the heartbeat detection task indicated its maladaptivity (Pollatos et al., 2007b, 2009; Stewart et al., 2001). However, some studies provided support for the adaptivity of sensitivity as measured by this procedure (Aronson et al., 2001; Johnston et al., 2012; Mailloux & Brener, 2002). A positive effect of sensitivity to bodily signals was also demonstrated when this construct was measured by the accuracy of respiratory symptom perception (Bogaerts et al., 2008). The same inconsistency was shown in studies that assessed this construct as perceived sensitivity to somatic signals in general, as some of the studies that used self-report questionnaires reported negative implications of this construct Oh et al., 2010; Spoor et al., 2005), and others showed its adaptivity (Daubenmier, 2005; Dittmann & Freedman, 2009; Gustafsson et al., 2010; Ouwens et al., 2009; Ross et al., 2009).

Therefore, considered together, these two perspectives, each supported by empirical evidence, call for further empirical investigation of the nature of sensitivity to somatic signals, its relation to the tendency to monitor these signals, and adaptiveness. This paper describes two studies that aim to examine whether sensitivity to and monitoring of bodily signals are related constructs that share certain qualities; whether these are distinct constructs, one pathogenic and associated with anxiety and the other a salutogenic marker of well-being; or whether their health effects depend on their interaction with each other and potential additional parameters, such as catastrophizing.

Study 1

This study examined two related questions, the first being whether sensitivity to and monitoring of bodily signals are associated with one another. More specifically, we assessed the relations between the level of sensitivity to somatic sensations that signify physiological states (e.g., pain, temperature, and hunger) and the degree of monitoring these sensations.

The second question was whether the two constructs are associated with health anxiety and preoccupation with somatic symptoms and illness, or whether only monitoring of bodily signals is an indicator of this anxiety. This question was examined by assessing the relations between both sensitivity to and monitoring of bodily signals, and hypochondriac tendency. Since sensitivity to somatic signals declines with age (Khalsa et al., 2009), these constructs were assessed among a sample of young adults.

Based on the theoretical background, we hypothesized that sensitivity to bodily signals and monitoring of these signals would be positively associated. We also hypothesized that monitoring of bodily signals would be positively associated with hypochondriac tendency. The conflicting views with regard to the adaptivity of sensitivity to somatic signals derive two conflicting research hypotheses: In accordance to the view that sensitivity to bodily signals is a marker of distress, it was hypothesized that sensitivity would be *positively* associated with hypochondriac tendency. In line with the perspective that views sensitivity to somatic signals a saluthogenic factor, however, it was hypothesized that sensitivity would be *inversely* associated with hypochondriac tendency.

Method

Participants and procedure

The sample was a convenience sample of 180 young adults (age 20–40), recruited by undergraduate students, as part of their participation in an empirical seminar. Fifty-four percent of the participants were female; the average age was 27.83 years ($SD = 4.41$), with a mean of 14.74 years of education ($SD = 1.98$). Seven percent of respondents reported having some chronic physical condition, such as asthma, irritable bowel syndrome or migraine. These respondents were included in the analyses.

Data was collected after approval by the institutional review board and receipt of informed consent from the participants.

Measures

Background variables included data regarding sex, age and level of education. Participants were also asked about their physical health, height and weight, and health-related behaviors such as engagement in physical activity, cigarette smoking and consumption of alcohol, medication and vitamins.

Sensitivity to somatic signals was assessed by the Body Awareness Questionnaire (BAQ; Shields et al., 1989), which assesses sensitivity to bodily processes and the ability to detect small changes in functioning and to anticipate bodily reactions to internal and environmental changes (e.g., "I notice differences in the way my body reacts to various foods", "I notice specific body responses to changes in the weather", and "I know in advance when I'm getting the flu"). Respondents are asked to indicate, on a 7-point Likert scale, the extent to which each item is true for him or her. A higher mean score reflects higher sensitivity to somatic cues. Previous studies demonstrated the scale's validity and reliability (Shields et al., 1989). Cronbach alpha for the current sample ($\alpha = 0.87$) was comparable to the original validation report (.77–.83; Shields et al., 1989).

Monitoring of somatic signals was assessed by an item adopted from the Body Vigilance Scale (BVS; Schmidt et al., 1997). The BVS is a four-item scale, designed to assess the tendency of "consciously attending to internal cues" (Schmidt et al., 1997). Yet, closer examination of this scale reveals a mixture of items assessing monitoring and sensitivity (e.g., item 2 "I am very sensitive to changes in my internal bodily sensations"). Thus, for the purposes of this study, we used Item 3 which states: "On average, how much time do you spend each day "scanning" your body for sensations (e.g., sweating, heart palpitations, dizziness)?" Individuals are asked to rate, on a scale, ranging from 0 ("no time") to 100 ("all the time") the extent to which they tend to monitor their body for such signals.

Hypochondriac tendency was measured by the Whiteley Index (WI; Pilowsky, 1967). This scale consists of 14 items tapping hypochondriac concerns such as being worried about physical health, being afraid of illness, or feeling that people are not taking your illnesses seriously enough. Respondents are asked to indicate whether or not they experience each concern. A higher score reflects a stronger hypochondriac tendency. Cronbach alpha for the current sample was high ($\alpha = 0.80$), comparable to previous reports ($\alpha = .75$; e.g., Conradt et al., 2006).

Data analysis

MANOVA analyses were conducted to test the associations of sensitivity and monitoring with categorical background variables (sex, physical activity, vitamin consumption, cigarette smoking and consumption of alcohol or medication), and Spearman correlations were computed to test their relations with continuous variables (age, years of education). Spearman correlations were also computed to test the pattern of associations between sensitivity, monitoring and hypochondriac tendency.

Then, a simultaneous regression analysis was conducted with hypochondriac tendency as the dependent variable and sensitivity, monitoring, and the interaction between sensitivity and monitoring, as the independent variables. A Kolmogorov–Smirnov test for normality of distribution was conducted prior to the regression, indicating that sensitivity is normally distributed (D = .06, n.s.), but monitoring and hypochondriac tendency are not (D = .19, $p < .000$; D = .18; $p < .001$, respectively). Further analyses indicated that for both variables, this effect results from a certain degree of skewness, therefore these variable were log-transformed prior to their inclusion in the regression model. In addition, all predictors were centered before they were entered into the multiple regression analysis, as suggested by (Kraemer & Blasey, 2004).

Results and discussion

Sensitivity, monitoring, demographics and health-related behaviors

MANOVA analysis, with sensitivity and monitoring as the dependent variables and sex as the independent variable, revealed significant effect for gender (*Pillai's trace* = .08, $F(2, 176) = 5.15$, $p < .01$). Univariate analyses indicated that women reported higher levels of sensitivity (M = 4.33, SE = 0.08, $p < .01$), and monitoring (M = 29.69, SE = 2.38, $p < .001$) than men (M = 3.98, SE = 0.92; M = 20.73, SE = 2.60; respectively). Age and education were not associated with either sensitivity or monitoring.

The two body awareness measures were not associated with participants' BMI, engagement in physical activity, vitamin consumption, cigarette smoking and consumption of alcohol or medication.

Sensitivity, monitoring, and hypochondriac tendency

Table 1 presents the means and standard deviations of sensitivity and monitoring, and the correlations between them. As can be seen, there is a positive moderate correlation between these measures. In addition, positive small correlations were found between hypochondriac tendency and sensitivity and monitoring.

In order to examine the unique and accumulated contribution of sensitivity, monitoring, and their interaction to the explained variance of hypochondriac tendencies, a regression analysis was conducted. Table 2 presents the results of the regression model. As can be seen, when entered into the regression model, only monitoring made a significant contribution to the explained variance of hypochondriac tendency ($R^2 = 0.10$; adjusted $R^2 = 0.08$, $F(3,178) = 6.29$, $p < .001$). As indicated by the tolerance and VIF indices, it seems that these effects were not biased by multicollinearity.

Table 1 Correlations between sensitivity, monitoring, and hypochondriac tendency (Study 1)

	Sensitivity	Monitoring	Hypochondriac tendency
Range	0–7	0–100	0–1
Mean (SD)	4.18 (0.85)	25.59 (23.87)	0.26 (0.22)
Sensitivity	1.00	0.38***	0.20*
Monitoring		1.00	0.29***
Hypochondriac tendency			1.00

* $p < .05$; *** $p < .001$

Table 2 Regression model for prediction of hypochondriac tendency (Study 1)

	B	SE	β	Tol	VIF
Sensitivity	0.03	0.4	0.07	0.81	1.23
Monitoring	0.26	0.05	0.27***	0.84	1.20
Sensitivity × monitoring	−.02	0.08	−.02	0.91	1.10

Tol tolerance, *VIF* variance inflation factor

*** $p < .001$

The findings of this study indicated a positive association between sensitivity to somatic sensations and monitoring of these signals. When this association is overlooked by examining simple correlations, sensitivity to somatic signals appears to be related to health anxiety.

Yet, the findings of Study 1 also showed that once the association between sensitivity to and monitoring of somatic signals is controlled for, the relation between sensitivity and hypochondriac tendency evaporates. That is, the shared variance between sensitivity and monitoring is responsible for the observed association between sensitivity and health anxiety.

Study 2

The findings of Study 1 suggest that sensitivity to and monitoring of bodily signals are related to one another. In addition, sensitivity, on its own, appears to be mildly associated with hypochondriac tendency, yet once the shared variance with monitoring was controlled for, this association was reduced. These findings, in line with the equivocal picture obtained by studies that examined the adaptivity of sensitivity to somatic signals, may suggest that sensitivity on its own is not saluthogenic or pathogenic, but rather its interaction with other qualities determines its adaptivity (See also Mehling et al., 2009). That is, it seems that the adaptivity of sensitivity is conditioned by other factors, which might be somewhat related to, or overlapped with, monitoring.

This argument is in line with Mehling et al. (2009) suggestion, according to which sensitivity and attentiveness to bodily signals may reflect either "anxiety-related hypervigilance toward pain and other physical sensations with catastrophizing interpretation bias" (p. 12), or a non-judgmental accepting awareness of these sensations. According to this suggestion, the adaptivity of sensitivity to bodily signals depends on the individual's mode of attention towards these signals. *Pain catstrophizing* reflects exaggerated negative orientation towards pain and somatic sensations (Sullivan et al., 1995, 2001). This orientation is represented by a negative cognitive set characterized by constant rumination of pain-related thoughts, magnification of the unpleasantness of these sensations, and pain-related helplessness (Sullivan et al., 1995). Pain catastrophizing was shown to be associated yet distinctive from trait anxiety (Sullivan et al., 1995). It has been shown to specifically affect the physical and emotional experience of pain and other somatic symptoms (Devoulyte & Sullivan, 2003; Sullivan et al., 2001).

Thus, the aim of Study 2 was to examine the hypothesis that the adaptivity of sensitivity to bodily signals would be moderated by level of pain catastrophizing. Adaptivity was evaluated by the level of trait anxiety. More specifically, we examined the interactions between sensitivity, monitoring, and pain catastrophizing in predicting trait anxiety. We hypothesized that when combined with *high* level of pain catastrophizing, sensitivity to bodily signals would be *positively* associated with anxiety, while when combined with *low* level of pain catastrophizing, sensitivity to bodily signals would be *inversely* associated with anxiety.

Method

Participants

The sample of this study is comprised of the 205 university students. Seventy-five percent of the participants were females, and the average age was 26.29 (SD = 3.95). Thirteen percent of the respondents reported some chronic physical condition such as asthma, irritable bowel syndrome or arthritis.

Data was collected by undergraduate physiotherapy students as part of their participation in a research seminar, after approval by the institutional review board and receipt of informed consent from the participants.

Measures

Background variables included sex, age and level of education. Participants were also asked whether they endorse any chronic physical condition.

Sensitivity to somatic signals of physiological processes was measured by the BAQ (Shields et al., 1989), as described in Study 1. Cronbach alpha for the current sample was 0.88.

Monitoring of somatic signals was assessed by the same item adopted from the BVS (Schmidt et al., 1997), as described in Study 1.

Pain Catastrophizing was assessed by the Pain Catastrophizing Scale (PCS; Sullivan et al., 1995). The PCS is composed of 13 items that measure pain-related reactions: rumination (reflecting an inability to suppress or divert attention away from pain-related thoughts), magnification (reflecting magnification of the unpleasantness of pain situations and expectancies for negative outcomes) and helplessness (reflecting the inability to deal with painful situations). Participants are asked to reflect on past painful experiences and indicate the degree to which they experienced each of 13 thoughts or feelings when experiencing pain, on a 5-point Likert scale. Studies supported the scale's validity (Sullivan et al., 1995). Cronbach alpha for the current sample was high ($\alpha = 0.91$), comparable to the original validation report ($\alpha = 0.87$; Sullivan et al., 1995).

Trait anxiety was assessed by a short version of the State-Trait Anxiety Inventory (STAI; Kesler et al., 2009; Spielberger et al., 1970). This 10-item version includes five items that are indications for anxiety (e.g., tense, upset), and five reversed items (e.g., calm, rested). Respondents are asked to indicate, on a 4-point Likert scale, the extent to which they usually feel these emotions. A higher score reflects a higher level of anxiety. Cronbach alpha for the current sample was high ($\alpha = 0.87$), comparable to previous reports for the short ($\alpha = .81$; Kesler et al., 2009), and full version ($\alpha = 0.89$; Barnes et al., 2002).

Data analysis

Spearman correlations were computed to test the pattern of associations between sensitivity, monitoring, pain catastrophizing, and trait anxiety. Then, a hierarchical regression analysis was conducted, with trait anxiety as the dependent variable, and sensitivity, monitoring, pain catastrophizing, and the interactions between them, as the independent variables. To examine whether controlling for the shared variance of sensitivity and monitoring affects the association between sensitivity and anxiety, the predictors were entered to the model in three blocks. The first block included sensitivity and monitoring, the second block included pain catastrphizing, and the third included the interactions between the predictors. Kolmogorov–Smirnov tests for examining normality of distribution indicated that sensitivity and pain catastrophizing are normally distributed (D = .05, n.s.; D = .06, n.s., respectively), but monitoring is not (D = .20, $p < .000$). Further analyses indicated that this effect results from a certain degree of skewness of monitoring. Thus this variable was log-transformed before entered to the regression model. In addition, all predictors were centered before they were entered into the multiple regression analysis, as suggested by Kraemer and Blasey (2004).

Results and discussion

Table 3 presents the correlations between the study variables. As can be seen, sensitivity and monitoring were moderately related. Monitoring was moderately associated with pain catastrophizing. Finally, a small correlation was found between anxiety and monitoring and moderate correlation between anxiety and pain catastrophizing.

Regression analyses examined the unique and accumulated contribution of the sensitivity, monitoring, pain catastrophizing, and their interaction to the explained variance of anxiety.

The regression model explained 19 % of the variance of level of anxiety ($R^2 = 0.22$; adjusted $R^2 = 0.19$; $F(7,200) = 7.56$, $p < .001$). As can be seen in Table 4, when sensitivity and monitoring were entered to the regression model, monitoring was positively associated with anxiety, and sensitivity was negatively associated with anxiety. These associations remained significant when pain catstrophizing was entered into the regression model. Yet the contribution of sensitivity to the explained variance of anxiety became insignificant in the third block, once the interactions were included in the regression model.

In addition, the three-way interaction between sensitivity, monitoring, and pain catastrophizing was also significant. Figure 1 presents the interaction plot illustrating the simple slopes. To interpret this interaction, a PROCESS procedure (Hayes, 2012) was computed. This computation revealed that sensitivity and anxiety were negatively associated among individuals with low levels of monitoring and pain catastrophizing ($b = -.13$, $p < .05$; slope 1) and among those with high levels of monitoring and pain catastrophizing ($b = -.19$, $p < .01$; slope 4).

Replicating the findings of Study 1, the findings of Study 2 demonstrated a significant association between sensitivity and monitoring. The findings also showed that when the association between sensitivity and monitoring is controlled for, sensitivity to somatic signals becomes a significant predictor of low levels of anxiety. This pattern of relation, in which the inclusion of two predictors in a regression model improves their predictive power, is considered a suppression situation (Tzelgov & Henik, 1991), or mutual suppression (Paulhus et al., 2004), meaning that although the inverse association between sensitivity to somatic signals and anxiety is often blurred, it is revealed once monitoring of these signals is taken into account.

Furthermore, the three-way interaction demonstrates that the association between sensitivity and anxiety is moderated by both monitoring and pain catastrophizing. A few trends are revealed by this interaction. First, as can be

Table 3 Correlations between sensitivity, monitoring, pain catastrophizing and anxiety (Study 2)

	Sensitivity	Monitoring	Pain catastrophizing	Anxiety
Range	1–7	0–100	1–5	1–4
Mean (SD)	4.64 (.98)	31.18 (27.63)	2.50 (.75)	2.03 (.56)
Sensitivity	1.00	.34***	.01	−.12
Monitoring		1.00	.44***	.27***
Pain catastrophizing			1.00	.37***
Anxiety				1.00

* $p < .05$; ** $p < .01$; *** $p < .001$

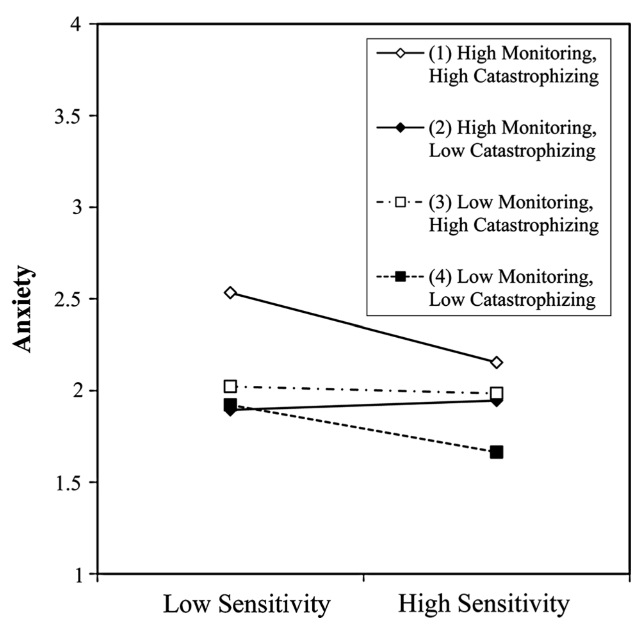

Fig. 1 A three-way interaction plot illustrating simple slopes of sensitivity on anxiety according to monitoring and pain catastrophizing (Study 2)

Table 4 Regression models for predicting anxiety (Study 2)

	B	SE	β	Tol	VIF
Block 1					
Sensitivity	−.13	.04	−.25***	.92	1.09
Monitoring	.47	.10	.35***	.92	1.09
Block 2					
Sensitivity	−.12	.04	−.22**	.91	1.10
Monitoring	.31	.10	.23**	.74	1.34
Pain catastrophizing	.19	.05	.26***	.81	1.23
Block 3					
Sensitivity	−.08	.04	−.14	.71	1.41
Monitoring	.28	.10	.21**	.73	1.37
Pain catastrophizing	.21	.05	.30***	.74	1.35
Sensitivity × monitoring	.02	.11	.01	.74	1.35
Sensitivity × catastrphizing	−.03	.06	−.04	.67	1.48
Monitoring × catastrophizing	.18	.13	.09	.88	1.14
Sensitivity × monitoring × catastrophizing	−.29	.13	−.17*	.72	1.38

Tol Tolerance, *VIF* Variance inflation factor

* $p < .05$; ** $p < .01$

seen in Fig. 1, sensitivity to bodily signals is salutogenic among individuals with low levels of monitoring and low levels of catastrophizing (slope 4), and among individuals with high levels of monitoring and pain catastrophizing (slope 1). Second, the most distressed group is comprised of individuals with high levels of monitoring and pain catastrophizing, and low levels of sensitivity, and the least distressed groups is comprised of individuals with low levels of monitoring and pain catastrophizing, and high levels of sensitivity. Third, among individuals who combine high levels of monitoring and low levels of pain catastrophizing (slope 2), and those who combine high levels of pain catastrophizing and low levels of monitoring (slope 3), sensitivity does not relate to anxiety.

General discussion

The findings of the two studies showed that sensitivity and monitoring are related to each other. The findings also demonstrated that monitoring is a maladaptive tendency. The picture is more complicated regarding the adaptivity of sensitivity, which was shown to either reflect vulnerability, or be a marker of well-being. It appears that the mode and the quality of attention of the individual engaged in this process are what differentiate between these two cases. That is, high sensitivity may reflect a tendency to be *receptive* to body signals and sensations free of a worried catastrophizing mode of attention, or it may result from engaging in *an* active top-down process of monitoring of such signals, which may be related to somatosensory amplification. The latter case was observed when the shared variance with monitoring was not controlled for. The former case was manifested, in this study by a combination of high sensitivity with low levels of monitoring and pain catastrophizing,

This interpretation is supported by findings showing that self-focus accompanied by a ruminative thinking style is less adaptive and related to depressive thinking patterns more than self-focus that is accompanied by a non-ruminative thinking style (Raes et al., 2008). Mehling et al. (2009) suggest that what constitutes the adaptive non-ruminative sensitivity to somatic signals is the ability to direct attention to the immediately experienced sensation in a non-judgmental manner, captured by the construct of mindfulness. Indeed, a recent study indicated that dispositional rumination exacerbates the relationship between life hassles and distress, whereas dispositional mindfulness attenuates this relationship (Marks et al., 2010).

The findings also point to the complicated pattern of relations between monitoring and pain catastrophizing. On the one hand, although the two factors are associated with one another, each made a unique contribution to anxiety. On the other hand, the findings that the individuals characterized by high levels of monitoring and low levels of pain catastrophizing, and those characterized by low levels of monitoring and high levels of pain catastrophizing had similar levels of anxiety, and that sensitivity did not affect this anxiety in either group, suggest some sort of dependence between these variables. This pattern of results may point to the possibility that monitoring and catastrophizing play a somewhat similar role within the process of perceiving and interpreting somatic information, resulting in suppressing one another's affect.

Studies suggest that the center of consciousness of one's internal states is in the human right insular cortex (Craig, 2002). The insula receives signals from the body tissues via various brain structures associated with autonomic and sensory processing. Imaging studies thus show that the insula is activated following noxious and innocuous stimuli from the skin (Coghill et al., 1999; Davis, 2000) and visceral tissues (Haase et al., 2009; Kinomuraa et al., 1994) and that its activation is associated with subjective appreciation of sensations such as pain (Brooks et al., 2002) and warmth (Craig et al., 2000). The insula is also interconnected with the amygdala, hypothalamus and orbitofrontal cortex and structures of the limbic system, and emotions such as sadness, anger, anxiety, panic, disgust and pain activate the insula (Damasio et al., 2000; Klasen et al., 2011; Ploghaus et al., 1999).

It has thus been postulated that the insular cortex contains a sensory representation of the physiological condition/homeostasis of the body, or an "interoceptive image of the body" (Craig, 2002). Lesions to the insular cortex in humans were found to disrupt homeostatic processing (Appenzeller & Oribe, 1997) and to interrupt the ability to feel the body (Greenspan & Winfield, 1992). The interoceptive image of the body may serve as a substrate for subjective feelings and emotions, and may be required to produce conscious decisions that are necessary for survival (Damasio, 1993). In other words, the sensory-emotional-cognitive integration mediated by the insula (Critchley, 2009; Gu et al., 2013) corresponds with self-awareness. Support for this hypothesis is the recent finding of increased insular activation during pain relief by mindfulness. Our finding of decreased anxiety in individuals with high levels of sensitivity and low levels of monitoring and pain catastrophizing reflects this complex integration that is related to self awareness. It is noteworthy that sensations and emotions are processed in other brain regions that are also related with the insula, such as the anterior cingulated cortex (Paus, 2001; Yoshino et al., 2010) and the orbitofrontal cortex (OFC; Royet et al., 2000). Body awareness appears to result from an integrated activation in several neuronal systems involved in the processing of sensory, emotional and cognitive aspects of the human experience, the center of which might be the insular cortex.

The findings of these studies should be considered in light of their limitations. The most essential reservations stem from the reliance on self-report questionnaires in general, and in assessing sensitivity and monitoring of somatic signals in particular. The first reservation derives from the assumption that sensitivity and monitoring of somatic signals are conscious processes on which individuals can report. Monitoring body signals is implicated in certain behaviors, and awareness is part of the definition of sensitivity to these signals. Moreover, previous studies suggest that anterior insular/opercular activity, which reflect interoceptive awareness is associated with conscious awareness of bodily process (Critchley et al., 2004). Yet, much of the processing of these signals occurs at a non-conscious level (Damasio, 1996). Therefore, one should take into account that due to the lack of objective measures of sensitivity, and the fact that it was measured by self-report questionnaires, what was actually measured is participants' subjective sense of sensitivity, rather than actual sensitivity. Findings of a previous study support the validity of subjective sensitivity by demonstrating a significant association between self-reported sensitivity and the ability to detect subtle bodily changes (Miller et al., 1981), yet, many others point to the unreliability of self-reports of physical sensation (see Pennebaker, 2000). Thus, one cannot rule out the possibility of a certain disparity between self-reported and actual sensitivity. Furthermore, although all the other study variables were measured by highly acceptable and widely used questionnaires, they are subject to the same limitations. Another though related reservation refers to the fact that the tendency to monitor bodily signals was measured by a single-item scale. Although previous studies provided evidence that indicate that well-designed single-item scales are not inferior to multiple-item questionnaires with regard to their validity (see Gardner et al., 1998), the applicability of this evidence to the assessment of monitoring needs further support. Taken together, these limitations call for more empirical studies that would further examine the conceptual background and validity of the assessment of sensitivity and monitoring. Finally, due to the convenience sampling procedures and cross-sectional designs, readers should be cautious in generalizing the results or concluding causal relationships.

Body awareness is an under researched concept. The reasons for this may lie in the tendency of health-related psychology research to focus on cognitive-emotional aspects of the self, while excluding bodily aspects of the self from the discussion (Lyons & Chamberlain, 2006). The findings of the current study, in line with other recent research directions (Mehling et al., 2009), indicate the significance of research and theories reflecting an integrative approach to human behavior.

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