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Attention and postural control in patients with conversion paresis

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ABSTRACT

Objective: Current theories of conversion disorder (CD) propose that motor symptoms are related to heightened self-monitoring and excessive cognitive control of movements. We tested this hypothesis using quantification of performance on a continuous perceptuo-motor task involving quiet standing.
Methods: Twelve CD patients and matched controls maintained static balance on a force platform under various attention conditions: (1) with eyes open; (2) with eyes closed (requiring enhanced attention to proprioceptive information to regulate posture); and (3) while performing an attention demanding cognitive task.
Results: Compared to controls, CD patients displayed a greater decrease in postural stability in the 'eyes-closed' versus 'eyes-open' condition. In contrast, cognitive distraction led to a normalization of balance in CD. Moreover, sensitivity to the balance interventions correlated significantly with trauma reports and dissociative symptoms.
Conclusion: These results indicate that attention plays a crucial role in postural control in CD. More specifically, patients seem to inadvertently use deliberate control of posture (i.e., cognitive investment) of an otherwise nearly automatized perceptuo-motor task. Attentional distraction resulted in a temporary normalization of balance, which may be used to train individuals with CD to guide their attention in a more effective way.

Introduction

Conversion disorder (CD) is a psychiatric syndrome, characterized by neurologic symptoms such as partial loss of voluntary motor control and altered bodily sensations, in the absence of any identifiable neurological or organic causes [1]. The onset and exacerbation of CD symptoms have been linked to psychological factors like trauma or stress, suggesting that psychological mechanisms play an important role [2,3]. Despite a long history of speculations about the causes of CD, the mechanisms behind the syndrome are not well understood [4–6]. Against this background, there is disagreement as to whether the name 'conversion disorder' is appropriate in the first place, since the term already implies a (as of yet unproven) specific psychological etiology [7].

Various studies have investigated abnormal motor performance in CD, and the contributing role of attentional factors. The currently prevailing view is that intentional (self-initiated) motor functioning is impaired, whereas automatic motor functioning seems to be intact [8]. In a recent study [9] motor-evoked potentials (MEPs) were evaluated using transcranial magnetic stimulation (TMS) in a group of conversion patients. The authors found reduced cortical excitability during imagining of own body movements, but not during action observation, suggesting that the voluntary movement initiation system is compromised in these patients. However, a more recent study by the same group [10] showed that some healthy subjects were able to down-regulate motor excitability when instructed to intentionally disobey the instruction to engage in a certain type of motor imagery. Thus, MEPs may not always be able to successfully differentiate 'true' motor conversion from malingering. There is also evidence for the role of heightened action-monitoring and self-focused attention, as evidenced by event-related potential (ERP) studies [11] and functional magnetic resonance imaging (fMRI) studies [12,13]. Recent accounts of medically unexplained symptoms, including conversion symptoms, attribute the sensory and motor symptoms to a set of erroneous beliefs (expectations) about specific perceptual sensations and movements, combined with an excessive attentional focus on bodily symptoms and signs [4,14]. Especially this excessive attentional focus seems to form one of the major maintaining factors in CD.

Studies that examined actual motor performance in CD have tended to employ one of two paradigms. On the one hand, studies have looked at motor preparation and execution of discrete movements, such as button presses [11,12]. Other studies, in contrast, have looked at characteristics of spontaneous bodily tremor [6,15]. Interestingly, both types of paradigms have yielded evidence for the modulating role of attention with regard to motor symptoms, which underscores the role of psychogenic mechanisms. To our knowledge only one recent study [16; (see below)] has examined performance on a motor task involving

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continuous perceptuo-motor control. Many everyday activities such as standing and walking are coordinated using the continuous pick-up of relevant perceptual quantities and the subsequent adjustment of movement parameters, which in itself is attention demanding. Attentional fluctuations have a direct impact on successful control of such activities, but it is unknown to what extent attentional interventions in conversion disorder impact on the execution of such tasks.

We examined maintenance of quiet standing in a group of individuals with CD and a group of controls. Quiet stance involves the integration of visual, somatosensory, and vestibular inputs, as is required to maintain stable and upright stance [17]. This seemingly simple task involves continuous monitoring of the body orientation with respect to the gravity vector, and performing minute postural adjustments in the face of external and internal perturbations. The resulting spontaneous postural excursions or 'body sway', as evidenced in the body center-of-mass (COM) or center-of-pressure (COP) trajectories, displays surprisingly complex dynamics, which may provide insight into the underlying motor control processes. Dual-tasking studies [18] have found that maintenance of balance is highly automatized, but at the same time subject to cognitive and attentional factors. Thus, balance control is neither fully intentional nor fully automatized, but occupies an intermediate position on the automaticity continuum [19]. A prevailing insight is that focusing attention on one's own stance disrupts the automatic balance processes [20,21] and results in decreased postural stability. Relatedly, closing the eyes while maintaining quiet stance also causes reduced postural stability, which is in part related to the fact that actors need to adopt an inward focus of attention towards internal sensory signals (joint proprioception and the vestibular sense) to regulate their balance [22]. Conversely, diverting attention from balance, e.g., by focussing on the external effects of one's own bodily movement [23] or by performing mental arithmetic [24] leads to more stable and more automatized balance.

The study of Wolfsegger et al. [16] examined postural fluctuations using accelerometers attached to the trunk in a group of individuals with suspected psychogenic gait and balance, and indeed found indications that distraction enhanced postural stability. However, the study failed to control for order effects. Furthermore the distractor involved physical contact (finger touch) which can directly interfere with postural control.

Because self-focussed attention has been suggested to play a major factor in CD [4,13,14,25], we decided to test our hypothesis by recording postural sway in patients with CD in three attention conditions: (1) standing with the eyes open (neutral); (2) standing with the eyes closed (enhanced attention to proprioceptive information) and (3) during cognitive distraction (reduced attention to proprioceptive information). We expected that standing with the eyes closed would lead to temporarily less stable balance in CD, whereas performing an attention-demanding cognitive task would result in more stable balance (cf. [16]), as exemplified by reduced postural excursions in CD compared to eyes open and eyes closed.

We additionally examined whether severity of dissociation and early trauma was correlated with postural abnormalities. Dissociative symptoms are often observed in conversion disorder [2,26]. Also, dissociative phenomena are associated with early childhood trauma [2,27]. Furthermore, a recent study [28] showed that number of aversive life events (in a non-clinical sample of students) was a predictor of postural freezing. Against this backdrop of findings, we examined whether dissociation and traumatic life events are associated with postural abnormalities.

Method

Participants

Twelve patients (46.0, SD = 8.5 years) diagnosed with conversion disorder on DSM-IV criteria [1] by a neurologist or a psychiatrist and 12 gender- and age-matched controls (45.0 y, SD = 9.3 years) participated. Table 1 shows demographic characteristics of the participants. All patients reported sensory-motor symptoms (especially paresis) in their lower body and/or gait disturbances. As part of the medical examination, all patients were screened for possible organic causes for their symptoms. Only cases were included where there were no signs of organic disturbances responsible for the symptoms. Patients were recruited by contacting health care professionals. None of the participants was a heavy smoker or user of alcohol or drugs. All the participants received 15 Euro cash for their participation. The study was approved by the Ethics Committee of Leiden University Medical Center and undertaken in accord with the Declaration of Helsinki. All participants signed an informed consent form.

Material

A custom-made stabilometric platform was used to assess body sway (1 m × 1 m; sampling frequency: 100 Hz; resolution: 0.28 N/bit; resonance frequency: 30 Hz); cf. [29]. The excursions of the center-of-pressure (COP) in the anterior–posterior and medio-lateral direction were recorded as a measure of postural (in)stability.

Dissociation was assessed using a set of 19 items adopted from the Clinician-Administered Dissociative States Scale (CADSS; [30]). The CADSS is a reliable and valid self-report instrument to assess state symptoms of dissociation. The full CADSS consists of two parts; a subject-rated part and an observer-rated part where dissociative behaviors are scored by a trained observer (8 items). For practical purposes only the first part was administered (cf. [31]), which is known as the Dissociative State Subscale (DSS; [32]). Each item consists of a symptom (e.g., do things seem to be moving in slow motion? Do you feel disconnected from your own body?), which is rated by the participant on a 0-to-4 scale. These scores were summed to obtain a total score.

Table 1
Participant characteristics.

CD	Age	Sex	Medication: AD	Medication: AN	Axis-I comorbidity	DSS	NLETQ
1	45	M	N	Y	Depressive disorder	33	10
2	55	F	Y	N	Depressive disorder	9	8
3	35	F	N	N		0	2
4	32	F	N	N		0	5
5	46	F	N	Y		0	4
6	53	F	N	N		15	6
7	55	M	N	N		4	6
8	42	M	N	Y		1	5
9	35	M	Y	N	PTSD	20	11
10	56	M	[a]	[a]		4	8
11	48	F	N	N	OCD	11	4
12	51	F	[a]	[a]	Social phobia, OCD, depressive disorder	4	2
Controls							
1	47	M	N	N		0	6
2	58	F	N	N		0	2
3	45	F	N	N		6	4
4	34	F	N	N		0	1
5	51	F	N	N		0	2
6	50	F	N	N		1	5
7	52	M	N	N		0	4
8	39	M	N	N		1	1
9	29	M	N	N		7	5
10	56	M	N	N		0	4
11	52	F	Y	N	Depressive disorder	0	4
12	46	F	N	N		1	1

AD = Anti-depressants; AN = anxiolytic; Y = Yes; N = No.
DSS = Dissociative State Subscale of the CADSS.
CADSS = Clinician-Administered Dissociative States Scale.
NLETQ = Negative Life Experiences and Trauma Questionnaire.
[a] Not registered.

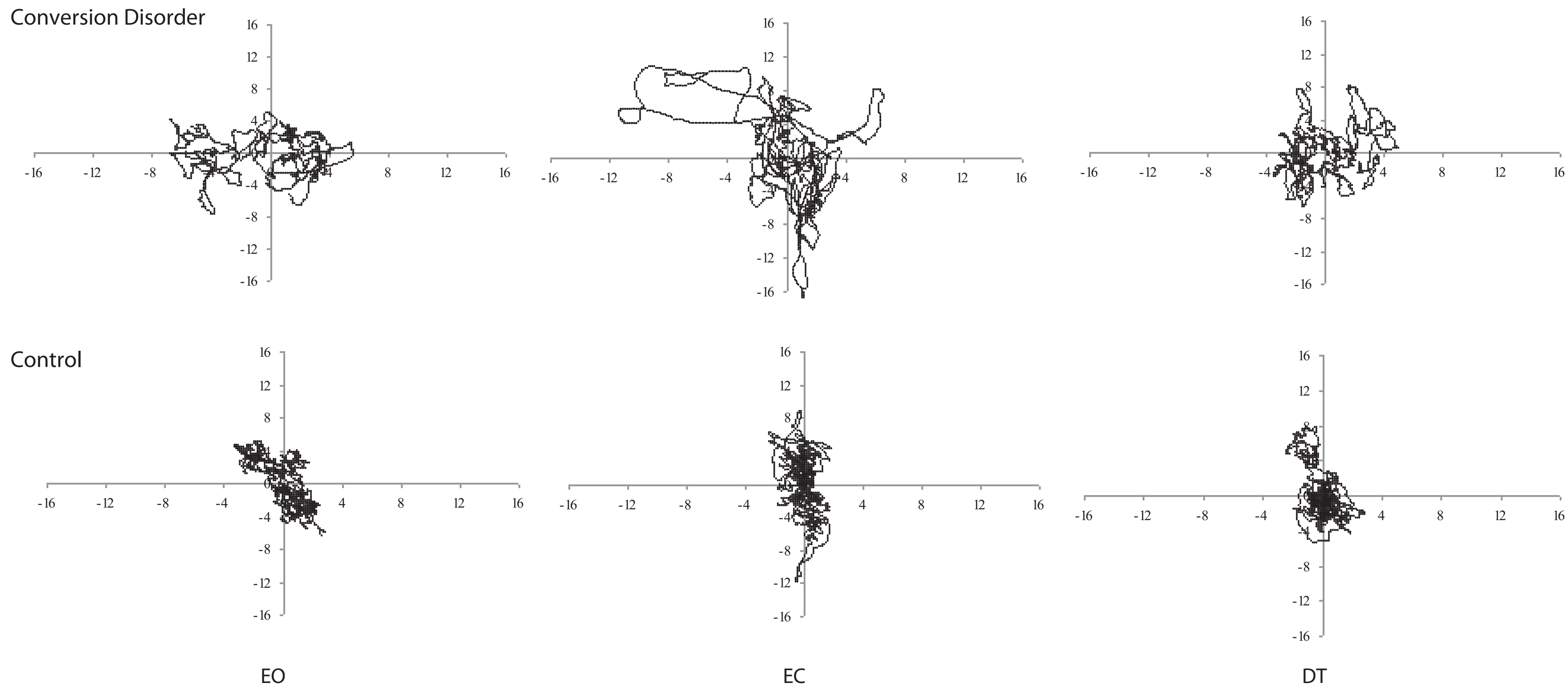

Fig. 1. Representative posturograms of a conversion patient (top) and a control (bottom) in the conditions EO (eyes open), EC (eyes closed), and DT (dual task). The graphs show time series of the participant's center of pressure (in mm), with *x*-axes representing mediolateral excursions (ML) and *y*-axes representing anterior–posterior excursions (AP).

Aversive life events and traumatic experiences were assessed with the Negative Life Experiences and Trauma Questionnaire (NLETQ [33]). The NLETQ consists of 24 items describing various events, such as sexual and physical assault and serious injury.

Values are reported in Table 1.

Procedure

Prior to testing, participants completed the DSS and the NLETQ. Next, they were asked to step onto the stabilometric platform, to keep both feet at the same position in a slightly splayed position and to look at the monitor in front of them (eye level; distance 1 m) containing a fixation cross. Participants were instructed to stand still and hold their arms still alongside their body. The experiment took place in a dimly lit room.

Participants engaged in three different conditions: (1) standing with eyes open (EO), (2) standing with eyes closed (EC), and (3) standing with eyes open while performing a dual task involving mental arithmetic (DT). The dual task consisted of silently counting backwards in steps of 7 from a starting value (around 300) that was provided by the experimenter. Each condition lasted 30 s and was presented 4 times. The resulting 12 trials were presented in random order. The entire balance recordings lasted 6 min in total. All participants performed the task without effort and without loss of balance.

Data analyses

MATLAB was used for analyzing postural sway excursions. The time-series were filtered (second-order low-pass Butterworth filter, cut-off frequency 10 Hz). To quantify postural sway, we calculated the following measures:

(1) the *radius* was calculated as the average COP distance to the origin of the mean-centered posturogram in the horizontal plane. In the posturographic literature this variable is also sometimes denoted as ‘sway amplitude’, or ‘mean radial distance’ [22,34,35].
(2) sway path length, which is the summed length of the COP trace in the AP-ML plane over the measurement interval (cf. [36]).

Excessive postural excursions, which may be indicative of postural instability, are characterized by relatively high values of *radius* and sway path length in the COP trace.

The postural measures were analyzed using repeated measures analyses of variance (rm-ANOVA) with within-subject factor Condition (EO, EC, DT) and between-subject factor Group (CD patients and controls). Alpha-level was set at 0.05. Effect sizes are reported as partial eta-squared (η^2). Group differences on the questionnaire data were assessed using one-way ANOVAs. We additionally used Pearson correlations to assess the relationship between the questionnaire scores and difference scores obtained with the posturographic measures. To this end, we derived for both COP parameters all three possible difference scores: EC *minus* EO; EC *minus* DT; EO *minus* DT.

Results

Postural effects

Fig. 1 shows representative posturograms for one CD patient and one control, for each of the three conditions. A two-way ANOVA for the *radius* showed a significant main effect of Condition ($F(2, 44) = 14.39$, $p < .001$, $\eta^2 = .39$) which was superseded by a Condition × Group interaction ($F(2, 44) = 10.84$, $p < .001$, $\eta^2 = .33$). The main effect of Group was not significant ($F(1, 22) = 2.88$, $p > .1$). To further explore this interaction, we performed separate ANOVAs for each group. This analysis revealed that the condition effect was significant for patients with conversion disorder ($F(2, 22) = 23.28$, $p < .001$, $\eta^2 = .68$) and not for controls ($F(2, 22) = 2.04$, $p = .153$). Univariate ANOVAs revealed a significant Condition effect for the conversion group; EO vs. EC, ($F(1, 11) = 14.08$, $p < .01$, $\eta^2 = .56$); EO vs. DT, ($F(1, 11) = 24.63$, $p < .001$, $\eta^2 = .69$); EC vs. DT ($F(1, 11) = 31.31$, $p < .001$, $\eta^2 = .74$). For the controls the difference between EO and EC was borderline significant ($F(1, 11) = 4.85$, $p = .05$, $\eta^2 = .31$), whereas the other contrasts were not significant (p's > .1). Fig. 2 shows the mean values of *radius* for groups across each of the three conditions.

The ANOVA for sway path length yielded similar effects; there was a main effect of Condition, ($F(2, 44) = 15.75$, $p < .001$, $\eta^2 = .42$), which was superseded by a Condition × Group interaction ($F(2, 44) = 5.65$, $p < .01$, $\eta^2 = .20$), and again no main effect of Group ($F(1, 22) = 1.33$, $p > .1$) Separate ANOVAs for each group revealed that the Condition effect was significant for the CD group ($F(2, 22) = 12.096$, $p < .001$, $\eta^2 = .52$) and also for controls ($F(2, 22) = 5.986$, $p < .01$, $\eta^2 = .35$). Univariate ANOVA's revealed that for the conversion group the difference between two of the three conditions was significant: EO vs. EC, ($F(1, 11) = 15.21$, $p < .01$, $\eta^2 = .58$), and EC vs. DT ($F(1, 11) = 13.53$, $p < .01$, $\eta^2 = .55$). In addition, for the controls only the EO vs. EC contrast was significant, ($F(1, 11) = 9.05$, $p < .05$, $\eta^2 = .45$) but no other contrasts were significant. Fig. 3 shows the mean values of sway path length for groups across each of the three conditions.

Mean values for all conditions are also presented in Table 2.

Questionnaire data

The one-way ANOVA on the DSS scores revealed that the CD group had significantly more dissociative symptoms (M = 8.4) than the controls (M = 1.3), $F(1, 22) = 5.61$, $p < .05$. Also, the CD group had experienced significantly more traumatic life events (M = 5.9) than the controls (M = 3.3), $F(1, 22) = 7.50$, $p < .05$. Dissociation correlated significantly with the difference in *radius* between eyes open and eyes closed (r = .451, $p < .05$), with the difference in *radius* between eyes closed and the dual task (r = .556, $p < .01$) and with the difference in sway path length between eyes open and eyes closed (r = .447, $p < .05$). These same correlations, performed separately for the 2 groups were not significant. The number of aversive life events showed a similar pattern of results. It correlated significantly with the difference in *radius* between eyes open and eyes closed (r = .458, $p < .05$), and with the difference in *radius* between eyes closed and the dual task (r = .669, $p < .01$). This relationship is shown in Fig. 4 for each group. When the same correlations were performed separately for the two groups none of the r-values were significant. These same correlations, performed separately for the two groups, were .535 and .512, respectively, for the CD group, and −.051 and .516 for the controls. These correlations were not significant. Finally, the number of aversive life events did not correlate with the difference scores for the sway path length.

Discussion

We examined postural behavior in a group of individuals diagnosed with conversion disorder, and a group of matched controls. Postural behavior was assessed under three conditions, eyes open, eyes closed, and while performing an attention demanding secondary task. These attention manipulations are common in the postural control literature, and reveal the efficiency with which balance is regulated.

Analysis of COP parameters showed that the CD group reacted differently to these interventions than the controls. First, closing the eyes had a stronger effect on postural behavior in the CD group than the controls; the combined results of the analysis of our postural parameters (*radius* and sway path length) revealed that the CD group displayed a greater increase in postural sway (suggestive of loss of stability) than controls as a result of closing the eyes. This effect is a typical attention effect. Under normal circumstances people guide their postural control largely on the basis of visual input. However, with the eyes closed, automatic visuo-motor solutions can no longer be relied upon, and proprioceptive and vestibular information channels have to be sampled, which requires an inward focus of attention (cf. [37]) and more active (cognitive) control of balance. This increased cognitive investment in balance is typically associated with enhanced postural sway (ibid.). The fact that CD patients responded stronger to this manipulation than the controls can be explained by cognitive attention theories of CD [14]. The inward focus of attention likely causes a qualitatively different processing mode; according to Edwards et al. [14] automatized movements are controlled using ‘slow, sequential, explicit processing that uses declarative rules that are inadequate to control complex movement patterns that are usually produced through implicit mechanisms’ (p. 12). As standing upright also qualifies as an overlearned motor activity, we feel that the effect of closing the eyes lends support to the thesis that individuals with CD have a tendency to control their balance using deliberate control, which is not efficient.

Second, the distraction condition during which participants performed an attention demanding secondary cognitive task (mental arithmetic) had pronounced effects on postural steadiness in the CD group. The manipulation led to a significant reduction in sway; smaller values

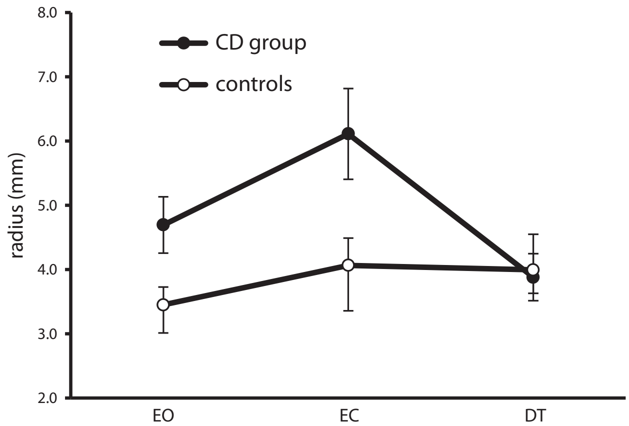

Fig. 2. Mean values of *radius* (mm) for the CD group and controls in the three conditions; EO (eyes open), EC (eyes closed), and DT (dual task). Error bars denote standard errors of the mean.

of *radius* compared to EO and EC, and smaller values of sway path length compared to EC. The control group showed no postural effects of this intervention. Thus, postural control in the CD group was highly sensitive to this cognitive intervention. This strongly suggests that under normal circumstances these individuals inadvertently invest a lot of cognitive effort in balance regulation that overrides otherwise intact automatized control mechanisms. Conversely, attentional distraction seems to lead to a normalization of balance, at least, during the course of the experimental trial. It is likely that this intervention resulted in a temporary shift towards more automatic and efficient mode of balance control.

Note that this finding bears some resemblance to the bedside physical signs used to make the diagnosis of motor conversion disorder. In Hoover's sign [38,39], muscle weakness in the suspected paretic leg tends to disappear when muscles in the alternate leg are activated, due to involuntary contraction of synergistic muscles. Although a positive Hoover's sign is a useful clinical test to confirm the diagnosis of motor conversion disorder, it does not provide a quantitative metric of motor control disturbance.

Our correlation analyses revealed that both dissociative experiences and traumatic life events correlated with postural behavior. More specifically, these scores correlated with postural decrements (loss of stability) during standing with the eyes closed. In other words, the postural unsteadiness which is typically found when maintaining quiet stance with the eyes closed, and which is associated with an inward

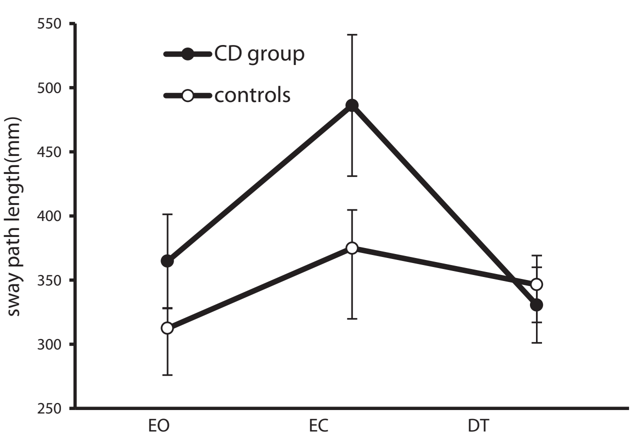

Fig. 3. Mean values of sway path length (mm) for the CD group and controls in the three conditions; EO (eyes open), EC (eyes closed), and DT (dual task). Error bars denote standard errors of the mean.

Table 2
Mean values (+ standard error of the mean) for the two postural parameters *radius*, and sway path length, separately for both groups (CD and controls) and the three experimental conditions (eyes open [EO], eyes closed [EC] and dual task [DT]).

	Radius (mm)		Sway path length (mm)	
	CD	Control	CD	Control
EO	4.7 (.4)	3.5 (.3)	365 (36)	312 (16)
EC	6.1 (.7)	4.1 (.4)	486 (55)	375 (30)
DT	3.9 (.4)	4.0 (.6)	330 (30)	346 (23)

focus of attention (see above) was positively related to factors frequently associated with conversion disorder such as dissociation and trauma.

Similar notions of inadequate top-down postural control at the expense of automatized postural control have been made for phobic postural vertigo (PVV), a condition characterized imbalance and vertigo [40,41], yet with unknown organic causes. PVV has been associated with excessive supraspinal control such as increased muscular co-contraction around the ankle joint [42,43]. It would be interesting to test whether CD patients show similar patterns of co-contraction.

Our study [16] demonstrates the role of attention in a continuous perceptuo-motor task (maintaining upright stance) in individuals with CD. Although effects of attention on balance in healthy individuals are well documented, contradictory findings exist in the literature [18]. This is probably due to the fact that in most individuals balance is nearly fully automatized, so that attentional interventions have little effect. However, the strong effects of attentional distraction in CD leading to (temporarily) normalization of postural control suggest that in CD attentional mechanisms play a profound role.

Limitations

It should be noted that the above set of findings may not be unique to motor CD, but that other motor abnormalities could have resulted in similar patterns of results. For example, Roerdink et al. [44] found effects of attentional distraction (mental arithmetic) on COP dynamics in patients recovering from stroke, highlighting the cognitive contributions to postural control in this patient group. Future studies should not only directly compare CD to controls, but should also include a group of disease controls such as multiple sclerosis [16], so that it can be established whether postural measures provide a useful diagnostic tool.

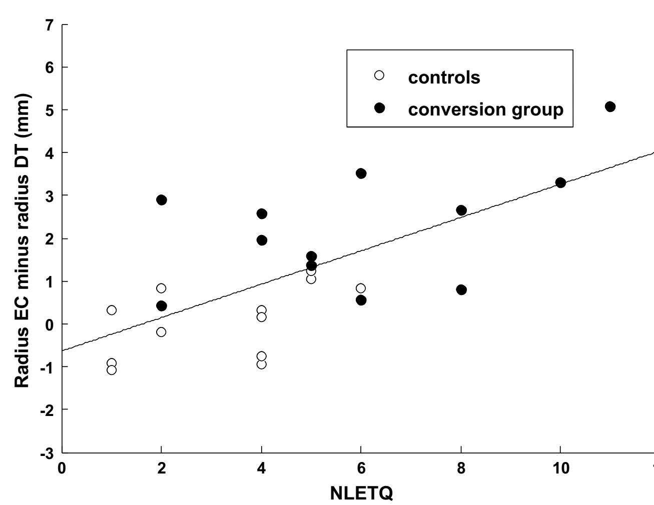

Fig. 4. Scatterplot displaying NLETQ scores plotted against the difference in *radius* between eyes closed (EC) and the dual task (DT), for both groups (black circles: conversion; white circles: controls). Also shown is the best-fitting line showing the relationship between the two variables across both groups (r = .669).

Our correlation analyses revealed an association between dissociative experiences and traumatic life events and postural behavior. It should be noted that the effects were found over both groups (CD and controls) and not within a group, and that the modest sample size warrants caution in interpretation. Another potential limitation is that life events were measured retrospectively. As a result, it is impossible to ascertain whether, and to what extent, these life events contributed in a causal manner to conversion symptomatology. Similarly, life events self reports may have been confounded by other unmeasured variables, such as personality and emotional disorder. Still, we feel the current effects, combined with similar findings obtained in a non-clinical sample [28] open up the intriguing possibility that traumatic life events may lead to embodied effects [45], such as postural abnormalities.

Conclusion

The finding that attentional distraction resulted in a temporary normalization of balance may have implications for treatment. Direct demonstration and communication of attention-modulation effects may prove to be effective, not only to inform the CD patients about the role of attention but also to train them directly to guide their attention in a more effective way [46,47].

Conflict of interest

The authors have no competing interests to report.

Acknowledgments

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References

[1] American Psychiatric Association. Diagnostic and statistical manual of mental disorder. Text Revision (DSM-IV-TR) 4th ed. Washington, DC: American Psychiatric Publishing; 2000.
[2] Brown RJ, Schrag A, Trimble MR. Dissociation, childhood interpersonal trauma, and family functioning in somatisation disorder. Am J Psychiatry 2005;162:899–905.
[3] Roelofs K, Spinhoven P. Trauma and medically unexplained symptoms towards an integration of cognitive and neuro-biological accounts. Clin Psychol Rev 2007;27:798–820.
[4] Brown RJ. Psychological mechanisms of medically unexplained symptoms: an integrative conceptual model. Psychol Bull 2004;130:793–812.
[5] Vuilleumier P. Hysterical conversion and brain function. Prog Brain Res 2005;150:309–29.
[6] Voon V, Gallea C, Hattori N, Bruno M, Ekanayake V, Hallett M. The involuntary nature of conversion disorder. Neurology 2010;74:223–8.
[7] Stone J, LaFrance Jr WC, Brown R, Spiegel D, Levenson JL, Sharpe M. Conversion disorder: current problems and solutions for DSM-5. J Psychosom Res 2011;71:369–76.
[8] Roelofs K, Näring GWB, Keijsers GPJ, Hoogduin CAL, van Galen GP, Maris E. Motor imagery in conversion paralysis. Cogn Neuropsychiatry 2001;6:21–40.
[9] Liepert J, Hassa T, Tüscher O, Schmidt R. Motor excitability during movement imagination and movement observation in psychogenic lower limb paresis. J Psychosom Res 2011;70:59–65.
[10] Liepert J, Shala J, Greiner J. Electrophysiological correlates of disobedience and feigning-like behaviour in motor imagery. Clin Neurophysiol 2014;125:763–7.
[11] Roelofs K, De Bruijn ERA, Van Galen GP. Hyperactive action monitoring during motor-initiation in conversion paralysis: an event-related potential study. Biol Psychol 2006;71:316–25.
[12] Cojan Y, Waber L, Carruzzo A, Vuilleumier P. Motor inhibition in hysterical conversion paralysis. Neuroimage 2009;47:1026–37.
[13] De Lange FP, Roelofs K, Toni I. Increased self-monitoring during imagined movements in conversion paralysis. Neuropsychologia 2007;45:2051–8.
[14] Edwards MJ, Adams RA, Brown H, Pareés I, Friston KJ. A Bayesian account of 'hysteria'. Brain 2012;135:3495–512.
[15] Kenney C, Diamond A, Mejia N, Davidson A, Hunter C, Jankovic J. Distinguishing psychogenic and essential tremor. J Neurol Sci 2007;263:94–9.
[16] Wolfsegger T, Pischinger B, Topakian R. Objectification of psychogenic postural instability by trunk sway analysis. J Neurol Sci 2013;334:14–7.
[17] Balasubramanian R, Wing AM. The dynamics of standing balance. Trends Cogn Sci 2002;6:531–6.
[18] Woollacott M, Shumway-Cook A. Attention and the control of posture and gait: a review of an emerging area of research. Gait Posture 2002;16:1–14.
[19] Stins JF, Michielsen ME, Roerdink M, Beek PJ. Sway regularity reflects attentional involvement in postural control: effects of expertise, vision and cognition. Gait Posture 2009;30:106–9.
[20] Huffman JL, Horslen BC, Carpenter MG, Adkin AL. Does increased postural threat lead to more conscious control of posture? Gait Posture 2009;30:528–32.
[21] Vuillerme N, Nafati G. How attentional focus on body sway affects postural control during quiet standing. Psychol Res 2007;71:192–200.
[22] Stins JF, Ledebt A, Emck C, Van Dokkum EH, Beek PJ. Patterns of postural sway in high anxious children. Behav Brain Funct 2009;5:42–50.
[23] McNevin NH, Wulf G. Attentional focus on supra-postural tasks affects postural control. Hum Mov Sci 2002;21:187–202.
[24] Stins JF, Roerdink M, Beek PJ. To freeze or not to freeze: affective and cognitive perturbations have markedly different effects on postural control. Hum Mov Sci 2011;30:190–202.
[25] Voon V, Brezing C, Gallea C, Hallett M. Aberrant supplementary motor complex and limbic activity during motor preparation in motor conversion disorder. Mov Disord 2011;26:2396–403.
[26] Roelofs K, Keijsers GPJ, Hoogduin CAL, Näring GWB, Moene F. Childhood abuse in patients with conversion disorder. Am J Psychiatry 2002;159:1908–13.
[27] Hagenaars MA, Fisch I, Van Minnen A. The effect of trauma onset and frequency on PTSD-associated symptoms. J Affect Disord 2011;132:192–9.
[28] Hagenaars MA, Stins JF, Roelofs K. Aversive life events enhance human freezing responses. J Exp Psychol Gen 2012;141:98–105.
[29] Roelofs K, Hagenaars M, Stins JF. Facing freeze: social threat induces bodily freeze in humans. Psychol Sci 2010;1:1575–81.
[30] Bremner JD, Krystal JH, Putnam FW, Southwick SM, Marmar C, Charney DS, et al. Measurement of dissociative states with the clinician-administered dissociative states scale (CADSS). J Trauma Stress 1998;11:125–36.
[31] Morgan CAM, Hazlett MG, Wang S, Richardson EG, Schnurr P, Southwick SM. Symptoms of dissociation in humans experiencing acute, uncontrollable stress: a prospective investigation. Am J Psychiatry 2001;158:1239–47.
[32] Hagenaars MA, van Minnen A, Holmes EA, Brewin CR, Hoogduin KAL. The effect of hypnotically induced somatoform dissociation on the development of intrusions after an aversive film. Cogn Emotion 2007;22:944–63.
[33] Engelhard IM, van den Hout MA, Kindt M, Arntz A, Schouten E. Peritraumatic dissociation and posttraumatic stress after pregnancy loss: a prospective study. Behav Res Ther 2003;41:67–78.
[34] Prieto TE, Myklebust JB, Hoffman RG, Lovett EG, Myklebust BM. Measures of postural steadiness: differences between healthy young and elderly adults. IEEE Trans Biomed Eng 1996;43:956–66.
[35] Smith AW, Ulmer FF, Wong DP. Gender differences in postural stability among children. J Hum Kinet 2014;33:25–32.
[36] Facchinetti LD, Imbiriba LA, Azevedo TM, Vargas CD, Volchan E. Postural modulation induced by pictures depicting prosocial or dangerous contexts. Neurosci Lett 2005;410:52–6.
[37] Donker SF, Roerdink M, Greven AJ, Beek PJ. Regularity of center-of-pressure trajectories depends on the amount of attention invested in postural control. Exp Brain Res 2007;181:1–11.
[38] McWhirter L, Stone J, Sandercock P, Whiteley W. Hoover's sign for the diagnosis of functional weakness: a prospective unblinded cohort study in patients with suspected stroke. J Psychosom Res 2011;71:384–6.
[39] Stone J, Sharpe M. Hoover's sign. Pract Neurol 2001;1:50–3.
[40] Schniepp R, Wuehr M, Huth S, Pradhan C, Brandt T, Jahn K. Gait characteristics of patients with phobic postural vertigo: effects of fear of falling, attention, and visual input. J Neurol 2014;261:738–46.
[41] Schniepp R, Wuehr M, Pradhan C, Novozhilov S, Krafczyk S, Brandt T, et al. Nonlinear variability of body sway in patients with phobic postural vertigo. Front Neurol 2013;4:115.
[42] Krafczyk S, Schlamp V, Dieterich M, Haberhauer P, Brandt T. Increased body sway at 3.5–8 Hz in patients with phobic postural vertigo. Neurosci Lett 1999;259:149–52.
[43] Querner V, Krafczyk S, Dietrich M, Brandt T. Patients with somatoform phobic postural vertigo: the more difficult the balance task, the better the balance performance. Neurosci Lett 2000;285:21–4.
[44] Roerdink M, De Haart M, Daffertshofer A, Donker SF, Geurts ACH, Peek BJ. Dynamical structure of center-of-pressure trajectories in patients recovering from stroke. Exp Brain Res 2006;174:256–69.
[45] Drayson Z. Embodied cognitive science and its implications for psychopathology. Philos Psychiatry Psychol 2009;16:329–40.
[46] Nielsen G, Stone J, Edwards MJ. Physiotherapy for functional (psychogenic) motor symptoms: a systematic review. J Psychosom Res 2013;75:93–102.
[47] Stone J, Edwards M. Trick or treat? Showing patients with functional (psychogenic) motor symptoms their physical signs. Neurology 2012;79:282–4.