Interoceptive awareness in patients with functional neurological symptoms

Lucia Ricciardi1§, Benedetta Demartini1,2§, Laura Crucianelli3, Charlotte Krahé4, Mark J Edwards1 and Aikaterini Fotopoulou5.

1 Sobell Department, UCL Institute of Neurology, Queen Square, London WC1N 3BG, UK

2 Cattedra di Psichiatria - Dipartimento di Scienze della Salute, Universita` degli Studi di Milano, Italy

3 Department of Psychology, University of Hertfordshire, London, UK

4Department of Neuroimaging, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, UK.

5 Division of Psychology and Language Sciences, CEHP Research Department, University College London, London, UK

§ These authors equally contributed to the study.

**Keywords**: interoception, functional neurological symptoms, heartbeat detection task, self-objectification

**Highlights**:

* we compared interoceptive awareness in a group of individuals with functional motor disorders versus healthy controls
* we employed a commonly used heartbeat detection task
* we found that people with functional motor disorders have lower interoceptive accuracy than controls
* the reduced interoceptive accuracy was predictive of their depressive symptoms and self-objectification

Corresponding author:

Aikaterini (Katerina) Fotopoulou

University College London

CEHP Research Department

1-19 Torrington Place

London WC1E 7HB

Tel: (+44) 020 3108 3079

Fax: (+44) 020 7916 8502

Email: a.fotopoulou@ucl.ac.uk

**Abstract**

Historically, emotional factors, such as trauma or psychological conflict, have been suggested as causal factors of functional motor disorders (FMD). More recent approaches have instead stressed potential neural and cognitive abnormalities in the allocation and maintenance of attention. Yet these studies have mostly focused on how attention is allocated to exteroceptive signals about the state of the body. Given the proposed important role of interoception for emotion, the study of FMD patients’ ability to monitor their interoceptive signals may serve as a useful, mechanistic link between studies that aim to identify key emotional factors in FMD, and those that examine specific sensorimotor or cognitive abnormalities.

In the current study, we compared the interoceptive awareness of a group of individuals with FMD (N = 16) with a group of healthy controls (N =17). We employed a commonly used heartbeat detection task which tracks the level of concordance between one’s heart rate and its subjective perception, as a proxy for interoceptive awareness more generally.

We found that FMD patients have lower interoceptive accuracy than healthy subjects, and such reduced interoceptive accuracy was predictive of their depressive symptoms, as well as their tendency to focus on the external features of their body (self-objectification). Contary to our predictions, interoceptive accuracy was not predictive of alexithymia. These results suggest a potental trade-off between the allocation of attention to internal versus external aspects of the body in FMD. More generally, they warrant further investigation of interoceptive awareness in this population, as a means to understand their emotional abnormalities at a more mechanistic level than studies concentrating on traumatic life events and related risk factors.

**Introduction**

The term functional neurological disorder describes patients that experience neurological symptoms (e.g. motor weakness, epileptic-type attacks, sensory disturbance), but assessment shows that normal function is possible in the relevant body parts. For example, in patients with functional unilateral leg weakness, power of hip extension will be weak when tested directly, but the apparently weak muscles will activate normally when the patient activates the opposite hip flexor (Hoover’s sign) (1). Feigning is not considered to be an adequate explanation for the symptoms in most patients (2). Historically, psychological, emotional factors, such as trauma, conflict or distress, have been suggested as causal factors. These explanations are reflected in the various alternative terms used to describe these disorders, such as psychogenic, psychosomatic, conversion, or hysteria. Distress and psychological trauma are indeed seen at higher rates in these patients than the healthy population (2), but they have not been found to be sensitive markers of functional neurological symptoms (3). Thus, an alternative, perhaps equally problematic terminology focuses on what patients do not have (non-organic, medically unexplained symptoms). Indeed, the related debates regarding the ‘psychogenic’ or ‘non-organic’ causes of these disorders portray a compartmentalised, dualistic brain and mind relation that has not been supported by centuries of scientific research. An important missing link that could help transcend such dualistic notions is the understanding of the pathophysiological mechanisms by which cognitive and emotional factors such as attention or distress could cause bodily symptoms of the sort seen in functional disorders. The aims of the present study, as outlined below, fall within this remit.

One subset of functional neurological disorder are functional movement disorders (FMD), in which the critical symptoms relate to movement (e.g.dystonia, tremor). A key feature that distinguishes patients with FMD from those with “organic” movement disorders is that the FMD requires attention to manifest: when attention is distracted there is typically a reduction, even disappearance of the movement disorder (4). Conversely, patients spend significantly more time directly looking at their affected limb during clinical examination compared to patients with organic tremor, suggesting a role for self-directed visual attention in generation of motor symptoms (5).

Despite previous clinical and research interest in potential abnormalities in the allocation and maintenance of attention, most studies on FMD have thus far focused on how attention is allocated to exteroceptive signals about the state of the body, i.e. visual or tactile signals (6). To our knowledge, no study has focused on the ability of patients with FMD to pay attention to signals arising from within the body, namely to interoceptive signals. Interoception can be defined as the perception of sensations relating to the physiological condition of the body, including those related to the function of internal organs, such as heart beat, or, respiration (7). Given the proposed important role of interoception for emotion (8), the study of FMD patients’ ability to monitor their interoceptive signals may serve as a useful, mechanistic link between studies that aim to identify key emotional factors in FMD, and those that examine specific sensorimotor or cognitive abnormalities.

We employed a well-validated and widely used method of measuring cardiac awareness (9-10). The heartbeat detection task is a procedure in which participants are asked to mentally tack (count silently) their heartbeats during rest, while their heart rate is also objectively measured. The level of concordance between one’s heart rate and its subjective perception is considered as a relatively stable trait of ‘interoceptive sensitivity’, a proxy for interoceptive and emotional awareness more generally. Individuals with higher interoceptive sensitivity are reported to experience more intense emotional experiences (11) and to show higher activation of brain areas thought to play a key role in emotional processing (insular cortex, anterior cingulate cortex (ACC), ventro-medial and dorsolateral prefrontal cortex (PFC) and the somatosensory cortex) (12).

In addition, various psychopathologies relating to emotion, such as depression that has high comorbidity with FMD, have been associated with abnormalities in interoceptive sensitivity (13-16). Moreover, interoceptive sensitivity has been linked to wider, multisensory representations of the body in both experimental (17-18) and clinical studies. For example, patients with somatoform and eating disorders have been found to show reduced levels of interoceptive sensitivity (19-21). Conversely, improvements in cardiac awareness have been linked with reduction of distress associated with somatic symptoms in these disorders (22). Thus, in this study we were interested to explore whether patients with FMD have altered interoceptive awareness in relation to controls, as measured ‘objectively’ with the aforementioned mental tracking method. Although the validity of this method has been recently challenged (e.g. Ring et al., 2015), the brevity of the task and its non-threatening nature renders it an ideal task for a first exploration of this topic in FMD patients, indicating whether future studies are warranted to apply additional control procedures and more thorough and lengthily measures in this population.

Furthermore, interoceptive sensitivity has been found to be negatively correlated with alexithymia (23), the ability to identify and describe one’s emotions (24). There are also some indications that patients with alexithymia show altered activation of brain structures involved in the processing of interoceptive signals (mainly cingulate cortex and insula) (25-26). As we have recently reported that patients with FMD have higher rates of alexithymia than patients with organic movement disorders or healthy controls (27), in the current study we were also interested to explore whether interoceptive awareness, as measured ‘objectively’ with the aforementioned mental tracking method was predictive of levels of alexithymia in the same population and in healthy controls.

Depression is one of the most common psychiatric comorbidities of FMD (28-29). In this study, we excluded individuals with major concomitant psychiatric disorders, including depression, but given that altered interoceptive awareness has been associated with mild to moderate depressive symptoms, particularly in healthy individuals and in subclinical samples (30-31), we also examined whether interoceptive sensitivity was predictive of concomitant depressive symptomatology in both groups. Finally, given recent suggestions that interoceptive awareness, the perception of the body from within, is negatively correlated with an appearance-based perception of the body (self-objectification) (32), we also examined whether interoceptive sensitivity was predictive of self-objectification in FMD patients and healthy controls.

We hypothesised that patients with FMD would have lower interoceptive sensitivity than healthy controls (HC) and such lower sensitivity would predict higher levels of alexithymia, depression and self-objectification, especially in the FMD group. Overall, we envisioned that such investigations could provide some insight into potential emotional abnormalities in patients with FMD at a more mechanistic level than studies concentrating on traumatic life events and related risk factors.

**Materials and Methods**

*Participants*

We recruited 17 consecutive patients with FMD from the movement disorder outpatient clinics at National Hospital for Neurology and Neurosurgery. Inclusion criteria were age > 18 years, a diagnosis of clinically established FMD according to Fahn and Williams criteria (33). Patients with any major concurrent neurological, cardiac or psychiatric disorders were excluded. One patient was subsequently excluded as an outlier he scored more than 2 SD above the groups mean on the heart beat detection task (see below) and there were indications that he did not follow instructions during the task. Predominant symptoms in the final sample (N = 16) included tremor (N = 5), fixed dystonia (N = 4), spasms (N = 4), tic-like/jerky movements (N = 2) and weakness (N = 2) with a mean symptom duration prior to the study of 7±6.9 years. Full clinical data are presented in Table 1.

------ Insert Table 1 about here --------

Eighteen healthy individuals, matched for age, gender and BMI, were also recruited and served as a control group. Individuals with a history of any major concurrent neurological, cardiac or psychiatric disorders were excluded. One individual was excluded as she failed to comply with the instructions of the main heart beat detection task (see below). In the final sample (N = 17), twelve were women and five were men. Full demographic data for both groups and comparisons between the groups are shown in Table 2. Patients and healthy controls gave written, informed consent. Institutional ethics approval was obtained and the experiment was conducted in accordance with the Declaration of Helsinki.

------ Insert Table 2 about here --------

*Procedure*

After arriving at the laboratory, participants’ body weight and height were obtained and they completed a questionnaire regarding socio-demographic and clinical information, where applicable. Items included age, educational level, current and former illness, medications taken and, for the patients, information on disease onset, progression and duration, as well as a description of symptoms. The experimental procedures and the self-report measures (see below) were conducted in a soft-lighted, sound-attenuated room. Self-report measures were administered last.

*Heart Beat Detection Task*

Participants were seated, with their wrists gently resting on the band of a heart rate monitor, which was located on a table in front of them. They underwent a ‘Heartbeat Perception Task’, which was performed according to the protocol described by Schandry (9). This task has good test–retest reliability (up to .81) and correlates highly with other heartbeat detection tasks (34). Heart rate was recorded with a Polar wrist worn heart rate monitor (model RS 800 CX), as in (35). Participants were first asked to sit quietly and relax without speaking for 30 s before the task started and they were then asked to count their heartbeats silently. They were asked to concentrate only on their heartbeats and were not permitted to take their pulse or to attempt any other physical manipulations, which could facilitate detection. There were three such counting phases lasting for 25 s, 35 s, and 45 s and separated by 30 s rest periods. The order of the phases was randomized between participants of each group. The ‘start’ and ‘stop’ signals of each counting phase were provided by the experimenter. After each stop signal, participants had to verbally report the number of counted heartbeats. Participants were informed neither about the length of the counting phases, nor about their performance.

*Self-report Measures*

The Toronto Alexithymia Scale (TAS-20; 36) was used as a measure of alexithymia. The TAS-20 is the most commonly used self-report measurement of alexithymia (36), with demonstrated good reliability and factorial validity (37). The scale consists of 20 items rated on a 5-point scale, anchored at ‘1 = strongly disagree’ to ‘5 = strongly agree’, with a total score ranging from 20 to 100. Three sub-scores can also be calculated but these were not used in the current study due to the relatively small sample sizes and related power issues. Higher scores indicate greater alexithymia. A total score of above 61 is considered the cut off score for alexithymia based on studies on the general population (36).

The Self-Objectification Questionnaire (SOQ) (38) was used to examine the degree to which participants experienced their body on the basis of observable, appearance-based (objectified) aspects versus non-observable, competence-based aspects. Participants are required to rank 10 body attributes by how important each is to their own physical self-concept, from 0 (for least impact) to 9 (greatest impact). Five of the attributes refer to appearance-based attributes (e.g. physical attractiveness) and five competence-based attributes (e.g. energy level). Scores could range from −25 to +25 with higher scores indicating a greater tendency to view one's body in terms of appearance-related attributes. The measure has been shown to have sufficient convergent validity and high test-retest reliability (r= .92; 38).

Our samples did not include any individual with severe clinical depression (see exclusion criteria above) but as altered interoceptive awareness has been associated with mild to moderate depressive symptoms (see Introduction), depressive symptoms were evaluated using the commonly used Montgomery Asberg Depression Rating Scale (MADRS) (39). The scale has been shown to have good psychometric properties in the original study, as well as several subsequent investigations (40-43). The scale includes 10 items measuring core symptoms and features of depression. These features are rated on a scale from 0-6, with 60 as the maximum and with higher scores indicating greater depression. A score greater than 30 or 35 on the MADRS indicates severe depression in most studies (43).

**Statistical analysis**

The accuracy of heartbeat perception (termed interoceptive sensitivity, IS) was calculated as the mean score of three heartbeat perception intervals according to the following transformation (8):

1/3 ∑ [(1- (|recorded heartbeats – counted heartbeats| / recorded heartbeats)].

Using this formula, the IS score can vary between 0 and 1, with higher scores indicating smaller differences between recorded and perceived heartbeats (i.e. more accuracy, or higher IS).

All analyses were conducted in Stata 13 (StataCorp, 2013). Non-parametric tests, corrected for multiple comparisons using the Bonferroni method, were used to compare demographic and psychometric characteristics of the two groups, as the data were not normally distributed. All reported results are based on two-tailed p values. Correlations between interoceptive awareness measures, and other psychometric variables were conducted using Spearman bivariate correlations, corrected for multiple comparisons, as above.

To investigate the relationship between group classification and IS, we conducted a simple linear regression on the IS scores with group (dummy-coded) as the regressor. To investigate which facets of FMD symptomatology were explained by the relation between IS and group, we conducted separate multiple linear regressions on MADRS depression scores, TAS-20 alexithymia scores and SOQ self-objectification scores. IS and group were the regressors, and we included the IS by group interaction term in each model. Interactions were followed up by examining the significance of the slopes within each group. Given correlations among psychometric variables, we controlled for TAS-20 scores in the analyses on MADRS depression scores and for MADRS scores in the analyses on TAS-20 and SOQ scores. Continuous variables were centred to avoid multicollinearity issues otherwise inherent in regression models. Finally, due to the aforementioned distribution issues we conducted these multiple regressions using non-parametric bootstrapping estimation (1000 repetitions), which does not make distributional assumptions on the data. We thus report bootstrapped standard errors and confidence intervals below.

**Results**

*Group Characteristics*

Age and BMI did not differ significantly between the groups although FMD patients were older than the control individuals, with a higher BMI (see Table 2). Gender ratio was also not significantly different between the groups (Chi-square test). The FMD patients were significantly more depressed than the control group, although no patient scored above the cut-off (total score of 30) for severe, clinical depression. The FMD patients were also more alexithymic than the control group, with six FMD patients and two healthy controls scoring above the cut-off (total score of 61), but the difference between the groups showed only a trend towards significance. Finally, no significant differences were observed between the groups in self-rated, body objectification.

*Correlations between Interoceptive Awareness and Other Variables*

Spearman’s bivariate correlations, conducted in each group separately to examine the relation between interoceptive sensitivity and the other psychometric variables (i.e., MADRS depression scores, TAS-20 alexithymia scores and SOQ self-objectification scores) revealed no significant correlations (see Table 3). However, when pooling participants across groups (N = 33) to increase statistical power, we observed a significant correlation between interoceptive sensitivity and MADRS depression scores (see Table 3).

---------Insert table 3 about here-----

*Regression Analyses*

When investigating the relationship between group classification and IS, Group was a significant predictor of IS (b = .15, SE = .07, p = .026, 95% CI [.02, .27]). As expected, patients showed lower IS (M = .50, SE = .05) than healthy controls (M = .65, SE = .04).

When investigating whether IS in interaction with group, and controlling for MADRS depression scores, predicted TAS-20 scores, we found that scores on the TAS-20 were not explained by IS (b = 10.50, SE = 22.18, p = .636, 95% CI [-32.98, 53.98]), group (b = .49, SE = 4.87, p = .919, 95% CI [-9.06, 10.05]) or their interaction (b = -11.22, SE = 28.16, p = .690, 95% CI [-66.41, 43.97]), while MADRS scores significantly predicted TAS-20 scores; the higher the depression score, the higher the alexithymia score (b = 1.41, SE = .37, p < .001, 95% CI [.69, 2.15]).

When investigating whether IS in interaction with group, and controlling for TAS-20 scores, predicted MADRS depression scores, IS and group emerged as significant predictors of MADRS depression scores (b = -21.40, SE = 9.17, p = .020, 95% CI [-39.37, -3.44] and b = -5.92, SE = 2.17, p = .006, 95% CI [-10.18, -1.67], respectively). In addition, there was a marginally significant interaction of interoceptive awareness and group on MADRS depression scores (b = 19.32, SE = 10.30, p = .061, 95% CI [-.87, 39.50]), although confidence intervals included zero. Following up this effect revealed that for patients (p = .020) but not for controls (p = .640), lower IS predicted higher depression scores. Lastly, TAS-20 scores also significantly predicted MADRS scores (b = .19, SE = .07, p = .005, 95% CI [.06, .33]) .

Finally, when investigating whether interoceptive awareness in interaction with group, controlling for MADRS depression scores, predicted SOQ self-objectification scores, IS emerged as a significant predictor (b = -44.46, SE = 16.94, p = .009, 95% CI [-77.66, -11.26]), while group did not (b = -1.18, SE = 4.74, p = .803, 95% CI [-10.48, 8.12]). However, there was a significant interaction between Group and IS, (b = 38.98, SE = 19.45, p = .045, 95% CI [.85, 77.11]). Following up this interaction, it was found that for patients (p = .009), but not for controls (p = .611), lower IS predicted higher self-objectification. Lastly, MADRS scores did not predict SOQ scores, (b = -.38, SE = .35, p = .273, 95% CI [-1.07, .30]).

**Discussion**

This study investigated the role of interoceptive awareness in functional motor disorders (FMD) and frequent concomitant symptoms such as alexithymia and sub-clinical depression. Interoceptive awareness was assessed objectively by means of a commonly used and well-validated heartbeat perception task, leading to estimates of interoceptive sensitivity (IS). Alexithymia and depression were assessed by self-report measures. The role of IS on reported, self-objectification (the tendency to perceive the body based on its outward physical appearance with less emphasis on inner body experiences) (44) was also investigated in exploratory analyses. As hypothesised, people with FMD showed lower IS compared to an age and BMI matched group of healthy controls. They were also found to report more depressive symptoms on average than the healthy controls and to be marginally more alexithymic. However, performance of the IS task was not associated with alexithymia scores within or across groups, even when controlling for other critical factors such as depression. By contrast, depression scores showed an overall negative relation with IS across groups, and IS was found to predict depressive symptomatology in the FMD patients, but not the controls. Finally, although self-objectification and IS scores did not show an overall association between or within groups, IS was predictive of self-objectification in the FMD but not the healthy control group in regression analyses.

Taken together our findings suggest that patients with FMD may show reduced awareness of internal body signals, this is a trait that may be related to some of their concomitant non-motor symptoms, such as sub-clinical, depressive and self-objectification tendencies. There is increasing evidence for the associaton between IS and sub-clinical depression (14,23,30,31) and even major depression disorder (15,16,30,45). For example, recent studies have found that patients with major depression disorder show lower IS, even when anxiety symptoms are controlled for (16). Moreover, lower performance on the IS task has been associated with reduced heartbeat evoked potentials (HEPs) in depressed individuals, an EEG measure that is thought to provide an objective correlate of interoceptive processing (15). Our findings are consistent with these studies, showing that lower performance on the IS task was marginally predictive of sub-clinical depression symptomatology in FMD patients, but not control subjects. These results suggest that IS contributes to deficits in emotional processing, known to be associated with depression and other related psychopathologies (30). This data however cannot inform the question of how these emotional difficulties relate specifically to symptom formation and maintenance in people with FMD.

In this respect, it is of interest that our results further demonstrate that even when controlling for depression in the regression analyses, IS still represents a significant predictor of self-objectification, especially in individuals with FMD. To our knowledge, no study has examined the role of self-objectification in FMD, or any related functional (psychogenic), or, somatoform disorder. However, a negative correlation between interoceptive sensitivity as measured by the same cardiac awareness task and self-objectification has been recently demonstrated in healthy controls (32), as well as patients with anorexia nervosa (20). More generally, it has been proposed that self-objectification is a risk factor for eating disorders; the preoccupation with the outside appearance of the body may use up some of the valuable resources needed for interoceptive awareness, so that these individuals become less aware of their own internal conditions, including emotional cues and bodily states such as hunger and satiety (46). Several psychometric studies have confirmed the association between self-objectification and eating disorders and more recently, interoceptive awareness has been found to actually mediate the relationship between self-objectification and disordered eating (47-48).

Given previous findings in FMD regarding the excessive attentional focus on the ‘exteroceptive’ state of the body (see Introduction), the current results warrant further investigation of the relationship between interoceptive awareness, self-objectification and symptomatology. On this regard, it will be interesting in future studies to investigate the hypothesis that, similarly to patients with eating disorders, individuals with FMD may dedicate great attention to their bodily symptoms as perceived from the outside, because they have limited ability to perceive the internal states of the body and vice versa.

Finally, contrary to our hypothesis, IS in FMD patients does not seem to relate to their degree of alexythimia, even when the effects of depression are controlled for. This finding is suprising, as IS has been previously negatively correlated with alexithymia (23) and FMD patients show high rates of alexithymia (27). Our findings will need to be replicated in larger FMD groups with higher degrees of alexithymia, and greater gender balance (23) before firm conclusions can be drawn. However, they do raise the possibility that in FMD patients alexithymia is not primarily caused by low awareness into one’s inner signals, but may instead be driven by other general factors such as depression (depression and alexithymia were found to predict each other in our entire sample), anxiety (see also below), or factors pertaining to the particular syndrome. For example, in previous studies, we have proposed that these patients are able to perceive signals of high autonomic arousal triggered during a (physical, or psychosocial) precipitating event, but they do not interpreted them as such. Instead, they misattribute them to a somatic illness (27). Thus, future, larger studies could explore whether this misattribution of sudden changes in the intensity of inner signals, versus the habitual reduced perception of inner signals themselves (as described above), are related to alexithymia in this population.

Our study had a number of limitations. First, it should be noted that although we excluded major, psychiatric disorders from our sample, we did not assess the prevalence of sub-clinical anxiety symptoms in our groups and anxiety might be a confounding factor for both alexithymia and depression (16). Second, although the TAS-20 is a well-validated and widely used instrument, the assessment of alexithymia on the basis of any self-reported scale might be not appropriate, as alexithymic patients are not very self-reflective (49). This limitation may also relate to the relatively low scores of alexithymia reported here. Third, most people with FMD in our sample were medicated, which could have biased the results. However, we do note that previous studies have not found differences in heartbeat perception between medicated and non-medicated depressed patients (15,45). Moreover, we did not assess differences in resting heart rate, heart rate variability, time estimation and regular physical activity that may have influenced the IS results, although a number of studies have not found differences in such variables between similar clinical groups and healthy controls (15,16,30). Another limitation is that no unequivocal conclusions can be drawn regarding the causal mechanisms of the relationship between IS and the FMD symptomatology, as our study was cross-sectional and it did not involve manipulations of IS. The last point is particularly important as despite the wide-use of heartbeat counting tasks, there is also accumulating evidence (e.g. Ring & Brener, 1996; Windmann et al., 1999; Ring et al, 2015) that performance on the HB counting task may not be equivocally indicative of interoceptive sensitivity and additional control measures, such as participants beliefs about heart rate, need to be taken account before firm conclusions on the relation between clinical symptomatology and interoceptive awareness can be drawn. Finally, an increased sample with a balanced gender ratio could allow comparisons between men and women, which we could not address in the present study and generally allow greater power for the exploration of more specific, directional hypotheses regarding the relationship between some of the tested variables, as well as additional clinical variables such as symptom duration and severity.

In conclusion, this study provides first indications for the possibility that FMD patients have lower interoceptive sensitivity than healthy subjects, and such reduced interoceptive sensitivity may be predictive of their depressive symptoms, as well as their tendency to focus on the external features of their body. These results warrant further investigation of interoceptive awareness in this population, as a means to understand their emotional abnormalities at a more mechanistic level than studies concentrating on traumatic life events and related risk factors.

**Acknowledgements**

A.F. was supported by a European Research Council Starting Investigator Award (ERC-2012-STG GA313755).

We thank the staff and patients of the participating clinics.

**References**

1. Hoover CF. A new sign for the detection of malingering and functional paresis of the lower extremities. JAMA1908; 51:746–7.
2. Hallett M, Fahn S, Jankovic J, et al. editors. Psychogenic movement disorders.Neurology and neuropsychiatry. Philadelphia: AAN Press, Lippincott Williams & Wilkins; 2006.
3. [Roelofs K](http://www.ncbi.nlm.nih.gov/pubmed?term=Roelofs%20K%5BAuthor%5D&cauthor=true&cauthor_uid=17728032), [Spinhoven P](http://www.ncbi.nlm.nih.gov/pubmed?term=Spinhoven%20P%5BAuthor%5D&cauthor=true&cauthor_uid=17728032). Trauma and medically unexplained symptoms towards an integration of cognitive and neuro-biological accounts. Clin Psychol Rev. 2007; 27(7): 798-820.
4. Schwingenschuh P, Katschnig P, Seiler S, et al. Moving toward ‘laboratory-supported’ criteria for psychogenic tremor. Mov Disord 2011; 26:2509–2515.
5. van Poppelen D, Saifee TA, Schwingenschuh P, et al. Attention to self in psychogenic tremor. Mov Disord 2011; 26:2575–2576.
6. Edwards MJ, Fotopoulou A. Parees I. Neurobiology of functional (psychogenic) movement disorders. Curr Opin Neurol. 2013 Aug; 26(4): 442–447.
7. Craig, AD. How do you feel? Interoception: The sense of the physiological condition of the body. Nature Reviews. Neuroscience. 2002; 3: 655–666.
8. Damasio AR. Descartes’ Error: Emotion, Reason, and the Human Brain. 1994.
9. Schandry R. Heart beat perception and emotional experience. Psychophysiology. 1981 Jul; 18(4):483-8.
10. Pollatos O, and Schandry R. Accuracy of heartbeat perception is reflected in the amplitude of the heartbeat-evoked brain potential. Psychophysiology. 2004; 41, 476–482.
11. Wiens S, Mezzacappa E, Katkin ES. Heartbeat detection and the experience of emotions. Cog & Emotion. 2000; 14 (3): 417–427.
12. Critchley HD, Wiens S, Rotshtein P, et al. Neural systems supporting interoceptive awareness. Nat Neurosci. 2004;7(2):189-95.
13. Pollatos, O., Traut-Mattausch, E. and Schandry, R. Differential effects of anxiety and depression on interoceptive accuracy. Depress. Anxiety. 2009; 26: 167–173.
14. Dunn BD, Stefanovitch I, Evans D, et al. [Can you feel the beat? Interoceptive awareness is an interactive function of anxiety- and depression-specific symptom dimensions](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2964892/). Behav Res Ther. 2010; 48 (11): 1133–1138.
15. [Terhaar J](http://www.ncbi.nlm.nih.gov/pubmed/?term=Terhaar%20J%5BAuthor%5D&cauthor=true&cauthor_uid=22541740), [Viola FC](http://www.ncbi.nlm.nih.gov/pubmed/?term=Viola%20FC%5BAuthor%5D&cauthor=true&cauthor_uid=22541740), [Bär KJ](http://www.ncbi.nlm.nih.gov/pubmed/?term=B%C3%A4r%20KJ%5BAuthor%5D&cauthor=true&cauthor_uid=22541740), et al. Heartbeat evoked potentials mirror altered body perception in depressed patients. Clin Neurophysiol. 2012;123 (10):1950-7.
16. [Furman DJ](http://www.ncbi.nlm.nih.gov/pubmed/?term=Furman%20DJ%5BAuthor%5D&cauthor=true&cauthor_uid=23972662), [Waugh CE](http://www.ncbi.nlm.nih.gov/pubmed/?term=Waugh%20CE%5BAuthor%5D&cauthor=true&cauthor_uid=23972662), [Bhattacharjee K](http://www.ncbi.nlm.nih.gov/pubmed/?term=Bhattacharjee%20K%5BAuthor%5D&cauthor=true&cauthor_uid=23972662), et al. Interoceptive awareness, positive affect, and decision making in major depressive disorder. J Affect Disord. 2013; 151(2): 780-5.
17. Tsakiris M, Tajadura-Jiménez A, and Costantini M. Just a heartbeat away from one’s body: interceptive sensitivity predicts the malleability of body-representations. Proc. Biol. Sci. 2011;278, 2470–2476.
18. [Suzuki K](http://www.ncbi.nlm.nih.gov/pubmed/?term=Suzuki%20K%5BAuthor%5D&cauthor=true&cauthor_uid=23993906), [Garfinkel SN](http://www.ncbi.nlm.nih.gov/pubmed/?term=Garfinkel%20SN%5BAuthor%5D&cauthor=true&cauthor_uid=23993906), [Critchley HD](http://www.ncbi.nlm.nih.gov/pubmed/?term=Critchley%20HD%5BAuthor%5D&cauthor=true&cauthor_uid=23993906), et al. Multisensory integration across exteroceptive and interoceptive domains modulates self-experience in the rubber-hand illusion. Neuropsychologia. 2013; 51 (13):2909-17.
19. Mussgay L; Klinkenberg N. Rüddel H. Heart beat perception in patients with depressive, somatoform, and personality disorders. Journal of Psychophysiology, 1999; 13(1): 27-36.
20. Pollatos O, Kurz AL, Albrecht J, et al. [Reduced perception of bodily signals in anorexia nervosa.](http://www.ncbi.nlm.nih.gov/pubmed/18928900) Eat Behav. 2008;9 (4):381-8.
21. [Schaefer M](http://www.ncbi.nlm.nih.gov/pubmed/?term=Schaefer%20M%5BAuthor%5D&cauthor=true&cauthor_uid=22642840), [Egloff B](http://www.ncbi.nlm.nih.gov/pubmed/?term=Egloff%20B%5BAuthor%5D&cauthor=true&cauthor_uid=22642840), [Witthöft M](http://www.ncbi.nlm.nih.gov/pubmed/?term=Witth%C3%B6ft%20M%5BAuthor%5D&cauthor=true&cauthor_uid=22642840). Is interoceptive awareness really altered in somatoform disorders? Testing competing theories with two paradigms of heartbeat perception. J Abnorm Psychol. 2012; 121(3): 719-24.
22. [Schaefer M](http://www.ncbi.nlm.nih.gov/pubmed/?term=Schaefer%20M%5BAuthor%5D&cauthor=true&cauthor_uid=25038304), [Egloff B](http://www.ncbi.nlm.nih.gov/pubmed/?term=Egloff%20B%5BAuthor%5D&cauthor=true&cauthor_uid=25038304), [Gerlach AL](http://www.ncbi.nlm.nih.gov/pubmed/?term=Gerlach%20AL%5BAuthor%5D&cauthor=true&cauthor_uid=25038304) et al. Improving heartbeat perception in patients with medically unexplained symptoms reduces symptom distress. Biol Psychol. 2014; 101: 69-76.
23. Herbert BM, Herbert C, and Pollatos O. On the relationship between interoceptive awareness and alexithymia: is interoceptive awareness related to emotional awareness? J. Pers. 2011; 79, 1149–1175.
24. Sifneos PE. The prevalence of 'alexithtymic' characteristic mechanisms in psychosomatic patients. Psychother Psychosom. 1973; 21:133–136.
25. Berthoz S, Artiges E, Van De Moortele PF et al. [Effect of impaired recognition and expression of emotions on frontocingulate cortices: an fMRI study of men with alexithymia.](http://www.ncbi.nlm.nih.gov/pubmed/12042184) Am J Psychiatry. 2002; 159 (6):961-7.
26. [Kano M](http://www.ncbi.nlm.nih.gov/pubmed/?term=Kano%20M%5BAuthor%5D&cauthor=true&cauthor_uid=12764066), Fukudo S, Gyoba J, et al. Specific brain processing of facial expressions in people with alexithymia: an H2 15O-PET study. Brain. 2003; 126 (6): 1474-8.
27. [Demartini B](http://www.ncbi.nlm.nih.gov/pubmed/?term=Demartini%20B%5BAuthor%5D&cauthor=true&cauthor_uid=24610939), [Petrochilos P](http://www.ncbi.nlm.nih.gov/pubmed/?term=Petrochilos%20P%5BAuthor%5D&cauthor=true&cauthor_uid=24610939), [Ricciardi L](http://www.ncbi.nlm.nih.gov/pubmed/?term=Ricciardi%20L%5BAuthor%5D&cauthor=true&cauthor_uid=24610939). The role of alexithymia in the development of functional motor symptoms (conversion disorder). J Neurol Neurosurg Psychiatry. 2014; 85(10): 1132-7.
28. Gelauff J, Stone J, Edwards M et al. The prognosis of functional (psychogenic) motor symptoms: a systematic review. J Neurol Neurosurg Psychiatry. 2014; 85(2): 220-6.
29. Binzer M, Andersen PM, Kullgren G. Clinical characteristics of patients with motor disability due to conversion disorder: a prospective control group study. J Neurol Neurosurg Psychiatry. 1997; 63 (1):83-8.
30. Dunn BD, Dalgleish T, Ogilvie AD,et al. Heartbeat perception in depression. Behaviour Research and Therapy. 2007; 45:1921–1930.
31. Pollatos O, Traut-Mattausch E, Schandry R. Differential effects of anxiety and depression on interoceptive accuracy. Depression and Anxiety. 2009; 26:167–173.
32. [Ainley V](http://www.ncbi.nlm.nih.gov/pubmed/?term=Ainley%20V%5BAuthor%5D&cauthor=true&cauthor_uid=24021852), [Maister L](http://www.ncbi.nlm.nih.gov/pubmed/?term=Maister%20L%5BAuthor%5D&cauthor=true&cauthor_uid=24021852), [Brokfeld J](http://www.ncbi.nlm.nih.gov/pubmed/?term=Brokfeld%20J%5BAuthor%5D&cauthor=true&cauthor_uid=24021852). More of myself: manipulating interoceptive awareness by heightened attention to bodily and narrative aspects of the self. Conscious Cogn. 2013; 22(4): 1231-8.
33. Fahn S, Williams DT. Psychogenic dystonia. Adv Neurol 1988; 50: 431–55.
34. Knoll JF, Hodapp V. A comparison between two methods for assessing heartbeat perception. Psychophysiology 1992; 29: 218–222.
35. [Crucianelli L](http://www.ncbi.nlm.nih.gov/pubmed/?term=Crucianelli%20L%5BAuthor%5D&cauthor=true&cauthor_uid=24115938), [Metcalf NK](http://www.ncbi.nlm.nih.gov/pubmed/?term=Metcalf%20NK%5BAuthor%5D&cauthor=true&cauthor_uid=24115938), [Fotopoulou AK](http://www.ncbi.nlm.nih.gov/pubmed/?term=Fotopoulou%20AK%5BAuthor%5D&cauthor=true&cauthor_uid=24115938) et al. Bodily pleasure matters: velocity of touch modulates body ownership during the rubber hand illusion. Front Psychol. 2013; 8: 4:703.
36. Bagby RM, Taylor GJ, Parker JD. The twenty-item Toronto Alexithymia Scale-II: convergent, discriminant, and concurrent validity. J Psychosom Research 1994; 38: 33-40.
37. Taylor GJ, Bagby RM, Parker JDA. The Twenty-Item Toronto Alexithymia Scale-IV: Reliability and factorial validity in different languages and cultures. Journal of Psychosomatic Research. 2003; 55: 277-283.
38. Fredrickson BL, Roberts TA, Noll SM, et al. That swimsuit becomes you: sex differences in self-objectification, restrained eating, and math performance. J Pers Social Psychol 1998; 75(1): 269–84.
39. Montgomery SA, Äsberg M. A new depression scale designed to be sensitive to change. Br. J. Psychiatry. 1979; 134:382–389.
40. Davidson J, Turnbull CD, Strickland R, et al. The Montgomery-Asberg Depression Scale: reliability and validity. Acta Psychiatr Scand. 1986; 73: 544– 8.
41. Maier W, Philipp M, Heuser I, et al. Improving depression severity assessment: I. reliability, internal validity and sensitivity to change of three observer depression scales. J Psychiatr Res. 1988; 22: 3– 12.
42. Williams JBW and Kobak KA. Development and reliability of a structured interview guide for the Montgomery–Åsberg Depression Rating Scale (SIGMA). The British Journal of Psychiatry. 2008; 192 (1) 52-58.
43. Cusin C, Yang H, Yeung A, et al. Rating Scales for Depression. In: L. Baer, M.A. Blais (eds.), Handbook of Clinical Rating Scales and Assessment in Psychiatry and Mental Health, Humana Press. 2010; 7-35.
44. Citrin LB, Roberts FA, and Fredrickson BL, Objectification Theory and Emotions. In [The Social Life of Emotions](http://ebooks.cambridge.org/ebook.jsf?bid=CBO9780511819568) A Feminist Psychological Perspective on Gendered Affect. Edited by Larissa Z. Tiedens   and Colin Wayne Leach. 2004: 203-224. Cambridge University Press.
45. Mussgay, L, Klinkenberg, N and Rüddel, H. Heartbeat perception in patients with depressive, somatoform, and personality disorders. Journal of Psychophysiology. 1999; 13, 27–36
46. Fredrickson, B. L., & Roberts, T.A. Objectification theory: Toward understanding women's lived experiences and mental health risks. Psychology of Women Quarterly. 1997; 21, 173-206.
47. Myers, TA and Crowther, JH. Is self-objectification related to interoceptive awareness? An examination of potential mediating pathways to disordered eating attitudes.  Psychology of Women Quarterly. 2008; 32, 172-180.
48. Peat CM, Muehlenkamp JJ. Self-objectification, disordered eating, and depression: A test of mediational pathways. Psychol Women Q. 2011; 35 (3) 441–450.
49. Ricciardi L, Demartini B, Fotopoulou A, et al. [Alexithymia in Neurological Disease: A Review.](http://www.ncbi.nlm.nih.gov/pubmed/25658681) J Neuropsychiatry Clin Neurosci. 2015. Feb 6.