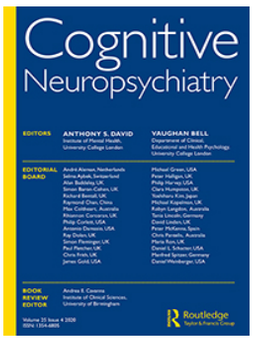

Cognitive Neuropsychiatry

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/pcnp20

Dissociation and interoception in functional neurological disorder

Susannah Pick, Maya Rojas-Aguiluz, Morgan Butler, Heather Mulrenan, Timothy R. Nicholson & Laura H. Goldstein

To cite this article: Susannah Pick, Maya Rojas-Aguiluz, Morgan Butler, Heather Mulrenan, Timothy R. Nicholson & Laura H. Goldstein (2020) Dissociation and interoception in functional neurological disorder, Cognitive Neuropsychiatry, 25:4, 294-311, DOI: 10.1080/13546805.2020.1791061

To link to this article: https://doi.org/10.1080/13546805.2020.1791061

© 2020 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

View supplementary material

Published online: 08 Jul 2020.

Submit your article to this journal

Article views: 2964

View related articles

View Crossmark data

Citing articles: 6 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=pcnp20

COGNITIVE NEUROPSYCHIATRY
2020, VOL. 25, NO. 4, 294–311
https://doi.org/10.1080/13546805.2020.1791061

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Dissociation and interoception in functional neurological disorder

Susannah Pick[a], Maya Rojas-Aguiluz[a], Morgan Butler[a], Heather Mulrenan[b], Timothy R. Nicholson[a] and Laura H. Goldstein[a]

[a]Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK; [b]GKT School of Medical Education, King's College London, London, UK

ABSTRACT

Introduction: We aimed to examine susceptibility to dissociation and the impact of dissociation on interoceptive processing in individuals with functional neurological disorder (FND). We hypothesised that dissociative states would be elevated and interoceptive accuracy and awareness impaired at baseline in people with FND, and that such differences would be exacerbated following acute dissociation.

Methods: Nineteen adults with FND were compared to 20 healthy controls. A modified heart-beat tracking task measured interoceptive accuracy and awareness (confidence) before and after a validated dissociation induction procedure. An exteroceptive processing control task was included. Mann–Whitney tests and *r*-values (effect size) were computed for between-group comparisons.

Results: The FND group displayed elevated dissociation at baseline ($p = 0.001$, $r = 0.528$) compared to controls which increased following dissociation-induction ($p < 0.001$, $r = 0.663$). Interoceptive accuracy did not differ between groups at baseline ($p = 0.967$, $r = 0.009$); however, the FND group had lower accuracy scores post-induction ($p = 0.021$, $r = 0.379$). A negative correlation (trend) between change scores for dissociation and interoceptive accuracy was noted ($r_s = -0.411$, $p = 0.057$). Confidence ratings on interoceptive and exteroceptive processing tasks were lower in the FND group (*p*-values < 0.05 or <0.01, *r*-values 0.331–0.489).

Conclusions: Individuals with FND experienced greater susceptibility to dissociation, metacognitive deficits and impaired interoceptive accuracy than controls after acute dissociation.

ARTICLE HISTORY
Received 21 March 2020
Accepted 29 June 2020

KEYWORDS
psychogenic non-epileptic seizures; dissociation; metacognition; dissociative; interoception

Introduction

Functional neurological disorder (FND) is defined by the presence of motor and sensory symptoms (e.g., seizures, paralysis, movement disorder, anaesthesia) that are not caused by identifiable neurological disease and that exhibit distinct clinical features that are

CONTACT Susannah Pick susannah.pick@kcl.ac.uk
Supplemental data for this article can be accessed https://doi.org/10.1080/13546805.2020.1791061

© 2020 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (http://creativecommons.org/licenses/by-nc-nd/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

inconsistent with other medical or neurological diagnosis (American Psychiatric Association, 2013). FND often results in severe and/or chronic symptoms with considerable impact on patients' psychosocial functioning and quality of life, in addition to significant health and social care costs (Carson & Lehn, 2017). Whilst explanatory models of the disorder are continually evolving, there is accumulating evidence suggesting important roles for altered cognitive processing of bodily signals (Edwards et al., 2012; Van den Bergh et al., 2017) and dissociation (Brown et al., 2007; Pick et al., 2017).

Dissociation in FND

Dissociation can be defined as an involuntary or automatic loss of integration between usually integrated mental processes, which can include altered awareness and control of memory, identity, movement, sensation, and affect (World Health Organisation, 1992). The broad concept of dissociation refers to a range of phenomena including depersonalisation, derealisation, emotional numbing, absorption, memory and identity impairments, in addition to bodily symptoms (i.e., "somatoform" dissociation) (Nijenhuis et al., 1996). The notion of dissociation as an underlying mechanism of FND originated in the work of Pierre Janet (1907) and persists in current international classification in which the term "dissociative neurological symptom disorder" is used (World Health Organization, 2018), in contrast to DSM-5 (i.e., "functional neurological symptom disorder" categorised in somatic symptom disorders).

There is a significant literature on the relationship between dissociation and FND. Many studies have reported the presence of elevated dissociative symptoms in FND samples using validated self-report scales (Brown et al., 2007; Goldstein & Mellers, 2006; Pick et al., 2017). A recent meta-analysis showed that the mean Dissociative Experiences Scale (Bernstein & Putnam, 1986) score for FND samples was comparable to that of depersonalisation-derealisation, borderline personality and post-traumatic stress disorders (Lyssenko et al., 2018). Moreover, other dissociative disorders (e.g., dissociative identity, dissociative disorder not otherwise specified, dissociative amnesia) and FND are frequently comorbid, suggesting shared risk factors (e.g., adverse life events, hypnotic susceptibility) and mechanisms (Brown et al., 2007). For example, SCID-D diagnosed dissociative disorders have been reported in 37% (Yayla et al., 2015) and 47% (Şar et al., 2004) of mixed symptom FND samples, and 50% (Bailles et al., 2004) and 91% (Bowman & Markand, 1996) of dissociative seizures samples.

Despite the evidence for elevated rates of dissociative symptoms and disorders in FND and proposals that dissociation is a core underlying mechanism in the disorder, there have been no previous studies examining susceptibility to dissociative states in controlled environments and few studies exploring how dissociative states affect other FND symptom-related processes. As dissociative states often involve alterations in the subjective experience of the bodily self (e.g., emotional numbing, out-of-body experiences), it is plausible that a predisposition towards dissociation in individuals with FND could contribute to the occurrence or severity of FND symptoms, mediated by its deleterious effects on somatic awareness (i.e., interoception) and control. As dissociative symptoms tend to fluctuate over time, it is probable that the causal influence of dissociation on FND symptoms would be most likely to occur under conditions that evoke or intensify dissociative states.

Interoception in FND

Contemporary predictive coding models have proposed that dysfunction of interoceptive processing contributes to the generation of FND and functional symptoms more generally (Van den Bergh et al., 2017). Yet, there have been only a small number of studies examining interoceptive differences in FND samples, all assessing cardiac interoceptive accuracy with the heartbeat tracking task (Schandry, 1981). Several of these studies reported reduced accuracy for heartbeat tracking in FND samples, including those with functional motor (Demartini et al., 2019; Ricciardi et al., 2016), seizure (Yogarajah et al., 2019) or mixed FND symptoms (Williams et al., 2019). Another study found no differences on the heartbeat tracking task in patients with dissociative seizures relative to controls (Jungilligens et al., 2019). Nevertheless, the broader literature indicates the presence of transdiagnostic interoceptive deficits in several disorders that share aetiological and phenomenological features with FND, including somatoform disorders (Bogaerts et al., 2008; Pollatos et al., 2011a, 2011b) and depression (Paulus & Stein, 2010; Pollatos et al., 2009).

Existing studies in FND have focused primarily on interoceptive accuracy without examination of interoceptive awareness (metacognitive evaluation of performance) or interoceptive sensibility (self-reported trait interoceptive abilities). Only one study (Yogarajah et al., 2019) examined interoceptive awareness, with findings suggesting impairments which correlated with self-reported (trait) dissociative experiences. Additional research is needed to elucidate the precise nature of interoceptive differences in FND samples and to examine how interoceptive processing relates to other relevant features of the disorder. Given the established evidence for elevated dissociation in FND and the conceptualisation of FND as a dissociative disorder in ICD-10, we sought to explore whether dissociative states might have a direct influence on interoception in this group.

Aims and hypotheses

There were three overall aims of this study. Firstly, we sought to examine in more detail dissociative experiences in individuals with FND by assessing susceptibility to state dissociation in the laboratory, using a previously validated dissociation induction manipulation (mirror-gazing). We assessed state dissociation using an established self-report measure (Clinician Administered Dissociative States Scale, CADSS; Bremner et al., 1998) immediately before and after the induction procedure. We tested the hypothesis that the FND group would report heightened dissociative symptoms at baseline relative to healthy controls, and that this difference would be greater following the dissociation induction.

The second aim was to assess several interoceptive processes in the same FND sample. We assessed interoceptive accuracy and awareness using a heartbeat tracking task, in which participants were asked to count their heartbeats for specified periods of time and report the number of beats perceived (accuracy) and the confidence in these reports (awareness). We hypothesised that the FND group would demonstrate reduced accuracy and lower confidence at baseline, compared to healthy controls. We also measured interoceptive sensibility using an existing self-report questionnaire to assess self-perceived trait-level interoceptive abilities (Multidimensional Assessment of

Interoceptive Awareness, MAIA; Mehling et al., 2018). As interoceptive sensibility has not been assessed in detail in FND samples before, we were unable to make specific predictions about the nature of potential group differences on this measure.

A final and central aim of the study was to assess whether acute dissociative states had a direct causal effect on interoceptive accuracy and awareness in the FND group. We examined this by administering the heartbeat tracking task immediately before and after the dissociation induction manipulation. We tested the hypothesis that induction of an acute dissociative state would cause an exacerbation of interoceptive impairments in the FND group, compared to healthy controls.

Exploratory analyses were conducted with the additional aims of examining whether dissociative states and interoception task performance were associated with important clinical and background characteristics of the FND sample, including autonomic arousal (skin conductance levels), and self-reported physical symptom severity, adverse life events, psychological distress (anxiety, depression) and (trait) interoceptive sensibility. It was predicted that elevated state dissociation would be associated with higher scores on background measures of adverse life events, psychological distress (anxiety, depression), physical symptoms, and reduced interoceptive accuracy/awareness in the FND group.

Materials and methods

Participants

Ethical approval was obtained from the King's College London Psychiatry, Nursing and Midwifery Research Ethics Committee (HR-18/19-10998). Twenty people with FND were recruited through advertisements distributed through patient support organisations (FND Hope, FND Action). Individuals with motor, seizure or sensory FND symptoms were eligible, as were those with multiple FND symptoms. Participants with FND provided evidence of the diagnosis with medical documentation, reviewed by a consultant neuropsychiatrist with FND expertise (TRN).

The comparison group consisted of 20 healthy control participants, recruited through advertisements on local community websites (e.g., Facebook groups). Each participant was reimbursed £25 for completing the study, as an expression of gratitude and to assist with any travel expenses incurred.

All participants were fluent in English, between 18–65 years old, had normal or corrected eyesight, and had no self-reported major psychiatric (e.g., psychosis, substance or alcohol dependence), neurological (e.g., stroke, multiple sclerosis) or cardiovascular (e.g., heart disease) diagnoses. Any participants taking medications that had a potential impact on cardiovascular functioning (e.g., beta-blockers) or attention and concentration (e.g., heavy dose/multiple opioids) were excluded, as were candidates with pacemakers.

We asked participants if they had any knowledge of their own heart rate (e.g., from wearable electronic devices, doctor visits, etc) and categorised their responses dichotomously (i.e., yes/no). Body mass index (BMI) was calculated on the basis of participants' self-reported height and weight. These factors were recorded because they can potentially influence performance on the heart-beat tracking task (Herbert & Pollatos, 2014; Ring & Brener, 1996).

Design

A mixed factorial design was adopted. The between-groups variable was clinical status (FND, non-clinical controls) and the within-groups variable was timepoint (baseline, post-induction).

The dependent variables were:

- state dissociation (pre- and post-induction)
- state positive and negative affect (pre- and post-induction)
- interoceptive accuracy (pre- and post-induction)
- interoceptive awareness (pre- and post-induction)
- skin conductance levels (baseline, pre-induction interoception task, dissociation-induction, post-induction interoception task)

Self-report measures

The following measures were administered at baseline:

- Traumatic Experiences Checklist (TEC) (Nijenhuis et al., 1999): assessed the presence/absence and subjective impact of 29 potentially traumatic life events, yielding a total number of traumatic events and an average impact score
- Multidimensional Assessment of Interoceptive Awareness (MAIA) (Mehling et al., 2018): 32 items assessed aspects of bodily awareness, including seven subscales (Noticing, Not-Distracting, Not-Worrying, Attention Regulation, Emotional Awareness, Self-Regulation, Body Listening, Trusting)
- Patient Health Questionnaire—9 (PHQ-9) (Kroenke et al., 2001): nine items assessed severity of depression, based on DSM-IV criteria
- Extended Patient Health Questionnaire—15 (PHQ-15) (Carson et al., 2015): 28 items assessed common somatic and neurological symptoms, each of which is rated as present/absent and a total score calculated (scale adapted from Kroenke et al., 2002)
- General Anxiety Disorder—7 (GAD-7) (Spitzer et al., 2006): a seven-item scale measured symptoms of general anxiety (e.g., worry, fear, arousal)

Two measures were administered immediately before and after the dissociation induction procedure (order counterbalanced) to assess task engagement and the effects of the manipulation, as follows:

- Clinician Administered Dissociative States Scale (CADSS) (Bremner et al., 1998): 28 items from the subjective scale assessed state dissociation
- Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988): 20 items measured positive and negative affective states using momentary assessment as described in the original validation of the scale

Interoception task

A modified heart-beat tracking task (Schandry, 1981) was used to measure interoceptive accuracy and awareness (Supplementary Materials), programmed and administered with

E-Prime experimental software (Psychology Software Tools, Inc). In this task, participants were asked to attend to and silently count their own heartbeats during three trials of 25, 35, and 45 s. The duration of the trials was identical for all participants but the order of the trials was randomised for each individual. The tracking trials were interspersed with 30 s rests in which participants fixated on the computer screen. The start and end of each heartbeat tracking and rest period was indicated on screen with the words "Start tracking", "Stop tracking" and "Rest". Immediately after each tracking period, participants were cued to say aloud the number of heartbeats they had counted, followed by a confidence rating (0–10, low-high certainty).

Participants wore a finger pulse transducer throughout the task, to record actual heart beats, which were recorded using a Powerlab data acquisition system and online LabChart software (v6.0, ADInstruments). Participants were explicitly asked not to attempt to monitor the passing of time by counting seconds. A practice trial was completed by all participants before starting the experimental procedures. In total, the duration of the task was approximately 5–10 min for all participants (including instructions, questions and practice trial).

Interoceptive accuracy was calculated using the following formula:

$$\frac{1}{3}\sum(1-(|\text{actual heart-beats}-\text{perceived heart-beats}|)/\text{actual heart-beats})$$

Dissociation-induction procedure

A mirror-gazing procedure (Caputo, 2010; Shin et al., 2019) was used to induce dissociative states. A large mirror was placed approximately 0-2-0.4 metres away from the participant, in a dimly lit testing room. An experimenter (MB) first provided the participant with instructions and answered any questions. The participant was then asked to sit quietly and gaze into the mirror for 10 min. The experimenter remained present throughout to monitor participants' wellbeing and compliance with the protocol but had no interaction with the participant. The mirror-gazing procedure has been shown to induce mild dissociation and is well tolerated in non-clinical samples (Brewin & Mersaditabari, 2013; Shin et al., 2019).

Cognitive tests

- National Adult Reading Test (NART) (Nelson, 1982): a 50-item reading test for English speakers, providing estimated standardised intelligence quotient scores (baseline).
- Shape counting task (Supplementary Materials): a simple computerised counting task followed identical procedures as the heart-beat tracking task, but participants were asked to count briefly presented geometric shape stimuli (star, triangle, square) presented on the screen at different rates (randomised stimulus duration 50–750msecs; randomised inter-trial interval 200–1000msecs). This was a control task to assess the influence of attention, concentration and task engagement, programmed and delivered with E-Prime software.

Skin conductance level measurement

Skin conductance levels (SCL) were recorded using the Powerlab/LabChart system, calibrated for each participant to detect a range from 0–50 microSiemens (μS). The procedures were identical to those described in a previous study (Pick et al., 2018).

Procedure

All activities took place in a quiet testing room at the Institute of Psychiatry, Psychology and Neuroscience. The research session lasted approximately 90–120 min on average. The detailed procedures are shown in Box 1 (Supplementary Materials).

Data processing & analysis

Skin conductance levels

Any time points including clear noise/movement artefact were excluded from analysis (reviewed by two raters: MH, MRA). Mean skin conductance levels (SCLs) were extracted for the following timepoints: (resting) baseline, interoception task (pre- and post-induction), dissociation induction (mirror-gazing).

Statistical analyses

The Kolmogorov–Smirnov test was used to assess normality of distribution for each variable. Most variables did not conform to an approximately normal distribution in one or both groups; therefore, non-parametric tests were used for most comparisons. Categorical variables were analysed with Pearson's chi-square or Fisher's exact tests. Continuous variables were analysed with Mann–Whitney U or independent samples t-tests tests, and respective *r*-values were computed for effect size as described in Field (2013). Exploratory Spearman's correlations assessed relationships between key experimental variables (state dissociation, interoception) and potentially relevant background and clinical variables. In accordance with Cohen (Cohen, 1992), the following effect size magnitudes for interpretation of *r*-values are reported: <0.1 negligible, 0.1–0.29 small, 0.3–0.49 medium, ≥0.5 large.

Where multiple tests were conducted on related variables (i.e., subscales of questionnaires, dependent variables in the experimental tasks), Bonferroni adjustments (0.05 / # tests) to (criterion) alpha values are reported to examine the influence of familywise error inflation on significance testing. Alpha values were not adjusted in the exploratory correlational analyses; however, effect sizes are presented to show the strength of the correlations (r_s values).

Results

Participant characteristics

One participant from the FND group was excluded from all analyses due to multiple outlying scores on several tests and failure to complete the experimental protocol. Table 1 displays the characteristics of the remaining participants. The groups were matched for gender, estimated IQ scores, handedness, and self-reported knowledge of own heart rate; however, the FND group were significantly older than controls, had a higher body

Table 1. Participant characteristics.

	FND ($n = 19$)	Controls ($n = 20$)	Test statistic	p
Age (years): Mdn (IQR)	44 (20)	27 (9.8)	$U = 96$	0.008
Female: *n* (%)	15 (79)	16 (80)	–	1.0 (Fisher's)
Right handedness: *n* (%)	16 (84)	16 (80)	–	$p = 1.0$ (Fisher's)
Estimated IQ: median (IQR)	117.7 (7.6)	117.8 (3.9)	$t = -0.06$	0.953
BMI: mean (SD)	28.8 (5.6)	24.3 (4.1)	$t = -2.88$	0.007
Knowledge of heart rate: *n* (%)	5 (26)	5 (25)	–	1.0 (Fisher's)
Physical health diagnosis: *n* (%)	15 (79)	3 (15)	–	<0.001 (Fisher's)
Mental health diagnosis: *n* (%)	13 (68)	1 (5)	–	<0.001 (Fisher's)
Medication: *n* (%)	15 (79)	6 (30)	$X^{2} = 0.39$	0.002
Anti-asthmatic	6 (32)			
Contraceptive		2 (10)		
Antidepressant	10 (53)	1 (5)		
Dietary supplement	6 (32)	1 (5)		
Anxiolytic	4 (21)			
NSAID	1 (5)	1 (5)		
Levothyroxine	1 (5)	1 (5)		
Antibiotic	1 (5)			
Anti-spasmodic	1 (5)			
Anti-muscarinic	1 (5)			
Opiate analgesic	2 (10)			
Paracetamol	1 (5)			
AED	6 (32)			
PPI	4 (21)			
EAI	1 (5)			
Anti-constipation	3 (16)			
Triptan	2 (10)			
Hypnotic	1 (5)			
Immunosuppressant	1 (5)			
Botox	1 (5)			
Most severe FND symptom: *n* (%)	Weakness/paralysis = 4 (21) Seizures = 5 (25) Sensory (bodily) = 5 (25) Movement disorder = 1 (5) Speech/swallow = 1 (5) Cognitive = 4 (20)			
FND duration (months): Mdn (IQR)	48 (58)			
Duration FND diagnosis (months): Mdn (IQR)	13 (38)			

Key: AED = anti-epileptic drug; BMI = body mass index; EAI = epinephrine auto-injector; FND = functional neurological disorder; IQ = intelligence quotient; IQR = interquartile range; Mdn = median; NSAID = non-steroidal anti-inflammatory drug; PPI = proton pump inhibitor; SD = standard deviation

mass index (BMI), were more likely to be taking medication, and to report the presence of current comorbid physical and mental health diagnoses.

Background/clinical measures

Compared to controls, the FND group reported significantly more adverse life experiences (TEC total scores), greater subjective impact of these experiences (TEC impact), and elevated scores on the PHQ-9 (depression), GAD-7 (generalised anxiety), and the extended PHQ-15 (physical/neurological symptoms) (Table 2).

Interoceptive sensibility

Lower scores on the "Not-Distracting" and "Trusting" subscales of the MAIA in the FND sample relative to controls suggested a greater tendency towards distracting from or avoiding

Table 2. Scores on background and clinical self-report measures.

	FND ($n = 19$) Mdn (IQR)	Controls ($n = 20$) Mdn (IQR)	U	p	r
TEC total events (0–29)	5.5 (8)	3 (3.8)	85	0.003*	0.476
TEC subjective impact (1–5)	3.8 (1.6)	3 (1.0)	95.5	0.007*	0.426
PHQ-9 (0–27)	13 (10.5)	1.5 (2)	26.5	<0.001	0.738
GAD-7 (0–21)	11 (13.5)	2 (4)	59.5	<0.001	0.590
Extended PHQ-15 (0–23)	14 (8.3)	2 (4.5)	26	<0.001	0.739
MAIA (0–5)					
Noticing	3.5 (1.5)	2.8 (1.9)	138.5	0.149	0.233
Not-distracting	1.3 (1.3)	3 (1.6)	61	<0.001*	0.582
Not-worrying	2.7 (1.7)	3.3 (1.3)	156	0.351	0.154
Attention regulation	2.4 (1.3)	2.9 (1.4)	160.5	0.411	0.133
Emotional awareness	3.4 (1.0)	3.1 (2.5)	136.5	0.134	0.241
Self-regulation	3 (1.3)	2.4 (1.4)	158	0.380	0.144
Body listening	2.3 (1.3)	2 (2.2)	145	0.214	0.204
Trusting	1.7 (3)	3.7 (1.8)	80.5	0.002*	0.495

Key: GAD-7 = Generalised Anxiety Disorder-7; IQR = interquartile range; MAIA = Multidimensional Assessment of Interoceptive Awareness; Mdn = median; PHQ = Patient Health Questionnaire; TEC = Traumatic Experiences Checklist.
*Remained significant with Bonferroni corrections (TEC adjusted alpha for two tests = 0.025; MAIA adjusted alpha for eight tests = 0.006).

aversive bodily experiences, alongside a reduced subjective experience of the body as safe, predictable and trustworthy (Table 2). These differences survived Bonferroni correction.

State dissociation and affect

The FND group had significantly higher total CADSS scores than controls at pre- and post-induction, indicating elevated dissociation throughout with large effect sizes (Table 3). However, the magnitude of the difference was greater post-induction. At baseline, scores were greater in the FND group for all three CADSS subscales, including derealisation ($U = 87$, $p = 0.003$, $r = 0.51$), depersonalisation ($U = 112.5$, $p = 0.028$, $r = 0.393$) and amnesia ($U = 66$, $p < 0.001$, $r = 0.652$). Although the significance for the depersonalisation subscale did not survive Bonferroni correction (adjusted alpha for three tests = 0.017), the effect size was medium. Post-induction scores on all three subscales were greater in the FND group, with all three being highly significant ($p < 0.001$) with large effect sizes (r values: derealization = 0.639; depersonalization = 0.61; amnesia = 0.624). The greatest change from pre–post induction in the FND group was on the depersonalisation subscale.

The groups did not differ significantly in PANAS positive affect scores at either timepoint. In contrast, the FND group reported significantly greater negative affect than controls at baseline and post-induction, although the difference was more marked post-

Table 3. State dissociation (CADSS) and affect (PANAS) statistics.

	FND ($n = 19$)	Controls ($n = 20$)	Test statistic	p	r
Baseline CADSS: Mdn (IQR)	6 (8.5)	0 (1)	$U = 78.5$	0.001[a]	0.528
Post-induction CADSS: Mdn (IQR)	9.5 (15.8)	1.5 (3)	$U = 43.5$	<0.001[a]	0.663
Baseline PANAS Positive: Mean (SD)	28.4 (5.3)	28.4 (9.1)	$t = -0.013$	0.989	0.002
Post-induction PANAS Positive: Mean (SD)	20.3 (6.6)	24.5 (11.4)	$t = 1.42$	0.167	0.248
Baseline PANAS Negative: Mdn (IQR)	13 (4.25)	10 (1)	$U = 90.5$	0.004*	0.469
Post-induction PANAS Negative: Mdn (IQR)	15 (6.5)	10 (0.75)	$U = 42.5$	<0.001*	0.699

Key: CADSS = Clinician Administered Dissociative State Scale; FND = functional neurological disorder; IQR = interquartile range; Mdn = median; PANAS = Positive and Negative Affect Schedule; SD = standard deviation.
[a]Remained significant with Bonferroni corrections (adjusted alpha for two tests with CADSS scores = 0.025).
*Remained significant with Bonferroni corrections (adjusted alpha for four tests with PANAS scores = 0.013).

induction (medium and large effect sizes respectively). The reported differences remained significant after Bonferroni adjustment. Total CADSS and PANAS negative affect scores were correlated positively at all time points in the FND group (r_s values = 0.421–0.795). Age was not significantly associated with CADSS scores at either timepoint.

Interoception task

Post-induction interoception task data were unavailable for three of the 19 FND participants due to technical problems with heartbeat recording ($n = 2$) and logistical issues i.e., patient unavailability ($n = 1$).

There was no significant between-group difference in interoceptive accuracy at baseline; however, the FND group displayed reduced interoceptive accuracy post-induction relative to controls (Table 4). This difference survived Bonferroni correction and represented a medium effect size. The FND group gave significantly lower confidence ratings on the interoception task at baseline and post-induction, with medium effect sizes at both timepoints, although the significance did not survive correction for multiple comparisons at baseline.

A non-significant trend indicated a moderate negative correlation between change scores (post-induction minus baseline) for interoceptive accuracy and CADSS in the FND group, suggesting that greater elevation in state dissociation was associated with more marked reduction in interoceptive accuracy ($r_s = -0.411$, $p = 0.057$). No such relationship was observed for the control group ($r_s = -0.159$, $p = 0.252$). There were no significant associations between interoceptive accuracy change scores and age, BMI or negative affect in either group.

Shape counting task

There were no significant between-group differences in shape counting accuracy scores at pre- or post-induction, with both groups performing well on the task (Table 5). The FND group reported less confidence on the shape counting task at both timepoints, with medium effect sizes and significance surviving Bonferroni adjustment.

Skin conductance levels

The SCL data were not normally distributed; however, a square root transformation normalised the data in both groups (untransformed values in Supplementary Materials). A

Table 4. Interoception task: accuracy and confidence.

Median (IQR)	*n*	FND	Controls	*U*	*p*	*r*
Baseline accuracy (0–1)	FND = 19 HC = 20	0.84 (0.32)	0.85 (0.37)	188	0.967	0.009
Post-induction accuracy (0–1)	FND = 16 HC = 20	0.55 (0.4)	0.8 (0.31)	88.5	0.021*	0.379
Baseline confidence (0–10)	FND = 19 HC = 20	4.5 (6.94)	7 (3.42)	116.5	0.038	0.331
Post-induction confidence (0–10)	FND = 16 HC = 20	3.99 (4.25)	7.67 (2.92)	68	0.003*	0.489

Key: FND = functional neurological disorder; HC = healthy control; IQR = interquartile range; *n* = number of participants.
*Remained significant with Bonferroni corrections (adjusted alpha for two tests each for accuracy and confidence scores = 0.025).

Table 5. Shape counting task: accuracy and confidence

Median (IQR)	*n*	FND	Controls	*U*	*p*	*r*
Baseline accuracy (0–1)	FND = 19 HC = 20	1 (0.02)	0.99 (0.03)	167.5	0.531	0.110
Post-induction accuracy (0–1)	FND=16 HC = 20	0.99 (0.02)	0.99 (0.02)	157	0.937	0.017
Baseline confidence (0–10)	FND = 19 HC = 20	7.99 (3.25)	9 (1.92)	89	0.004*	0.458
Post-induction confidence (0–10)	FND = 16 HC = 20	7.17 (3.5)	8.83 (2.67)	87.5	0.02*	0.386

Key: FND = functional neurological disorder; HC = healthy control; IQR = interquartile range; *n* = number of participants.
*Remained significant with Bonferroni corrections (adjusted alpha for two tests each for accuracy and confidence scores = 0.025).

mixed factorial ANOVA with the square root transformed SCL values revealed a highly significant main effect of time (F (2.097, 73.4) = 54.6, $p < 0.001$, np2 = 0.610), with mean SCL values rising at each timepoint in both groups. Average SCL values were greater in the FND group at all timepoints; however, the main effect of group was not significant (F (1, 35) = 1.05, $p = 0.312$, np2 = 0.029) and there was no significant interaction between group and time (F (2.097, 73.4) = 0.66, $p = 0.527$, np2 = 0.018). Neither anxiety (GAD-7) nor depression (PHQ-9) scores were significant covariates of SCL. There were no significant correlations between SCLs at any time point and interoceptive accuracy or CADSS change scores.

Exploratory analyses

State dissociation and background/clinical features

Total CADSS scores were correlated positively with the following features in the FND group: anxiety (GAD-7; pre-induction $r_s = 0.625$, $p = 0.04$; post-induction $r_s = 0.562$, $p = 0.012$), depression (PHQ-9; pre-induction $r_s = 0.513$, $p = 0.025$), number of traumatic life experiences (TEC total; pre-induction $r_s = 0.563$, $p = 0.012$; post-induction $r_s = 0.456$, $p = 0.05$), impact of traumatic experiences (TEC impact; pre-induction $r_s = 0.562$, $p = 0.012$; post-induction $r_s = 0.564$, $p = 0.012$), and physical symptom severity (extended PHQ-15; pre-induction $r_s = 0.603$, $p = 0.006$). However, CADSS total change scores were not significantly associated with any of these features. There were no other significant relationships between CADSS scores and any other background or clinical variable in the FND group.

Interoception and background/clinical features

Strong negative correlations (Spearman's rho) were noted between MAIA "Trusting" and PHQ-9 ($r_s = -0.560$, $p = 0.013$), GAD-7 ($r_s = -0.649$, $p = 0.003$), PHQ-15 ($r_s = -0.543$, $p = 0.016$), TEC total ($r_s = -0.535$, $p = 0.018$).

There were no other significant associations between background and clinical features and the following variables in the FND group specifically: interoceptive accuracy change scores, pre-induction interoceptive accuracy and confidence (awareness), post-induction interoceptive accuracy and confidence, MAIA subscale scores.

Potential influence of reduced FND sample post-induction

Given that the FND sample was reduced to 16 participants post-induction, the baseline analyses for CADSS, interoception and shape counting tasks were rerun including only the same 16 FND participants (Supplementary Materials). The pattern of findings were the same as the baseline analyses including all 19 FND participants on most variables. The only difference in findings was in interoceptive confidence ratings, which were no longer significantly different between groups with the reduced sample, although a moderate effect size was still observed ($p = 0.067$, $r = 0.308$).

Discussion

The study aimed to examine further the relevance and interactions of dissociation and interoceptive dysfunction in FND by assessing interoceptive accuracy and awareness before and after experimental induction of a dissociative state in a mixed symptom FND sample. The findings showed elevated susceptibility to dissociation and generalised metacognitive deficits in the FND sample, in addition to the providing the first evidence of a direct effect of acute dissociation on interoceptive accuracy in this population.

Susceptibility to dissociation

Elevated state dissociation and greater susceptibility to dissociation induction was observed in the FND group (elevated CADSS scores at both timepoints), with the difference being larger after the induction procedure. These findings corroborate previous assertions that dissociative tendencies are a significant difficulty for many with the diagnosis (Brown et al., 2007; Pick et al., 2017). The fact that the greatest post-induction change was observed on the CADSS depersonalisation subscale indicated that people with FND are susceptible to both detachment and compartmentalisation phenomena (Brown et al., 2007; Holmes et al., 2005). There were positive associations between total TEC scores (adverse life events) and state dissociation scores in the FND group. Together, these findings accord with previous studies showing elevations in a range of dissociative symptoms in FND samples and a relationship between dissociative symptoms and other relevant risk factors in this group (Goldstein & Mellers, 2006; Hendrickson et al., 2015; Lyssenko et al., 2018; Pick et al., 2017). In future studies, it would be of interest to examine FND patients' qualitative descriptions of acute dissociative states, to explore further the phenomenology of these experiences.

The observation of clear relationships between state dissociative symptoms and negative affect, general psychological distress, and physical symptom severity in this FND sample highlights the potential importance of dissociative symptoms for symptom burden and outcomes in this disorder.

Interoceptive accuracy and sensibility

We observed no impairment in interoceptive accuracy in the FND group at baseline, which contrasted with some previous studies (Demartini et al., 2019; Ricciardi et al., 2016; Williams et al., 2019; Yogarajah et al., 2019), but concurred with another (Jungilligens et al., 2019). Reasons for these differences could include divergent sampling strategies

and other methodological differences. For example, studies have included different FND symptom types, disparate approaches to controlling for psychiatric comorbidities, variable consideration of other possible confounds (e.g., BMI, medication, knowledge of heart rate), and several studies may have had limited statistical power due to small sample sizes.

Despite the lack of interoceptive accuracy impairments observed at baseline in our sample, the experimental dissociation induction procedure resulted in a significant impairment in the FND group. This finding, along with the negative correlation between state dissociation (CADSS) and interoceptive accuracy change scores, indicate that the induced dissociative state caused directly the reduction in interoceptive accuracy in the FND group. These results support the proposal that dissociation could be a key mechanistic process underlying altered subjective awareness of bodily sensations in FND, and thus might directly contribute to the generation or exacerbation of FND symptoms.

Interestingly, in this study, whilst elevated negative affect was reported by the FND group pre- and post-induction (more marked at the latter timepoint), this was not associated with significantly elevated autonomic arousal (SCLs), highlighting the possible presence of interoceptive impairments and replicating previous findings of discordant subjective and autonomic affective responses (Pick et al., 2019).

Regarding interoceptive sensibility, scores on the MAIA only revealed two key differences in self-perceived interoceptive processes in the FND group. The FND group reported being more likely to distract from or ignore unpleasant bodily sensations (i.e., lower scores on the "Not-distracting" subscale), which could potentially be a predisposing or maintaining factor in FND, or could be a consequence of the disorder. Another key difference was on the "Trusting" subscale, showing that the FND sample perceived their bodies as less trustworthy and safe than the control group. The negative correlation between Trusting and TEC total scores suggested that this experience of the body as unsafe and untrustworthy could be linked to predispositional factors and thus potentially predated the onset of symptoms.

Metacognitive awareness

Confidence ratings were lower in the FND group relative to controls on both the interoception and exteroception control tasks, both pre- and post-induction. Given that performance was unimpaired on the interoception task at baseline and on the exteroception task at both timepoints, these findings point towards a generalised deficit in metacognitive awareness, specifically an underestimation of performance. There have been proposals that metacognitive impairments are a core deficit in at least some forms of FND (Bègue et al., 2018; Bhome et al., 2019), although well powered rigorous empirical studies supporting this are lacking. One study, for example, provided evidence for differences in patterns of neural activation during confidence judgements on a visuomotor task in participants with functional motor symptoms, but did not reveal behavioural metacognitive deficits (Bègue et al., 2018). Matthews et al. (2020) similarly did not observe behavioural evidence of metacognitive impairment on a visual perception task in participants with functional motor symptoms. The present findings provide some preliminary behavioural evidence to support the view that metacognition may be compromised in FND.

Potential clinical implications

This study has several clinical implications. Interventions aimed at identification and management of dissociative experiences could be valuable in this group, particularly involving controlled exposure to dissociation-inducing stimuli, in combination with grounding and body- or emotion-focused techniques. Examples of existing treatments that may include some of these features are eye movement desensitisation and reprocessing (Cope et al., 2019) and mindfulness-based therapies (Baslet et al., 2020).

Furthermore, therapeutic interventions emphasising awareness and control of bodily processes more generally could improve interoceptive abilities in this population. Possible approaches for improving bodily awareness include body awareness therapy, body-oriented psychotherapy and alternative interventions (e.g., yoga, tai-chi) (Mehling et al., 2011). Finally, the present findings support the proposal that treatments aimed at addressing metacognitive deficits could be beneficial in this group (Bhome et al., 2019).

Strengths and limitations

Key strengths of the study were the use of a novel approach for examining dissociative tendencies in FND (dissociation induction), the assessment of several measures of interoception, inclusion of a cognitive control task, and the first examination of the influence of dissociative states on interoception in this population. The inclusion of patients with a range of common FND symptoms enhanced the generalisability of the findings. The exclusion of several comorbid disorders and medications that could have affected task performance was also a helpful aspect of the study design.

The study had some limitations. The relatively small sample size and requirement to use non-parametric statistical tests limited the power to detect significant effects. Nevertheless, we have presented effect size values to compensate for this weakness. The inclusion of individuals with varied FND symptoms in the same sample may have obscured potential differences between FND subgroups, although it should be noted that all the participants in the FND group had more than one symptom type. The coincidental group difference in age was a potential confound; however, we did not observe any significant correlations between age and the experimental dependent variables in either group.

The presence of comorbid physical and mental health diagnoses and the use of psychotropic medications (i.e., antidepressants, anxiolytics) in the FND sample may have influenced the findings. Scores on measures of anxiety and depression were elevated in the FND group, but neither anxiety nor depression correlated significantly with interoception task performance.

It cannot be definitively concluded that there were no comorbid neurological diagnoses in the FND sample, because we did not include a detailed clinical assessment by a member of the research team. However, the diagnosis was confirmed by relevant medical documentation and two of the authors (SP and TRN) scrutinised this carefully to minimise the possibility of misdiagnosis or neurological comorbidity. Whilst it is a strength that we assessed BMI and participants' knowledge of their heart rate, these variables were based on self-reported information so it is possible that there may have been inaccuracies. Finally, the lack of a clinical (neurological, psychiatric) control group potentially limits the specificity of the findings.

Conclusions

This study suggests that individuals with FND display greater susceptibility to dissociative states than controls and that acute dissociation results in impaired interoceptive accuracy in this group. It is therefore possible that dissociation may contribute to the generation or exacerbation of FND symptoms via its detrimental effects on interoceptive processing. The results provide preliminary evidence for a generalised deficit in metacognitive awareness across both interoceptive and exteroceptive processing tasks. More research is needed to examine the relevance and impact of dissociation, interoceptive and metacognitive difficulties in this population and to explore potential clinical implications.

Acknowledgements

We thank FND Hope UK and FND Action for their assistance with advertising the study to their members, and all participants for their involvement.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.) (DSM-5).

Bailles, E., Pintor, L., Fernandez Egea, E., Torres, X., Matrai, S., de Pablo, J., & Arroyo, S. (2004). Psychiatric disorders, trauma, and MMPI profile in a Spanish sample of nonepileptic seizure patients. *Gen Hosp Psychiatry*, *26*(4), 310–315. https://doi.org/10.1016/j.genhosppsych.2004.04.003.

Baslet, G., Ehlert, A., Oser, M., & Dworetzky, B. A. (2020). Mindfulness-based therapy for psychogenic nonepileptic seizures. *Epilepsy & Behavior*, *103*, 106534. https://doi.org/10.1016/j.yebeh.2019.106534

Bègue, I., Blakemore, R., Klug, J., Cojan, Y., Galli, S., Berney, A., Aybek, S., & Vuilleumier, P. (2018). Metacognition of visuomotor decisions in conversion disorder. *Neuropsychologia*, *114*, 251–265. https://doi.org/10.1016/j.neuropsychologia.2018.04.018

Bernstein, E. M., & Putnam, F. W. (1986). Development, reliability, and validity of a dissociation scale. *The Journal of Nervous and Mental Disease*, *174*(12), 727–735. https://doi.org/10.1097/00005053-198612000-00004

Bhome, R., McWilliams, A., Huntley, J. D., Fleming, S. M., & Howard, R. J. (2019). Metacognition in functional cognitive disorder- a potential mechanism and treatment target. *Cognitive Neuropsychiatry*, *24*(5), 311–321. https://doi.org/10.1080/13546805.2019.1651708

Bogaerts, K., Millen, A., Li, W., De Peuter, S., Van Diest, I., Vlemincx, E., Fannes, S., & Van den Bergh, O. (2008). High symptom reporters are less interoceptively accurate in a symptom-related context. *Journal of Psychosomatic Research*, *65*(5), 417–424. https://doi.org/10.1016/j.jpsychores.2008.03.019

Bowman, E. S., & Markand, O. N. (1996). Psychodynamics and psychiatric diagnoses of pseudoseizure subjects. *American Journal of Psychiatry*, *153*(1), 57–63. https://doi.org/10.1176/ajp.153.1.57

Bremner, J. D., Krystal, J. H., Putnam, F. W., Southwick, S. M., Marmar, C., Charney, D. S., & Mazure, C. M. (1998). Measurement of dissociative states with the clinician-administered dissociative states scale (CADSS). *Journal of Traumatic Stress*, *11*(1), 125–136. https://doi.org/10.1023/A:1024465317902

Brewin, C. R., & Mersaditabari, N. (2013). Experimentally-induced dissociation impairs visual memory. *Consciousness and Cognition*, *22*(4), 1189–1194. https://doi.org/10.1016/j.concog.2013.07.007

Brown, R. J., Cardeña, E., Nijenhuis, E., Sar, V., & van der Hart, O. (2007). Should conversion disorder be reclassified as a dissociative disorder in DSM V? *Psychosomatics*, *48*(5), 369–378. https://doi.org/10.1176/appi.psy.48.5.369

Caputo, G. B. (2010). Strange-face-in-the-mirror illusion. *Perception*, *39*(7), 1007–1008. https://doi.org/10.1068/p6466

Carson, A., & Lehn, A. (2017). Epidemiology. *Handbook of Clinical Neurology*, *139*, 47–60. https://doi.org/10.1016/B978-0-12-801772-2.00005-9

Carson, A. J., Stone, J., Hansen, C. H., Duncan, R., Cavanagh, J., Matthews, K., Murray, G., & Sharpe, M. (2015). Somatic symptom count scores do not identify patients with symptoms unexplained by disease: A prospective cohort study of neurology outpatients. *Journal of Neurology, Neurosurgery, and Psychiatry*, *86*(3), 295–301. https://doi.org/10.1136/jnnp-2014-308234

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Cope, S. R., Mountford, L., Smith, J. G., & Agrawal, N. (2019). EMDR to Treat functional neurological disorder: A review. *Journal of EMDR Practice and Research*, *12*(3), 118–132. https://doi.org/10.1891/1933-3196.12.3.118

Demartini, B., Volpe, R., Mattavelli, G., Goeta, D., D'Agostino, A., & Gambini, O. (2019). The neuromodulatory effect of tDCS in patients affected by functional motor symptoms: An exploratory study. *Neurological Sciences*, *40*(9), 1821–1827. https://doi.org/10.1007/s10072-019-03912-5

Edwards, M. J., Adams, R. A., Brown, H., Parees, I., & Friston, K. J. (2012). A Bayesian account of 'hysteria'. *Brain*, *135*(11), 3495–3512. https://doi.org/10.1093/brain/aws129

Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed). Sage.

Goldstein, L. H., & Mellers, J. D. C. (2006). Ictal symptoms of anxiety, avoidance behaviour, and dissociation in patients with dissociative seizures. *Journal of Neurology, Neurosurgery & Psychiatry*, *77*(5), 616–621. https://doi.org/10.1136/jnnp.2005.066878

Hendrickson, R., Popescu, A., Ghearing, G., & Bagic, A. (2015). Thoughts, emotions, and dissociative features differentiate patients with epilepsy from patients with psychogenic nonepileptic spells (PNESs). *Epilepsy & Behavior*, *51*, 158–162. https://doi.org/10.1016/j.yebeh.2015.07.016

Herbert, B. M., & Pollatos, O. (2014). Attenuated interoceptive sensitivity in overweight and obese individuals. *Eating Behaviors*, *15*(3), 445–448. https://doi.org/10.1016/j.eatbeh.2014.06.002

Holmes, E. A., Brown, R. J., Mansell, W., Fearon, R., Hunter, E., Frasquilho, F., & Oakley, D. A. (2005). Are there two qualitatively distinct forms of dissociation? A review and some clinical implications. *Clinical Psychology Review*, *25*(1), 1–23. https://doi.org/10.1016/j.cpr.2004.08.006

Janet, P. (1907). *The major symptoms of hysteria*. Classics of Psychiatry & Behavioral Sciences Library, Division of Gryphon Editions.

Jungilligens, J., Wellmer, J., Schlegel, U., Kessler, H., Axmacher, N., & Popkirov, S. (2019). Impaired emotional and behavioural awareness and control in patients with dissociative seizures. *Psychological Medicine*, 1–9. https://doi.org/10.1017/S0033291719002861

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2002). The PHQ-15: validity of a new measure for evaluating the severity of somatic symptoms. *Psychosomatic Medicine*, *64*(02), 258–266.

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9. *Journal of General Internal Medicine*, *16*(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Lyssenko, L., Schmahl, C., Bockhacker, L., Vonderlin, R., Bohus, M., & Kleindienst, N. (2018). Dissociation in psychiatric disorders: A meta-analysis of studies using the dissociative experiences scale. *The American Journal of Psychiatry*, *175*(1), 37–46. https://doi.org/10.1176/appi.ajp.2017.17010025

Matthews, J., Nagao, K., Ding, C., Newby, R., Kempster, P., & Hohwy, J. (2020). Raised visual contrast thresholds with intact attention and metacognition in functional motor disorder. *Cortex*, *125*, 161–174. https://doi.org/10.1016/j.cortex.2019.12.009

Mehling, W. E., Acree, M., Stewart, A., Silas, J., & Jones, A. (2018). The multidimensional assessment of interoceptive awareness, version 2 (MAIA-2). *PloS One*, *13*(12), e0208034–e0208034. https://doi.org/10.1371/journal.pone.0208034

Mehling, W. E., Wrubel, J., Daubenmier, J. J., Price, C. J., Kerr, C. E., Silow, T., Gopisetty, V., & Stewart, A. L. (2011). Body awareness: A phenomenological inquiry into the common ground of mind-body therapies. *Philosophy, Ethics, and Humanities in Medicine*, *6*(1), 6. https://doi.org/10.1186/1747-5341-6-6

Nelson, H. E. (1982). *National adult reading test (NART): For the assessment of premorbid intelligence in patients with dementia: Test manual*. Nfer-Nelson.

Nijenhuis, E. R. S., Spinhoven, P., Van Dyck, R., Van Der Hart, O., & Vanderlinden, J. (1996). The development and psychometric characteristics of the somatoform dissociation questionnaire (SDQ-20). *Journal of Nervous and Mental Disease*, *184*(11), 688–694. https://doi.org/10.1097/00005053-199611000-00006

Nijenhuis, E. R. S., van der Hart, O., & Vanderlinden, J. (1999). The traumatic experiences checklist (TEC). In E. R. S. Nijenhuis (Ed.), *Somatoform dissociation: Phenomena, measurement, and theoretical issues* (pp. 223–229). Von Gorcum.

Paulus, M. P., & Stein, M. B. (2010). Interoception in anxiety and depression. *Brain Structure & Function*, *214*(5-6), 451–463. https://doi.org/10.1007/s00429-010-0258-9

Pick, S., Goldstein, L. H., Perez, D. L., & Nicholson, T. R. (2019). Emotional processing in functional neurological disorder: A review, biopsychosocial model and research agenda. *Journal of Neurology, Neurosurgery, and Psychiatry*, *90*(6), 704–711. https://doi.org/10.1136/jnnp-2018-319201

Pick, S., Mellers, J. D. C., & Goldstein, L. H. (2017). Dissociation in patients with dissociative seizures: Relationships with trauma and seizure symptoms. *Psychological Medicine*, *47*(7), 1215–1229. https://doi.org/10.1017/S0033291716003093

Pick, S., Mellers, J. D. C., & Goldstein, L. H. (2018). Autonomic and subjective responsivity to emotional images in people with dissociative seizures. *Journal of Neuropsychology*, *12*(2), 341–355. https://doi.org/10.1111/jnp.12144

Pollatos, O., Dietel, A., Herbert, B. M., Wankner, S., Wachsmuth, C., Henningsen, P., & Sack, M. (2011a). Blunted autonomic reactivity and increased pain tolerance in somatoform patients. *Pain*, *152*(9), 2157–2164. https://doi.org/10.1016/j.pain.2011.05.024

Pollatos, O., Herbert, B. M., Wankner, S., Dietel, A., Wachsmuth, C., Henningsen, P., & Sack, M. (2011b). Autonomic imbalance is associated with reduced facial recognition in somatoform disorders. *Journal of Psychosomatic Research*, *71*(4), 232–239. https://doi.org/10.1016/j.jpsychores.2011.03.012

Pollatos, O., Traut-Mattausch, E., & Schandry, R. (2009). Differential effects of anxiety and depression on interoceptive accuracy. *Depression and Anxiety*, *26*(2), 167–173. https://doi.org/10.1002/da.20504

Ricciardi, L., Demartini, B., Crucianelli, L., Krahe, C., Edwards, M. J., & Fotopoulou, A. (2016). Interoceptive awareness in patients with functional neurological symptoms. *Biological Psychology*, *113*, 68–74. https://doi.org/10.1016/j.biopsycho.2015.10.009

Ring, C., & Brener, J. (1996). Influence of beliefs about heart rate and actual heart rate on heartbeat counting. *Psychophysiology*, *33*(5), 541–546. https://doi.org/10.1111/j.1469-8986.1996.tb02430.x

Şar, V., Akyuz, G., Kundakci, T., Kiziltan, E., & Dogan, O. (2004). Childhood trauma, dissociation, and psychiatric comorbidity in patients with conversion disorder. *American Journal of Psychiatry*, *161*(12), 2271–2276. https://doi.org/10.1176/ajp.161.12.2271

Schandry, R. (1981). Heartbeat perception and emotional experience. *Psychophysiology*, *18*(4), 483–488. https://doi.org/10.1111/j.1469-8986.1981.tb02486.x

Shin, G. I., Goldstein, L. H., & Pick, S. (2019). Evidence for subjective emotional numbing following induced acute dissociation. *Behaviour Research and Therapy*, *119*, 103407. https://doi.org/10.1016/j.brat.2019.05.004

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine*, *166*(10), 1092–1097. https://doi.org/10.1001/archinte.166.10.1092

Van den Bergh, O., Witthöft, M., Petersen, S., & Brown, R. J. (2017). Symptoms and the body: Taking the inferential leap. *Neuroscience & Biobehavioral Reviews*, *74*, 185–203. https://doi.org/10.1016/j.neubiorev.2017.01.015

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54* (6), 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063

Williams, I. A., Reuber, M., & Levita, L. (2019). 24 Relationship between interoception and stress in patients with functional neurological symptom disorder. *Journal of Neurology, Neurosurgery & Psychiatry*, *90*(Suppl 2), A11.2–A11. https://doi.org/10.1136/jnnp-2019-BNPA.24

World Health Organisation. (1992). *The ICD-10 classification of mental and behavioural disorders: Clinical descriptions and diagnostic guidelines.*

World Health Organization. (2018). *International statistical classification of diseases and related health problems* (11th ed.). https://icd.who.int/en

Yayla, S., Bakim, B., Tankaya, O., Ozer, O. A., Karamustafalioglu, O., Ertekin, H., & Tekin, A. (2015). Psychiatric comorbidity in patients with conversion disorder and prevalence of dissociative symptoms. *Journal of Trauma & Dissociation*, *16*(1), 29–38. https://doi.org/10.1080/15299732.2014.938214

Yogarajah, M., Koreki, A., Agrawal, N., Cope, S., Eilon, T., Van Praag, C. G., Garfkinel, S., Critchley, H., Mula, M., & Edwards, M. (2019). 17 State and trait interoception is disrupted in functional seizures. *Journal of Neurology, Neurosurgery & Psychiatry*, *90*(Suppl 2), A8.1–A8. https://doi.org/10.1136/jnnp-2019-BNPA.17