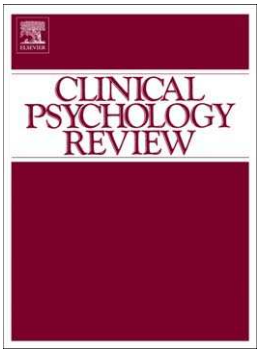

Article:
Brown, R.J. and Reuber, M. orcid.org/0000-0002-4104-6705 (2016) Towards an integrative theory of psychogenic non-epileptic seizures (PNES). Clinical Psychology Review, 47. pp. 55-70. ISSN 0272-7358

https://doi.org/10.1016/j.cpr.2016.06.003



Towards an integrative theory of psychogenic non-epileptic seizures (PNES)

Richard J. Brown, Markus Reuber

PII: S0272-7358(16)30075-7
DOI: doi: 10.1016/j.cpr.2016.06.003
Reference: CPR 1531

To appear in: *Clinical Psychology Review*

Received date: 25 February 2016
Revised date: 16 June 2016
Accepted date: 16 June 2016

Please cite this article as: Brown, R.J. & Reuber, M., Towards an integrative theory of psychogenic non-epileptic seizures (PNES), *Clinical Psychology Review* (2016), doi: 10.1016/j.cpr.2016.06.003

Towards an integrative theory of psychogenic non-epileptic seizures (PNES)

Richard J. Brown[a] and Markus Reuber[b]

a. Corresponding author: 2nd Floor Zochonis Building, Brunswick Street, School of Psychological Sciences, University of Manchester, Manchester, M13 9PL, UK. E-mail: richard.j.brown@manchester.ac.uk Tel: +44(0)161 306 0400. Fax: +44(0)161 306 0406

b. Academic Neurology Unit, University of Sheffield, Royal Hallamshire Hospital, Glossop Road, Sheffield, S10 2JF, UK. Email: m.reuber@sheffield.ac.uk Tel: +44 (0)114 2268763

ABSTRACT

Psychogenic Nonepileptic Seizures (PNES) superficially resemble epileptic seizures but are thought to have a psychological rather than epileptic basis. Patients with PNES vary widely in terms of background, personality profiles, comorbidities, response to treatment and outcomes. Previous accounts interpreting these seizures as the activation of dissociated material, a physical manifestation of emotional distress, hard-wired reflex responses, or learned behaviours cannot explain key features of the phenomenon. Drawing on a brief review of the literature on etiology, correlates and phenomenology of PNES, this paper integrates existing approaches and data within a novel explanatory framework that applies to all PNES patients with subjectively involuntary seizures. Following the Integrative Cognitive Model of medically unexplained symptoms, we suggest that the central feature of all PNES is the automatic activation of a mental representation of seizures (the "seizure scaffold") in the context of a high level inhibitory processing dysfunction. This often arises in response to elevated autonomic arousal, and may disrupt the individual's awareness of distressing material, but can become divorced from abnormal autonomic and emotional activity. This model accounts both for existing findings and the heterogeneity of patients with PNES, whilst leading to a number of novel hypotheses against which it can be evaluated.

KEYWORDS

Psychogenic non-epileptic seizures (PNES); Dissociation; Integrative Cognitive Model; representation; autonomic arousal; interoception

INTRODUCTION

Psychogenic Nonepileptic Seizures (PNES) are episodic disturbances of normal functioning and reduced self-control associated with a range of motor, sensory, and mental manifestations that superficially resemble epileptic attacks, but which are not caused by epileptic activity in the brain. PNES are newly diagnosed in more than 5/100,000 per year (Duncan, Razvi, & Mulhern, 2011), and the prevalence of this diagnosis has been estimated to be as high as 33/100,000 (Benbadis, Allen, & Hauser, 2000). PNES most frequently manifest in early adulthood but may first present in children as young as five and in older adults (Reuber, Fernandez, Bauer, Helmstaedter, & Elger, 2002). About one in five patients first presenting to a seizure clinic is diagnosed with PNES (Angus-Leppan, 2008).

PNES is not a category conceived through psychopathological research or theory. The diagnostic entity "PNES" has primarily developed because patients with these seizures present to medical settings that are also used by patients with epilepsy, and because experts charged with making diagnoses have tended to attribute these phenomena to "psychological" causes without wanting to commit themselves to a particular mechanism or to identifying a specific psychiatric disorder. Indeed, in the current nosologies, patients with PNES fall into a number of different categories: most, but not all, fulfil the diagnostic criteria of Functional Neurological Symptom (Conversion) Disorder in DSM-5 (American Psychiatric Association, 2013); diagnoses of Somatic Symptom Disorder, Dissociative Disorder or Post-Traumatic Stress Disorder may also be appropriate. In the context of these categorical conceptualisations, PNES would not be considered the result of willed action. However, some PNES-like behaviours may be wilfully produced as manifestations of Factitious Disorder or Malingering (the latter not being a mental disorder). While we accept that there are currently no objective tests capable of establishing whether actions are volitional or non-volitional (and there may not be a clear categorical distinction between these two types of actions), our focus in this paper is on PNES that are experienced as involuntary events and can be conceptualised as such.

In clinical reality, the diagnosis of PNES follows the exclusion of alternative, "physical" explanations for a patient's seizures[i]. The distinction of PNES from epilepsy or other

pathophysiological disorders is often an iterative process. In view of the paroxysmal nature of the disorder, initial diagnoses are usually based on the description of seizure manifestations by patients and observers. As time goes by, more detailed witness reports may become available, and observers may capture typical seizures on video. Unremarkable interictal tests (such as structural magnetic resonance imaging, MRI, of the brain; electroencephalography, EEG; electrocardiography, ECG) may make alternative explanations for the paroxysmal symptoms less likely. In those with sufficiently frequent seizures, events may be captured by simultaneous video-EEG recording and, on close examination, found to exhibit behavioural manifestations typical of PNES rather than epilepsy and an absence of ictal or postictal epileptic EEG changes (LaFrance, Baker, Duncan, Goldstein, & Reuber, 2013).

Most recent accounts suggest that various factors can contribute to the onset and maintenance of PNES, with the precise contribution varying from individual to individual (e.g., Baslet, 2011; Bodde et al., 2009; Goldstein, Deale, Mitchell-O'Malley, Toone, & Mellers, 2004; Reuber, 2009). Some theorists (e.g., Baslet, 2011; Goldstein et al., 2004) make specific claims about the nature of PNES; others (e.g., Bodde et al., 2009; Reuber, 2009) speak generally about predisposing, precipitating and perpetuating factors without clearly specifying what they consider PNES to actually be. Often, the focus is more on why PNES have developed rather than how, that is, on etiology rather than mechanism. In contrast, the focus in this paper is on the latter.

In the sections below we distinguish between four main candidate mechanisms for PNES, distilled from existing theories of these phenomena. We then consider the evidence for these mechanisms and the limitations of existing approaches in this area. We continue by presenting a novel model of PNES that seeks to address these limitations by incorporating existing accounts within an over-arching theoretical framework, which clarifies the necessary and sufficient components of PNES, and their relationship with other clinical phenomena. We conclude by exploring the empirical and clinical implications of this model.

EXISTING MODELS OF PNES

Model 1: PNES as the activation of dissociated material

Models based on this idea (e.g., Bowman, 2006; Harden, 1997; Kuyk, Van Dyck, & Spinhoven, 1996; Nijenhuis, 2004) originate in Pierre Janet's 19th century account of hysteria. The central premise is that PNES result from a breakdown in psychological integration, in which memories and/or mental functions are separated or "dissociated" from consciousness. This account suggests that PNES are sensorimotor flashbacks that arise when dissociated material pertaining to past traumatic events intrudes into awareness, typically in response to a trauma reminder. These are

misinterpreted as seizures because only fragments of the dissociated material are available to awareness and their links to traumatic events are not recognized. Alternatively, the individual may recognise the reliving component of the experience but be unwilling or unable to articulate it; here the misinterpretation may be on the part of observers who see only the external features of the event. By this view, PNES are no different to other post-traumatic reliving phenomena, such as those seen in post-traumatic stress disorder (PTSD).

Model 2: PNES as hard-wired responses

According to this account, PNES reflect the operation of pre-wired behavioural tendencies (e.g., Baslet, 2011; Kretschmer, 1944), such as an intrinsic stress response similar to other defensive reactions (e.g., freeze; startle; Nijenhuis, Vanderlinden & Spinhoven, 1998). This may arise as an acute response to threat and/or alteration in arousal and is thought to serve a basic biological function, such as protecting the organism, regulating arousal or facilitating recuperation. It may occur in response to traumatic events or as part of a post-traumatic reaction, but is more than a simple reliving phenomenon. One variant of this account (Goldstein & Mellers, 2006) suggests that PNES are altered states of consciousness akin to panic attacks, in which the subjective fear component is dissociated from awareness (so-called 'panic without panic'). Here PNES are assumed to result from acute arousal that triggers a dissociative state characterized by emotional numbing, depersonalization-derealization and other aspects of the attacks. The dissociation described in this account of PNES is different to that in other models, however, in that it implicates an acute state of detachment rather than the activation of compartmentalized material (Brown, In press).

Model 3: PNES as a physical manifestation of emotional distress

In this account, PNES are typically seen as defensive responses that serve the function of enabling the individual to express distress or solve personal problems without having to acknowledge their emotional origins. This account originates in the Freudian concept of conversion and later psychodynamic ideas about somatization (e.g., Breuer & Freud, 1893-1895). One variant suggests that the features of PNES are the physical components of emotional states that the individual is either unwilling to recognize (i.e., is avoiding) or misinterprets for some reason, perhaps because they lack the ability to identify and/or name their emotions (two separate aspects of the alexithymia construct; see e.g., Coffey, Berenbaum, & Kerns, 2003).

Model 4: PNES as learned behaviours

This approach (e.g., Moore & Baker, 1997; Sirven & Glosser, 1998) suggests that PNES are habitual behaviours that are maintained by operant conditioning (positive and negative reinforcement in the behavioural tradition), and/or because they confer some intrinsic or extrinsic benefit (primary

and secondary gain in the psychodynamic tradition). A central component of this approach is that PNES develop in the context of seizure models, such as family members with epilepsy, from whom the behaviour is learnt.

EMPIRICAL EVIDENCE FOR CURRENT MODELS

In this section we discuss the extent to which existing research on PNES supports or challenges each of the four models. A summary of the key arguments for and against each model is provided in Table 1.

---INSERT TABLE 1 ABOUT HERE---

Trauma and adversity

Numerous studies have considered whether patients with PNES are characterized by a history of adversity, particularly physical, sexual and (to a lesser extent) psychological abuse or neglect in childhood. Comparatively few studies have investigated whether PNES are precipitated by adverse events. Most studies have found that rates of childhood trauma are higher in patients with PNES than controls with epilepsy (for reviews see Fiszman, Alves-Leon, Nunes, D'Andrea, & Figueira, 2004; Sharpe & Faye, 2006; Brown & Reuber, 2016). Prevalence rates are substantial (85-100%) in some studies but are much lower in others and vary hugely according to patient selection and the definition used. Putting to one side the extensive methodological problems with research on this topic (see e.g., Sharpe & Faye, 2006), it is clear that a sizeable proportion of patients with PNES do not report a history of potentially traumatizing events (Brown & Reuber, 2016). In addition, in most studies, only a minority of patients (~40%; Fiszman et al., 2004) meet diagnostic criteria for PTSD. Although this number is likely to be higher when the dissociative sub-type of PTSD is taken into consideration, it is hard to reconcile these findings with the notion that PNES are inherently post-traumatic phenomena. As such, Model 1 is unlikely to offer a complete account of PNES unless a broader definition of adversity is adopted as a potential source of mental fragmentation. Nevertheless, traumatic events seem to be clinically relevant in many cases of PNES, and several studies suggest that a history of trauma is more common in patients who develop PNES than patients who develop other functional neurological symptoms (e.g. Reuber, Howlett, Khan, & Grunewald, 2007; Stone, Sharpe, & Binzer, 2004). A comprehensive account of PNES must be able to accommodate these findings, without relying on them to explain the phenomenon.

Dissociative “traits”

Most research on dissociation in patients with PNES has used “trait” measures such as the Dissociative Experience Scales (DES; Bernstein & Putnam, 1996), reflecting an assumption that the mental fragmentation thought to be responsible for PNES will render them vulnerable to dissociative

phenomena more generally. Across ten studies reviewed by Brown and Reuber (2016), DES scores were moderately higher (median Cohen's d = 0.66) in patients with PNES compared to controls with epilepsy. The median DES score for patients with PNES across these studies (21.5) is comparable to psychiatric patients more generally (van Ijzendoorn & Schuengel, 1996) and substantially lower than the average within PTSD populations (32.6; ibid). There was also considerable variability, with the mean DES score of the PNES group (15.0; n = 132) in the largest and most rigorous study being somewhat lower than average and not significantly different from patients with epilepsy (d = 0.19; Alper et al., 1997).

Taken together, these findings cast doubt on the notion that a general tendency to experience dissociative phenomena is an inherent characteristic of patients with PNES. There is a question mark over whether measures such as the DES provide a meaningful test of dissociation theories of PNES, however. A high DES score might be regarded as evidence of mental fragmentation, for example, and therefore as support for Model 1. It might also indicate a tendency to experience mental detachment, however, which would be more consistent with panic without panic (i.e., Model 2). Conversely, low scores on the DES may simply indicate that fragmentation or detachment are relatively circumscribed and not part of a broader tendency to experience other symptoms of this sort. It may also be that dissociative traits in patients with PNES manifest more as a tendency to experience somatoform dissociation (i.e., "medically unexplained" or functional neurological symptoms), rather than the "psychoform" dissociation measured by scales such as the DES (e.g., Nijenhuis, 2004; see below). Indeed, patients with PNES score consistently higher on the Somatoform Dissociation Questionnaire (SDQ-20; Nijenhuis, Spinhoven, Van Dyck & Van Der Hart, 1996) than controls with epilepsy (Brown & Reuber, 2016).

High suggestibility has also been identified as a predisposing trait for PNES by some adherents of Model 1 (e.g., Kuyk et al., 1996), in keeping with Janet's original model of dissociation. There is some evidence that groups with PNES are more suggestible than controls with epilepsy (e.g., Barry, Atzman, & Morrell, 2000; Kuyk, Spinhoven, & van Dyck, 1999), and, unlike in epilepsy, suggestion methods can elicit PNES in most patients (e.g., Benbadis, Johnson, et al., 2000; McGonigal, Oto, Russell, Greene, & Duncan, 2002; Slater, Brown, Jacobs, & Ramsay, 1995). However, not all studies have found elevated suggestibility in groups with PNES (Goldstein, Drew, Mellers, Mitchell-O'Malley, & Oakley, 2000; Litwin & Cardeña, 2000), and many PNES patients score in the low suggestible range (e.g., Kuyk et al., 1999). It therefore seems unlikely that high suggestibility is a necessary precondition for the development of PNES.

Anxiety and dissociation during PNES

Comparatively few studies have considered whether dissociation is evident during PNES themselves. In one large study of "ictal" PNES symptoms, relatively few patients claimed they were aware of unpleasant memories at the time of their attacks, suggesting that this is relatively infrequent (<25%; Reuber et al., 2011). To our knowledge, however, the question of whether participants' attacks resemble aspects of events that they cannot recall (a stronger test of Model 1) remains unanswered. Perhaps the best evidence for mental fragmentation during PNES is an innovative, albeit small, study by Kuyk et al (1999), who found that memories of ictal events for which the patient had previously been amnesic could be retrieved through hypnotic suggestion. Another study demonstrated that patients with PNES gained increasing access to their "ictal" experience (without hypnosis) during the course of an intensive psychotherapy programme (von Fabeck, 2010). This simply demonstrates that compartmentalization of memories, which is a key component of Model 1, may occur in some patients with PNES at the time of their attacks; however, it does not prove that the attacks themselves are the product of compartmentalized material being activated.

There is better evidence for other dissociative phenomena arising during PNES. Arguably the best study in this area (Hendrickson et al., 2015) found that 61.4% of 223 patients with PNES reported recurrent symptoms of unreality, detachment and disconnection (i.e., depersonalization-derealization) immediately before, during or after their attacks; only 28.9% of patients with epilepsy (n = 128) reported similar experiences (cf. Goldstein & Mellers, 2006; Reuber et al., 2011). Other studies have found that a substantial proportion of patients with PNES report symptoms of arousal at the time of their attacks (Galimberti et al., 2003; Goldstein & Mellers, 2006; Hendrickson, Popescu, Dixit, Ghearing, & Bagic, 2014) but that subjective anxiety is comparatively infrequent. Hendrickson et al (2014), for example, found that 82.6% of their participants with PNES reported four of more physical panic symptoms (compared to 34.6% of the group with epilepsy), while Hendrickson et al (2015) revealed that only 40% of the PNES group reported feeling anxious. Although fewer patients with epilepsy in these studies reported subjective anxiety (23%), this represents a much larger proportion of those who reported four or more physical panic symptoms than in the PNES group (66.5% vs. 48.4%). These data are particularly revealing in the context of studies indicating that there are two distinct clusters of patients with PNES, one of which reports high levels of psychopathology (including anxiety) compared to controls with epilepsy and the other which does not (Brown et al., 2013; Cragar, Berry, Schmitt, & Fakhoury, 2005; Reuber, Pukrop, Bauer, Derfuss, & Elger, 2004; Uliaszek, Prensky, & Baslet, 2012). Taken together, these findings suggest that many people with PNES experience elevated physical arousal but do not recognize or describe themselves as anxious (Goldstein & Mellers, 2006; Dimaro et al, 2014). This may explain why scores on explicit

measures of general anxiety (i.e., outside the attacks) are only moderately elevated in groups of patients with PNES, and only slightly higher than controls with epilepsy in 28 studies comparing the two (median d = 0.24; Brown & Reuber, 2016). It also provides some support for the panic without panic model of PNES, although it is unclear how that concept might apply in cases where subjective anxiety is reported.

Somatization and emotional processing

Evidence concerning the apparent disparity between physical and subjective symptoms of anxiety could also be regarded as consistent with the idea that PNES are a physical manifestation of emotional distress (Model 3). The main evidence base pertaining to that model comes from studies comparing patients with PNES and those with epilepsy on questionnaires that purport to measure this tendency directly, such as the Minnesota Multiphasic Personality Inventory (MMPI hysteria and hypochondriasis sub-scales; Hathaway & McKinley, 1940), the Personality Assessment Inventory (PAI conversion and somatization sub-scales; Morey, 1991) and the Symptom Checklist 90 (SCL-90 somatization sub-scale; Derogatis, Lipman, Rickels et al., 1974). Over twenty such studies have been conducted, with PNES patients scoring substantially higher in all cases (MMPI studies: hysteria sub-scale median d = 1.28; hypochondriasis sub-scale median d = 0.95; non-MMPI studies: median d = 0.75; for details see Brown & Reuber, 2016). This difference seems to remain when anxiety, depression and trauma-exposure are controlled for (Reuber, House, Pukrop, Bauer, & Elger, 2003; Roberts et al., 2012) and is apparent across different sub-groups of PNES patients, despite substantial differences in psychopathology more generally (Brown et al., 2013; Cragar et al., 2005; Uliaszek et al., 2012). Other studies have found that non-seizure medically unexplained symptoms (MUS) are common in patients with PNES (e.g., Bowman & Markand, 1996; Dixit, Popescu, Bagic, Ghearing, & Hendrickson, 2013; Duncan et al., 2011; Elliott & Charyton, 2014; McKenzie, Oto, Graham, & Duncan, 2011), who also tend to rate their physical health and functioning as worse than people with epilepsy (Al Marzooqi, Baker, Reilly, & Salmon, 2004). A higher number of somatic symptoms reported by patients with PNES is also associated with a greater severity of the disorder (even when dissociation and other psychopathology are controlled for) and with poorer outcomes (Reuber et al, 2003; Reuber, Pukrop, Bauer et al., 2003).

Taken together, these studies clearly indicate that a tendency to report physical symptoms and disability is comparatively common in patients with PNES. This, coupled with the findings concerning the relatively modest levels of explicit anxiety described above, could be taken as evidence that patients with PNES tend to focus on the physical rather than the emotional components of their distress. Scales such as the MMPI, PAI and SCL-90 only measure physical symptoms and

not the processes giving rise to them, however. As such, it is unclear whether these findings indicate an active avoidance of emotional material, which is a central component of the original conversion and somatization models, or something less motivated, such as a heightened awareness of normal bodily events. Evidence suggesting a link between PNES and problems filtering out irrelevant stimuli (Pouretemad, Thompson, & Fenwick, 1998; Almis, Cumurcu, Unal, Ozcan & Aytas, 2013) could be seen as more consistent with the latter interpretation.

Studies addressing how patients with PNES manage their emotions paint a mixed picture. Roughly a third of this group have pronounced difficulties recognising their emotional states (i.e., alexithymia; Kaplan et al., 2013; Myers, Matzner, Lancman, Perrine, & Lancman, 2013; Tojek, Lumley, Barkley, Mahr, & Thomas, 2000; Wolf et al., 2015; for a review see Brown & Reuber, 2016). However, the rate of alexithymia in patients with PNES is largely comparable to that seen in patients with epilepsy and other medical outpatients (Tojek et al. 2000; Myers et al., 2013; Taylor, Bagby & Parker, 1997). Several studies have found higher levels of physically and/or emotionally avoidant behaviour in patients with PNES compared to healthy controls (Bakvis, Spinhoven, Zitman, & Roelofs, 2011; Cronje & Pretorius, 2013; Dimaro et al., 2014; Frances, Baker, & Appleton, 1999; Goldstein, Drew, Mellers, Mitchell-O'Malley, & Oakley, 2000) and epilepsy (Goldstein & Mellers, 2006; Novakova, Howlett, Baker, & Reuber, 2015; cf. Frances et al., 1999). Similarly, Jawad et al (1995) found evidence of defensive denial in patients with PNES, as did Stone, Binzer and Sharpe (2004) who also identified a tendency to emphasize somatic rather than emotional causes for their difficulties. A tendency to suppress affect was identified by Novakova et al (2015) and Gul and Ahmad (2014), whereas problems with emotional regulation were found by Roberts et al (2012). In contrast, other studies have found no evidence for disproportionate denial (Kaplan et al., 2013; Testa & Brandt, 2010; Testa, Krauss, Lesser, & Brandt, 2012) or emotional suppression (Testa et al., 2012) in this group. As before, these variable findings probably reflect the heterogeneity of patients with PNES: Reuber et al (2004), Uliaszek et al (2012) and Brown et al (2013) all found emotion regulation problems in only a sub-set of patients with PNES, alongside elevated psychopathology more generally. Brown et al (2013) found that alexithymia was consistently elevated in this group but much less common in a separate cluster of PNES patients with less psychopathology.

On balance, these findings suggest that a significant proportion of patients might be considered emotionally avoidant, which could be seen as consistent with Model 3. The existence of a sub-group of patients with PNES who report multiple physical symptoms but otherwise deny significant psychopathology has also been interpreted as evidence that PNES are a physical manifestation of emotional distress (Reuber et al., 2004; Cragar et al., 2005; Uliaszek et al., 2012). It

is difficult, however, to reconcile that interpretation with evidence suggesting that the most emotionally dysregulated and alexithymic patients also have the highest levels of psychopathology and physical symptom scores. It is also unclear how it would explain the negative findings of those studies that failed to find evidence of denial and emotional suppression. Also problematic is the fact that a relationship between PNES and difficulties managing affect could be regarded as consistent with all of the models described above, and therefore says little about the precise mechanisms of these phenomena. Finally, it is uncertain whether the physical component of an emotional state could realistically explain the defining features of PNES (i.e., loss/alteration of consciousness; abnormal movements) without additional theoretical assumptions. The Freudian model does posit a mechanism (i.e., conversion) to explain these features, but how such a mechanism might operate remains unclear.

Stereotyping of symptoms

The idea that PNES reflect a hard-wired behavioural tendency (Model 2) is consistent with evidence suggesting that attack semiology is relatively stereotypic both between and within individuals (Seneviratne, Reutens, & D'Souza, 2010) and the existence of various culture-specific syndromes that closely resemble PNES (Brown & Lewis-Fernández, 2011). Other studies have found that PNES are quite variable within patients (Reuber et al., 2011), however, and that there are cultural variations in the presentation of PNES-like phenomena (Brown & Lewis-Fernández, 2011). PNES have also been shown to be considerably less stereotyped than either epilepsy or syncope (Reuber, Chen, Jamnadas-Khoda et al., In press). The number of, and variability between, different semiological sub-types of PNES (six in Seneviratne et al., 2010), and the fact that one seizure type can merge into another in a single PNES, also do not map easily onto a single hard-wired response. At least some modification of Model 2 is therefore required if it is to be a complete account of PNES.

Symptom learning

A possible link between PNES and prior exposure to seizures is often cited as evidence that PNES are learnt behaviours (Model 4) modelled on events encountered elsewhere (e.g., Moore & Baker, 1997; Bodde et al., 2009). It is well established that patients with PNES are more likely to have epilepsy than the general population (Reuber et al., 2003), suggesting that some element of learning may be involved. Similarly, Bautista, Gonzales-Salazar and Ochoa (2008) found that patients with PNES were more likely than those with epilepsy to have encountered seizures in other people before the onset of their own attacks. Other studies have found that patients with PNES are disproportionately likely to have a history of mild head injury, often with brief loss of consciousness,

in the weeks or months prior to the onset of their attacks (e.g., Elliott & Charyton, 2014; LaFrance et al, 2013; Mokleby et al., 2002; see Brown & Reuber, 2016). Few studies have considered whether positive and negative reinforcement influence the development and maintenance of PNES, however. There is some evidence that patients with PNES are more likely to be claiming public benefits than patients with epilepsy (Binder, Salinsky, & Smith, 1994; Kristensen & Alving, 1992), although this is more likely to be attributable to psychiatric co-morbidity than the attacks themselves (Brown & Reuber, 2016).

Summary

This brief overview demonstrates that there is evidence for each of the four main models of PNES, although the same body of evidence suggests that none of the models in their current form can provide a universal account of the disorder. One of the key limitations of models in this area is that they rarely provide an explicit account of key aspects of the phenomenology and semiology of PNES, such as the perceived involuntariness and apparent loss of consciousness reported by many patients, or the unusual motor movements that are often exhibited.

One likely reason for conflicting findings (or, in some cases, discordant interpretations of broadly concordant findings) is the clinical heterogeneity of PNES. Heterogeneous contributory mechanisms are not only observed between different individuals with PNES, but the factors contributing to PNES may also change over the course of the disorder. Thus, an initial tendency to exhibit dissociative responses to particular stimuli may be aggravated by symptom misinterpretation and turned into a chronic problem by positive and negative reinforcement. What is more, the mechanisms described thus far are not mutually exclusive, and could be active simultaneously in a single patient. Indeed, most theorists draw on more than one of these when attempting to explain PNES (see e.g., Baslet, 2011; Bodde et al., 2009; Reuber, 2009). Unfortunately, the boundaries and connections between these mechanisms are rarely defined. This makes it difficult to generate precise hypotheses about their role or relative contribution in PNES. Indeed, many authors use generic terms that obscure potentially important differences between underlying mechanisms. The term "dissociation", for example, could refer to either mental fragmentation (i.e., Model 1) or an altered state of consciousness characterized by depersonalization (i.e., Model 2), with very different clinical and empirical implications in each case. Similarly, high scores on measures such as the SDQ-20 could be seen as evidence for Model 1 if the scale is regarded as a measure of dissociative traits, or Model 3 if it is regarded as a more general measure of physical symptom reporting. Evidence indicating that a significant proportion of patients with PNES have experienced health-related trauma (Duncan & Oto, 2008) also suggests a potential bridge between Models 1 and 3.

In the following sections, we attempt to address these shortcomings by integrating existing models of PNES within an over-arching framework, which describes in detail how these different mechanisms relate to each other and their relative contribution to the development and maintenance of PNES. In so doing, we explain existing findings concerning PNES whilst making a number of novel predictions for future study.

TOWARDS AN INTEGRATIVE THEORY OF PNES

Explanatory domain

Within the literature, any paroxysmal event that resembles or is attributed to epilepsy, but which is apparently generated by "psychological" rather than epileptic processes, may be regarded as a form of PNES. Although useful for the clinical practice of neurologists, such an approach is problematic in that it obscures important differences between potentially distinct phenomena. Evidence suggests that a proportion of patients with a diagnosis of PNES have anxiety disorders (e.g., panic) that could entirely explain their attacks (Alper, Devinsky, Perrine, Vazquez, & Luciano, 1995). Similarly, there are patients with PTSD, Dissociative Identity Disorder (DID), Depersonalization Disorder, Factitious Disorder or challenging behaviour in the context of learning disability whose "seizures" are essentially explained by those conditions, and who may not have attracted the PNES label had they had been assessed by a psychiatrist rather than a neurologist. In other cases, however, such diagnoses are insufficient to explain the existence and/or the presentation of the attacks and need to be regarded as comorbid rather than explanatory. Why these different phenomena all attract the same label is an interesting question, but this is arguably not what theories of PNES are intended to explain. Moreover, incorporating them all within a common explanatory framework makes it difficult to delineate precise psychological mechanisms and raises major problems when it comes to selecting homogeneous groups for research or developing effective treatment strategies.

We suggest that the phenomenon of fundamental interest to researchers in the field of PNES is that variant of DSM-5 Conversion (Functional Neurological Symptom) Disorder characterized by behavioural and experiential paroxysms that resemble epileptic seizures but which cannot be fully accounted for by other psychiatric conditions like Panic Disorder, Depersonalization Disorder, PTSD, DID, Somatic Symptom Disorder etc. That is not to say that PNES cannot occur in the context of these conditions: indeed, they may be a central symptom of them or interact in other ways. The key point is that it should be possible to explain PNES without reference to these conditions, whilst also being able to accommodate their co-occurrence.

Having pinned down the population of interest, what phenomena must a theory of PNES explain? First, there is the initial onset of seizures, followed by their development into a problem that is maintained over time. Second, there are the characteristic features of the attacks themselves, particularly their seizure-like semiology (e.g., abnormal motor movements) and phenomenology (e.g., perceived involuntariness; alterations in awareness and responsivity), as well as the fact that these can be highly stereotyped and yet also vary significantly both between and within individuals over time. Third, an explanatory model needs to acknowledge that PNES are particularly dramatic moments of a disorder also characterized by abnormal functioning between seizures. Finally, it must explain the apparent similarities between different patients with PNES, as well as how they diverge. With regards to the latter, it is clear that patients with PNES vary significantly in their reports of seizure experiences and overt psychopathology, and that they may or may not report exposure to potentially traumatizing events.

The Integrative Cognitive Model

Arguably the most consistent finding in this area is that patients with PNES report more physical symptoms of all types than relevant controls, including patients with comparable trauma histories (Roberts et al., 2012); this seems to be true regardless of the overall level of psychopathology (Brown & Reuber, 2016). One way of interpreting this is that PNES are one manifestation of a broader tendency to experience and report "medically unexplained" physical symptoms (MUS), all of which result from similar underlying processes. This idea is central to Model 3 described above. However, there do appear to be some differences between patients with PNES and other MUS. Guz et al (2003), for example, found that patients with PNES (n = 23) reported significantly more dissociation than conversion disorder patients with motor symptoms or deficits. Similarly, there is evidence that patients with PNES are more likely to report histories of abuse, childhood adversity and significant life stressors prior to the onset of their symptoms than patients with functional (i.e., medically unexplained) movement disorders (FMD; Stone et al. 2004; Driver-Dunckley, Stonnington, Locke, & Noe, 2011; Reuber, Howlett, Khan, & Grunewald, 2007). Conversely, a history of explicit anxiety was identified as more common in patients with FMD than PNES by Driver-Dunckley et al (2011). There are also differences in phenomenology: PNES are clearly episodic in nature, unlike some other MUS that are more continuous. Most patients with PNES report that their episodes involve impairment of consciousness. Even if PNES and other MUS have some mechanisms in common, it is clearly necessary to account for these differences as well.

Given the evident overlap between many features of PNES and other MUS, we believe that a comprehensive account of PNES must draw on, and be consistent with, theory concerning MUS in

general. Accordingly, the model we present here builds on the Integrative Cognitive Model (ICM) of MUS (Brown, 2002a, 2004, 2006, 2013a,b), which was developed as an over-arching account of functional symptoms. Although the ICM has been applied to PNES previously (e.g., Brown, 2013a), we go beyond the original account by elucidating the role of emotional processes in PNES, which have received only minimal attention in previous versions of the model. We also draw on the specific evidence base pertaining to PNES to identify potential differences between this phenomenon and other MUS, which have not been considered previously within the ICM.

Consciousness, emotional processing and behaviour

A central principle within the ICM is that an understanding of ordinary consciousness and action control is necessary if we are to explain functional symptoms like PNES (Brown, 2004, 2006, 2013a,b). The ICM adopts a constructivist approach to perception, assuming that the contents of awareness are an inference made about current inputs based on knowledge stored within the system. According to the model, inputs from the internal and external environment automatically trigger a parallel spread of activation within associative memory, simultaneously generating a number of possible hypotheses about the cause and nature of those inputs. The most active hypothesis is then combined with sensory data to produce a multi-modal representation that forms the contents of conscious awareness and provides the basis for further cognition and action. By this view, perception, cognition and action are partly determined by what is present in the world, partly by what the perceptual system predicts will be present given past experience and partly by inherent structural properties of the system (i.e., what it is capable of representing).

In the original ICM, no reference was made to the role of emotional evaluation in the perceptual process. Here, we follow Barrett and Bar (2009) in assuming that the basic 'gist' of inputs to the system are captured shortly after stimulus registration, triggering autonomic and endocrine changes that recreate the internal milieu associated with similar stimuli in the past (see also Van der Bergh, Witthöft, Petersen & Brown, submitted). This allows the system to predict whether those stimuli are aversive, appetitive or neutral, and to motivate action (e.g., approach, avoid, communicate to others) accordingly. The tendency to categorize stimuli as threatening at this early stage of processing varies according to differences in state and trait anxiety (Hariri, 2009; Yiend, 2010; Robinson, Letkiewicz, Overstreet et al., 2011), and probably variations in arousal more generally. This process is largely unconscious, although the individual may become aware of non-specific intuitions or "gut feelings" in relation to the stimulus (e.g., threatening vs. rewarding; avoid vs. approach), as well as associated autonomic symptoms. The precise nature and meaning of the stimulus will only become apparent after further processing has taken place, however. This will

involve both pre-conscious (in the form of further spreading of activation within associative memory and other systems) and post-conscious processing (in the form of active reasoning about the meaning of inferences and feelings arising from the lower level).

The ICM assumes that the outputs of perceptual and emotional inference automatically activate a hierarchical system of procedural representations (schemata) specifying the attentional, evaluative, cognitive, autonomic and motoric processes involved in executing well-learned actions. At the top of this hierarchy are high-level programs corresponding to general situations (e.g., "driving a car", "going to a restaurant"). Within each of these high-level programs are simpler representations corresponding to different acts within that situation (e.g., "reversing", "ordering food"); each of these representations has even simpler sub-programs describing the various elements of the act (e.g., "changing gear", "reading the menu") and so on. These programs are activated to varying degrees by perceptual output; when a threshold level of activation is reached, the program is triggered automatically and the associated behaviour (or cognitive process) runs until completion unless it is impeded or inhibited by other information in the system. This automatic execution of programs ("contention scheduling" in Norman & Shallice, 1986) provides the system with a means of controlling routine cognition and action that is rapid, highly efficient, and consumes relatively few processing resources. Behaviours controlled at this level are experienced as occurring without conscious effort, meaning that much complex behaviour is performed automatically and with minimal will or conscious representation. Functionally speaking, such acts are "unwilled" but are typically experienced by the individual as ego-syntonic and voluntary (albeit effortless) due to their congruence with relevant information (e.g., goals; the context of the action) in the system (Brown & Oakley, 2004).

An additional means of control is required in cases where the system lacks the appropriate representations to guide behaviour effectively. In the ICM, novel actions are controlled by a secondary attentional system (SAS), a high-level, executive system that controls action indirectly by biasing the relative activation levels of lower-level programs. Secondary attention is the site of self-regulatory processing, whereby cognition and action are moderated in the pursuit of personal goals. In addition to increasing the activation of relevant programs, a key function of this system is to inhibit the activation of inappropriate programs. Behaviours controlled at this level are "willed"; they are perceived as mentally demanding, and are associated with a sense of conscious volition and self-awareness (Brown & Oakley, 2004). On a neural level, this system is sub-served by a complex network of structures with particular representation in frontal and prefrontal areas (Shallice & Cooper, 2011).

Functional symptoms and the activation of rogue representations

A central tenet of the ICM is that numerous factors other than stimuli themselves influence the activation of hypotheses during the perceptual process, meaning that the most active hypothesis may not be the one with the closest relationship to actual events in the world. If the match is good, perceptual experience will be an accurate reflection of reality. If the match is poor, however, then experience will be distorted, influencing behaviour accordingly. As the processes by which knowledge shape perception are preconscious, however, the individual is unaware that their experience is a misrepresentation. Many perceptual illusions, magic tricks and phenomena like the placebo effect all capitalize upon this tendency to perceive what we expect as much as what is actually "out there". The same applies to behavioural programs; here, too, the most active representation (and therefore the behavioural/cognitive routine enacted) may not have the closest match with the perceptual input, meaning that unwanted experiences can arise when automatically triggered behaviours (broadly speaking, "habits") conflict with the individual's goals. Dialing an out-of-date telephone number, hypnotic behaviours and inappropriate responses in the children's game Simon says are familiar non-clinical examples of behaviours that are executed "on auto-pilot" in this way. Here the behaviours are experienced as occurring involuntarily (and are potentially ego-dystonic) because they are either inconsistent with system goals or, in the case of hypnotic phenomena, because beliefs about the context suggest they should be experienced that way (Brown & Oakley, 2004).

The essence of the ICM is that functional symptoms arise when the activation levels of hypotheses or representations pertaining to physical illness increase to the point where the system regards them as the best explanation of, or response to, what is happening in that moment, regardless of how consistent they are with sensory inputs. As the individual has no introspective access to the inferences underlying perception, the resulting symptoms are experienced as 'real'. Brown (2004) coined the term rogue representations to refer to hypotheses and programs that distort perception and action in this way.

By this view, the type of symptom experienced depends on the nature of the rogue representation involved. If the representation specifies the presence of a nociceptive stimulus, for example, unexplained pain will result. If it is a cognitive routine inhibiting visual processing, the experience will be one of functional blindness. According to this account, the onset and maintenance of functional symptoms can be understood with reference to the factors that trigger the initial activation of a rogue representation and maintain that activation over time. In the original version of the model, anything that increased attention to the rogue representation was identified as particularly

important in this regard (Brown, 2002a, 2004, 2006). More recently, it has been suggested that high-level attentional dysfunction also contributes to functional symptoms, by undermining the individual's ability to inhibit discrepant mental representations (Brown, 2013a, b; In press; Dimaro et al, 2014).

The mechanisms of PNES

In previous descriptions of the ICM, it was suggested that PNES are essentially the same as other functional symptoms, except that the underlying rogue representation is characterized by motoric (e.g., convulsive movements) and cognitive (e.g., loss of awareness) features that resemble an epileptic event (e.g., Brown, 2013a). By that view, all seizure types could be explained with reference to the rogue representation concept, including convulsive, syncope-like and panic-like attacks, as well as more complex seizures involving automatisms, hallucinations etc. Whilst we retain this basic notion here, it is apparent that there are certain features of PNES that are not easily accounted for by this concept. In particular, several of the studies described above suggest that many patients with PNES experience multiple autonomic symptoms around the time of their attacks, sometimes in the absence of subjective fear (i.e., 'panic without panic'). Similarly, both Reinsberger et al (2012) and Van der Kruijs, Vonck, Langereis et al (2016) found objective evidence for increased arousal before PNES followed by a significant reduction post-ictally (see also Ponnusamy, Marques, & Reuber, 2012). There is also evidence for ictal depersonalization and derealization in many patients. How might these findings be accommodated in the ICM?

As in the original ICM, we suggest that the central component of PNES is a transient loss in behavioural/cognitive control arising from the automatic execution of a seizure representation in memory (the seizure scaffold; see below); unlike the original ICM, however, we suggest that this often occurs in the context of significant autonomic changes related to threat processing. More specifically, we suggest that there are three separate stages that are commonly (although not universally; see below) found in PNES (Figure 1). The first stage is characterized by an acute increase in sympathetic arousal associated with a range of autonomic symptoms, which may or may not be accompanied by a lack of subjective fear (cf. Model 2); we discuss why these changes are represented as physical rather than emotional experiences below. This compromises inhibitory processing (typically in the context of compromised high-level processing more generally), rendering the individual vulnerable to the automatic activation of rogue representations. This, coupled with the prediction (conscious or otherwise) that an attack is likely to occur, results in a runaway surge of activation in the seizure scaffold. This triggers the second stage, in which the cognitive-behavioural component of the scaffold is executed, resulting in the attack-proper (cf. Model 4). Although ego-

dystonic, this experience interrupts the sympathetic response in the third stage of the process, triggering a reduction in arousal. There may also be a rebound increase in parasympathetic tone in the recovery phase (minutes to hours) following a PNES, which could help to explain common post-ictal phenomena such as exhaustion, reduced alertness and cognitive capacity.

The semiology and phenomenology of the attack is related to the content of the seizure scaffold, a dynamic mental representation that develops as experiences and information accumulate and interact with inherent behavioural response patterns, resulting in considerable individual differences. In some cases, the scaffold may consist mainly of material stored following previous exposure to seizures/seizure-like phenomena and related experiences (e.g., loss of consciousness). In others, inherent components (i.e., 'hard-wired' behavioural patterns) are likely to be more relevant, such as actions and cognitive biases typically associated with emotions such as fear, anger and/or disgust (cf. Kretschmer, 1923; Baslet, 2011); this is consistent with the apparently universal existence of PNES-like phenomena across cultures (Brown & Lewis-Fernández, 2011; Martinez-Taboas, 2005) and the stereotyping of symtoms often seen. Rather than being cognitively impenetrable reflexes, we assume that these are general action tendencies that can be modified by other information, beliefs and goals within the system, consistent with the apparent variability of PNES between and within cultures and individuals (cf. Baslet, 2011).

--- INSERT FIGURE 1 ABOUT HERE ---

Verifying and characterizing a reduction in arousal during PNES, which we mainly posit on theoretical rather than empirical grounds, will be an important task for future research. Many of the symptoms associated with PNES certainly fit this profile as do the physiological data described by Reinsberger et al (2012) and Van der Kruijs et al (2016). From a theoretical perspective, such a reduction in arousal would contribute to the development of symptom chronicity via a process of negative reinforcement (cf. Model 4). In this respect, the model is consistent with a behavioural understanding of PNES, as well as the psychodynamic idea that PNES can serve a psychological function for some individuals. Whilst we believe that many PNES are characterised by an initial increase and subsequent decrease in sympathetic arousal, however, we only consider the execution of the seizure program (i.e., stage 2 above) to be an essential aspect of PNES, which may arise if there is sufficient activation of the seizure scaffold in the context of a high-level processing dysfunction (dashed area in Figure 1). Indeed, as the system comes to predict that potentially unpleasant arousal (and/or other distressing experiences, such as cognitive dissonance) can be averted by executing the seizure program, so conditioned stimuli may come to elicit attacks before any threat or arousal is experienced. This explains why symptoms of arousal are not a universal occurrence during PNES

(see e.g., Hendrickson et al., 2014; Brown & Reuber, 2016). We predict that such symptoms will be more common in the early stages of the condition, before the effects of conditioning are established and generalized.

An interesting, but potentially fraught, question is the extent to which individuals might willfully submit to seizures in order to experience the resulting "relief", which was identified as a feature in several patients with PNES discussed by Stone and Carson (2013; also Reuber et al., 2011). This concept potentially applies to our account, as the build-up of arousal/dissonance in the pre-ictal phase is likely to be disturbing to the individual, particularly where they perceive it as a physical experience that is out of their control (see below). As the individual learns that seizures bring about a degree of relief from this in the short term, so submitting to the (apparently) inevitable might come to be regarded as preferable to remaining distressed or "fighting a losing battle". However, we do not believe that submitting in this way is a necessary component of the seizure experience; moreover, if it occurs, it does so some way into a process that includes both unwanted and uncontrolled elements. Thus, while there may be varying degrees to which processes perceived as voluntary contribute to the seizure experience, involuntary processes are always a feature of PNES in this account.

In the sections below we expand on different aspects of this model, including how they fit with the evidence in this area and what they imply in terms of novel predictions for future study.

Relationship with other clinical phenomena

The emphasis on the automatic activation of mental representations enables the model to explain the perceived involuntariness of PNES, which reflects the fact that the process is unwilled and inconsistent with the individual's goals. We suggest that this aspect of the process is common to other functional neurological symptoms (FNS), and that the main difference in symptom semiology and phenomenology pertains to the content of the underlying mental representations. However, we also suggest that the rapid, paroxysmal and often acutely frightening nature of PNES means that they are more likely to be accompanied (and triggered) by symptoms of hyper-arousal than other FNS (although increased arousal may also be apparent in the early stages of other sudden-onset symptoms; Stone et al., 2012). Indeed, this may explain why patients with more continuous FNS are even less likely to perceive their problem as 'emotional' than patients with PNES (Ludwig, Whitehead, Sharpe et al., 2015). This panic-like surge in arousal will also feed into the seizure scaffold, influencing how sensory and emotional information is processed during the ictus and creating a platform for non-epileptic events that share some of the subjective characteristics of hyper-arousal, but without the underlying physiological changes.

We propose that hyper-arousal also accounts for the evident overlap between many PNES, panic attacks and the autonomic symptoms observed in many cases of PTSD. Indeed, we assume that the surge in arousal that accompanies reliving phenomena in PTSD is a common trigger for many PNES, consistent with the increased prevalence of trauma in this group compared to patients with other FNS (Stone et al., 2004; Driver-Dunckley et al., 2011; Reuber et al, 2007). It is also consistent with studies showing reduced medial prefrontal and rostral anterior cingulate activity during episodes of hyper-arousal and traumatic re-living (Lanius, Vermetten, Loewenstein et al., 2010; Lanius, Brand, Vermetten et al., 2012), which are thought to be indicative of reduced inhibitory processing in PTSD.

If the initial source of hyper-arousal is a traumatic flashback, then it is likely that the flashback will be a key component of the seizure scaffold (cf. Model 1; see below). In this respect, many PNES related to trauma might be thought of as a kind of reliving phenomenon. This is reminiscent of psychodynamic ideas concerning the recapitulation of trauma material during PNES (e.g., Breuer & Freud, 1893-1895/1955), although the concept of symbolism is not crucial in the current account. Importantly, hyper-arousal is not an essential component of PNES in our model, clearly distinguishing them from panic attacks and explaining why PNES may occur in the absence of a trauma history or obvious acute stressors. Moreover, the seizure scaffold may or may not incorporate elements of traumatic memories; even where this is the case, seizures can still be triggered in the absence of flashbacks or trauma recollection more generally if there are other sources of activation for the scaffold.

Emotional processing

If hyper- and hypo-arousal are common, if not essential, features of PNES, why do patients tend to focus on the physical aspects of these changes rather than subjective emotional states such as fear? Similarly, if threat processing is a key component of PNES, why is there only a small difference between this group and patients with epilepsy in terms of subjective anxiety symptoms? If anything, the available evidence suggests that that difference is driven by a sub-group of patients with very high self-reported anxiety, and that the wider group of patients with PNES report levels of anxiety that are comparable to those reported by healthy controls (Brown & Reuber, 2016). In contrast, physical symptom reports are consistently elevated in patients with PNES, even in sub-groups with relatively few problems in other areas.

Taken together, these findings seem consistent with the idea that patients with PNES tend to represent emotional states as physical symptoms rather than affective experiences (i.e., Model 3). One possibility is that this tendency is motivated by the threat-value associated with recognizing the

emotional state(s) in question, perhaps because they are inconsistent with the individual's self-concept or because acknowledging the reality of their circumstances feels too dangerous. Although originally a psychodynamic idea, a similar concept is also central to cognitive dissonance theory, which asserts that conflicting thoughts, feelings, behaviours etc. are associated with tension and anxiety, and motivate attempts to alleviate those feelings by reducing the conflict. Focusing attention on the physical component of the experience might allow the individual to reduce dissonance, whilst meeting an intrinsic need to render the experience predictable, a central concept within predictive coding models of functional neurological symptoms (Edwards et al., 2012) and symptom reporting more generally (Van den Bergh et al., submitted). In other words, if it is too threatening for the individual to recognize the emotional character of their experiences, a physical explanation for them is better than the anxiety associated with outright uncertainty (a case of "better the devil you know"; Van den Bergh et al., submitted). Emotional suppression/avoidance may also reduce the precision of interoceptive signals, making the individual more reliant on beliefs and expectations about what is happening in the body and thereby vulnerable to perceptual distortion (ibid). In some ways, this is a modern take on the Freudian concept that converting distress into physical symptoms prevents an unhealthy build-up of neural energy. Since the initial threat evaluation is pre-conscious, this shift in representation may be entirely outside the individual's awareness. The results of the only study in this area to consider preconscious threat evaluation (Bakvis et al., 2009) are consistent with this idea. It may also help explain the link between PNES and physical symptom reporting more generally, which we predict will be associated with a tendency to represent emotional states in a similar manner. For other people, the failure to represent emotional experiences as such may be due to intrinsic deficits in the ability to identify and/or describe emotional states or the cognitive consequences of high-level processing dysfunction, rather than being defensive in origin. The idea that this is only present in some individuals with PNES would explain the inconsistent findings on alexithymia in this group (Brown & Reuber, 2016).

In some circumstances, focusing on the physical aspects of one's experiences may constitute a highly adaptive response that enables the individual to retain a relatively normal sense of self and well-being in the face of on-going adversity (Dimaro et al., 2014, 2015). Indeed, there is evidence that patients who do not experience subjective fear symptoms during their panic attacks are better adjusted than those who do (Chen et al., 2009). One potential cost of representing their emotional states in this way, however, is that it can prevent them from deploying appropriate compensatory responses (e.g., assertion; planful coping; problem solving) to the internal and external stressors responsible for their distress. Indeed, several studies have found that patients with PNES are less

likely to engage in planful coping than controls (e.g., Frances et al., 1999; Goldstein et al., 2000; Testa et al, 2012). This is likely to result in chronic stress and over-arousal, compromising inhibitory processing as well as the individual's ability to reflect, control action and self-regulate more generally.

Several other findings described above are consistent with the idea that patients with PNES are emotionally avoidant, including the evidence of emotional suppression demonstrated by Gul and Ahmad (2014), the repression/denial reported by Jawad et al (1995), the emotional avoidance identified by Bakvis et al (2011), Dimaro et al (2014) and Novakova et al (2015) and the avoidant coping reported by Frances et al (1999), Goldstein et al (2000), Cronje and Pretorius (2013) and Goldstein and Mellers (2006). This concept may also go some way towards explaining the increased rate of dissociative experiences in this group, both generally and at the times of the attacks themselves. An influential and well-evidenced model by Sierra and Berrios (1998) suggests that depersonalization results from a hard-wired threat response involving the top-down inhibition of emotional processing in the amygdala. This process is evident in both depersonalization disorder (Sierra & David, 2007) and in the dissociative sub-type of PTSD characterized by depersonalization symptoms (Lanius et al., 2010, 2012). Although such an interpretation is somewhat removed from models derived from Janet's dissociation theory, it is appealing since it suggests that DES scores will often be elevated in patients with PNES, without this being necessary or sufficient to explain the phenomenon. It is therefore more consistent with evidence showing that not all patients with PNES exhibit high scores on measures such as the DES, and why overall group means tend to be elevated but somewhat lower than those seen in other conditions such as PTSD and DID (Brown & Reuber, 2016).

PNES and mental fragmentation

While this link with depersonalization is seen as indicative of a broader tendency to suppress affect, and therefore a predisposing factor for PNES, the concept of dissociative fragmentation (i.e., Model 1; aka compartmentalization) is more directly relevant to the automatic activation of rogue representations that lies at the heart of the model. Indeed, this idea bears a close resemblance to Janet's original suggestion that functional symptoms arise when mental fragments (perceptual hypotheses and cognition/action representations in our account) are activated by internal and external cues, distorting behaviour and experience accordingly. Importantly, the mechanism underlying PNES in this account operates at a relatively late stage in processing, leaving earlier processing intact but compartmentalized; this explains, for example, the reversible amnesia observed in the PNES patients studied by Kuyk et al (1999). It also suggests that other ictal deficits reported by PNES

patients will occur in the context of intact functioning in the affected modalities; thus, patients who report loss of consciousness during PNES should show evidence of (largely) intact auditory and somatosensory processing during the ictus if an appropriately indirect or implicit measure is used. This could be an important test of the model. Our approach departs from Model 1, however, by assuming that the mental fragments in question may or may not relate to previous traumatic experiences, a notion that is actually more consistent with Janet's original account than more recent dissociation approaches.

High level processing dysfunction

A central concept here is that the seizure scaffold will be automatically triggered when its activation threshold is exceeded unless the secondary attentional system inhibits it. Anything that undermines the secondary attentional system therefore increases the likelihood of PNES (cf. Janet, 1889). Evidence suggests that depression (e.g., Austin, Mitchell, & Goodwin, 2001), anxiety (e.g., Derakshan & Eysenck, 2009), PTSD (e.g., Polak, Witteveen, Reitsma, & Olff, 2012; Lanius et al., 2010, 2012), early-life adversity (e.g., Pechtel & Pizzagalli, 2011), stress (e.g., Holmes & Wellman, 2009) and poor sensory gating (e.g., Truelove-Hill & Yadon, 2015) are all associated with deficits in executive functioning, which may partly explain their association with PNES. The resulting high level processing dysfunction is reminiscent of the "unstable cognitive-emotional system" postulated by Baslet (2011) as a predisposing factor for the phenomenon, although our emphasis here is specifically on high-level inhibitory processes. We propose that a key source of this dysfunction is on-going stress and arousal, which may arise from a number of different sources including difficult or traumatizing life events (which are often associated with HPA-axis dysregulation; Roelofs & Spinhoven, 2007), physical illness, relationship problems, social isolation, emotional conflicts and so on. Although there are problems with the literature in this area, the available evidence is largely consistent with increased exposure both to traumatic events in childhood and to chronic stress in adulthood in patients with PNES (e.g., Brown & Reuber, 2016; Fiszman et al., 2004; Sharpe & Faye, 2006; Stone et al., 2004; Tojek et al., 2000). We suggest that the inconsistent findings regarding the role of stress and trauma reflect the fact that they have an indirect effect on PNES, mediated by their effects on arousal levels and high-level inhibitory functioning; in this sense, trauma and serious adversity are not necessary for PNES to develop, but may be predisposing factors for some people. In others, more subtle stressors, such as chronically unsupportive relationships or those where unrealistic demands are placed on the individual, may be much more relevant.

The extent to which these stressors/threats produce attentional dysfunction will depend on several factors, including the nature and duration of the stressors themselves, the use and nature of any

coping strategies, the availability of social support and the social environment more generally, and the individual's intrinsic reactivity to stress/threat. The most deleterious effects are likely to be found in situations where the individual is unable to use adaptive coping strategies, such as when they are repeatedly exposed to unavoidable adversity (e.g., a traumatic family environment; persecution and torture; high levels of traumatic flashbacks), has poor problem-solving and affect regulation skills, lacks appropriate social support, and/or is relatively unable to represent emotional states symbolically (i.e., alexithymia). In other cases, coping strategies may be either ineffective at managing stress (e.g., worry), confer vulnerability to further stressful events (e.g., stigma related to self-harm; risk-taking behaviours) and/or directly compromise attentional function (e.g., affect/thought suppression; worry/rumination; drug and alcohol misuse; self-poisoning; taking anti-epileptic drugs, painkillers, sedatives, anti-depressants etc.; Wells, 2000). There is also a reciprocal relationship between strategy use and attentional functioning, such that the greater the extent of attentional dysfunction, the less the individual will be able to select and execute appropriate coping strategies; this increases the likelihood of further attentional dysfunction, setting up a vicious cycle. Other factors adversely affecting brain functioning (acquired or congenital brain injury; epilepsy) may also impact on attentional ability, which could account for the relationship between PNES, non-specific brain injury (Reuber, Qurishi, et al., 2003) and epilepsy (Kotsopoulos et al., 2003; Reuber, Fernandez, Bauer, Singh, & Elger, 2002).

There is some neuropsychological and experimental evidence for impaired attentional-executive functioning in patients with PNES and symptoms such as memory and concentration problems are commonly reported by this group (e.g., Bakvis, Spinhoven, Putman, Zitman, & Roelofs, 2010; Pouretemad, Thompson, & Fenwick, 1998; Strutt, Hill, Scott, Uber-Zak, & Fogel, 2011; Willment, Hill, Baslet & Loring, 2015). Roelofs, Van Galen, Eling, Keijsers and Hoogduin (2003) also found evidence of an attentional deficit in patients with conversion paresis, which would involve similar mechanisms to PNES in the current model. Better characterizing this deficit is a task for future studies. It is an open question whether such deficits would manifest between seizures or in the pre-ictal period only; the latter would be of particular interest, although is clearly challenging to test.

Expectations

The model presented here suggests that PNES arise when the cognitive system places undue weight on the prediction that attacks will occur in certain circumstances. Another way of putting this is that PNES are a kind of self-fulfilling prophecy driven by the expectation that attacks are likely to occur. Importantly, however, these expectations exert their influence pre-consciously, meaning that the individual may or may not be aware of their influence. This concept has much in common with

the predictive coding account of FNS described by Edwards et al (2012). We suggest that these expectations are acquired incidentally when there is an initial experience (or set of experiences) resembling or otherwise suggesting a seizure in the context of cues (e.g., increased muscle tension, tremor and other panic-like symptoms resulting from increased anxiety/arousal) and beliefs suggesting that this will recur. This fits with evidence described above concerning the learned behaviour model of PNES, such as the frequent co-occurrence of PNES and epilepsy, increased exposure to seizure models in others, and the disproportionate prevalence of prior head injury with loss of consciousness in this group (see Brown & Reuber, 2016, for a review). Such expectations may also result from health-related traumatic experiences, which are very common in late-onset PNES in particular (Duncan, Oto, Martin, & Pelosi, 2006). Prior physical illness or injury is also frequently found in patients with other FNS (Stone et al., 2008), consistent with the common mechanism proposed here.

Whilst these studies are in keeping with the proposed model, prospective research using systematic measures in patients with new-onset PNES are clearly required to estimate the true prevalence of the relationship between PNES and antecedent events that create expectations for seizure onset. These events are likely to go beyond head injury and panic attacks to encompass a wider set of potentially relevant experiences, such as other conditions associated with transient loss of consciousness (e.g., syncope), disorientation (e.g., presyncope, hyperventilation), states of depersonalization-derealization and any other event that could be mistakenly attributed to a seizure/epilepsy.

The model also predicts that a disproportionate sensitivity to expectancy manipulations, such as hypnotic and non-hypnotic suggestion, will be a risk factor for developing PNES and other functional symptoms. Evidence of a relationship between PNES and hypnotic suggestibility (e.g., Barry et al., 2000; Goldstein et al., 2000; Kuyk et al. 1999) could be seen as consistent with this, as could the effectiveness of suggestion-based seizure-induction methods (e.g. McGonigal et al, 2002). In both cases the findings are mixed, however, perhaps reflecting participants' fears about losing control and/or other negative beliefs about suggestion/hypnosis. A better test of the hypothesis might be to use measures that place less emphasis on participants willfully submitting to suggestions, such as the Sensory Suggestibility scale (Gheorghiu & Reyher, 1982).

Seizure semiology and phenomenology

More compelling evidence for the model would be provided by experimental studies manipulating expectations about the nature of PNES. A key prediction is that the semiology and phenomenology of PNES will partly reflect knowledge, beliefs and other mental representations that

comprise the seizure scaffold. The studies carried out to date have only compared different PNES over a very short period of time and highlighted the stereotypy of different seizures (e.g., Seneviratne et al, 2010). One possibility is that benign information could be incorporated into established expectancy manipulations (e.g., intravenous saline; photic stimulation) used to provoke attacks in some epilepsy units, with a view to studying how this information shapes the nature of subsequent symptoms. It should also be possible to study whether the success rate of symptom provocation methods is associated with the degree of overlap between specific expectations and the content of the seizure scaffold, as assessed on an individual basis. For example, one could predict that photic stimulation would only be successful in patients who believe that their attacks are photo-sensitive. Again, we are not aware of any existing studies on this topic. A more challenging, but potentially more ethical, option would be to study the relationship between naturally occurring events (e.g., exposure to epileptic attacks whilst undergoing diagnostic monitoring) and whether this influences subsequent PNES during the assessment. Anecdotal reports of the effect of such exposure are widespread, but we are not aware of any studies that have addressed this empirically.

A small number of studies have considered how patients with PNES perceive their illness (e.g., Whitehead, Kandler, & Reuber, 2013), although we are not aware of any studies on what these patients believe about epilepsy and epileptic attacks, which could illuminate this aspect of the model.
Attending to seizure cues and triggers

We assume that the seizure scaffold is elaborated every time the person experiences an attack in different circumstances, potentially increasing the number of cues that can trigger attacks over time via interoceptive conditioning (for evidence concerning this process in patients with other functional symptoms see Van den Bergh, Stegen & Van de Woestijne, et al., 1997; Van den Bergh, Winters, Devriese & Van Diest, 2002). Traumatic intrusions and symptoms of hyper- and hypo-arousal are likely to be particularly important in this regard. An obvious prediction, albeit one that has not been subjected to systematic empirical scrutiny, is that symptoms associated with these states will be common triggers for PNES. This will include stressful and threatening situations that result in hyper-arousal, but should extend beyond this. Indeed, a common clinical anecdote is that patients with PNES often deny experiencing attacks when they are stressed, and that they tend to occur when the patient finally has the chance to relax. Although this remains to be evaluated empirically, it would be consistent with our hypothesis that PNES are just as likely to be triggered by symptoms of hypo- as hyper-arousal.

It should be possible, at least in theory, to relate the development of seizure semiology and phenomenology to experiences, events and contexts that the individual encounters over time.

Importantly, however, the individual may not be aware of, or able to articulate, the knowledge that contributes to the scaffold, much of which is acquired incidentally and stored in forms (e.g., complex associations of semantic, perceptual, emotional and procedural information) that are not readily accessible to reflection. A priority for future research will therefore be to develop methods for assessing individual differences in the seizure scaffold that don't rely exclusively on self-report.

We hypothesize that the likelihood of an attack occurring in the context of such cues depends on the extent to which the individual is looking out for or attending to them. This will partly be a function of the pre-existing activation levels of the seizure scaffold, which constitutes the extent to which a seizure is "expected" to occur[ii], and partly of threat processing, which triggers hypervigilance for, and facilitates engagement with, potential threat cues. A broader deficit in high-level attention, which we assume is a separate attentional factor to hypervigilance, may also contribute to this process by disrupting disengagement from relevant threat cues. Existing research on threat bias in PNES (e.g., Bakvis et al., 2009) is insufficient to verify these hypotheses, however, which should be a focus for future studies.

Other factors contributing to PNES development and maintenance

According to the model, symptom development is largely determined by factors that lead to over-activation of the seizure program, or which undermine the individual's capacity to inhibit it. Any such factor has the potential to predispose, precipitate and/or perpetuate PNES, with the precise combination of factors varying between individuals. We have already considered some of the factors that are relevant in this regard. Unfortunately, the quality and scope of research in this area make it difficult to draw firm conclusions regarding other important factors. We will therefore make a number of suggestions that are consistent with our model of PNES, but which clearly require empirical study.

Several factors identified in the cognitive behavioural model are likely to be important, particularly the tendency to interpret symptoms as seizures/epilepsy and a possible cause for concern. We suggest that this results in responses from the self and others that serve to elaborate, consolidate and activate the seizure scaffold, such as seeking information about seizures (e.g., on the Internet) and pursuing medical assessment and treatment. The scaffold will also be activated every time the individual seeks medical help, information or other reassurance in relation to their symptoms, and the resulting outcome (e.g., "keep an eye on it"; anxiety-provoking and/or misleading information on the Internet; inappropriate prescription of anti-epileptic drugs and their side effects) may perpetuate this further. Each of these coping strategies may have the additional effect of maintaining hypervigilance, plus negative emotional consequences such as stress, anxiety and depression. General avoidance of

feared situations (e.g., going out; being alone; bathing; cooking), which has been found in several studies on PNES (Cronje & Pretorius, 2013; Frances et al. 1999; Goldstein et al., 2000; Goldstein & Mellers, 2006), may allow unhelpful beliefs about the likelihood and dangerousness of seizures (both aspects of the scaffold) to proliferate, whilst fostering worry, rumination and social isolation (Robson, Drew, Walker & Reuber, 2012). From the psychodynamic/interpersonal perspective, unhealthy relationships with oneself and others also provide fertile ground for unhelpful responses to PNES, such as toxic appraisals (e.g., "I'm pathetic for having this problem"; "She's putting it on!"), the use of unhelpful coping strategies (e.g., repeated doctor visits; over-protection from others) and conflict with medical staff and carers, undermining social supports and leading to unstable therapeutic relationships.

PNES patient sub-types

A central assumption of the model described here is that the seizure scaffold is relatively fluid and has a stochastic activation threshold that must be exceeded in order for PNES to occur. We assume that multiple neuronal systems and pathways contribute to the development, activation and maintenance of the scaffold, and thereby the occurrence and features of PNES. We believe this approach captures the phenomenology of PNES better than one based on categorical patient sub-types, whilst allowing for the likelihood that different factors will vary in importance over time within individual patients. Nevertheless, the model easily accommodates evidence pointing to the existence of distinct sub-groups of PNES patients characterized by relatively high or low levels of psychopathology (e.g., Brown et al., 2013; Cragar et al., 2005; Reuber et al., 2004; Uliaszek et al., 2012). Patients with significant psychopathology exhibit a wide range of risk factors for the development of PNES in the current model, including insecure attachment, emotional under-regulation, maladaptive coping, and increased exposure to stressors (e.g., problematic relationships) and potentially traumatizing events. This pattern of difficulties, reminiscent of that seen in borderline personality disorder, is likely to be associated with significant high level processing deficits (Ruocco, 2005) and is therefore in keeping with the approach described here. We also incorporate the idea that suppressing, denying or otherwise failing to recognize stress and emotional experiences, coupled with a tendency to focus on physical rather than affective states, are likely to contribute to PNES in many patients. Such factors are thought to explain why a substantial proportion of patients with PNES exhibit relatively low levels of psychopathology but numerous physical symptoms.

As we saw previously, it is an open question whether all patients with PNES have difficulties regulating their affect in an adaptive manner. One of the advantages of the proposed model is that it links PNES to normal psychological processes (learning, attention, automatic behavioural control),

which go awry for various reasons. This leaves open the possibility that symptoms could arise in the absence of significant psychopathology, affective dysregulation or emotional suppression. Indeed, the approach on which this model is based assumes that the same basic mechanisms are involved in both pathological (e.g., PNES and other MUS) and non-pathological compartmentalization phenomena (e.g., temporary symptoms produced by hypnotic suggestion; Brown, 2002b, 2013b; Janet, 1889; Oakley, 1999). It also suggests that there are more basic predisposing factors for these phenomena, such as heightened suggestibility, the tendency to become absorbed in experiences (Bell, Oakley, Halligan, & Deeley, 2011; Brown & Oakley, 2004) and poor interoceptive accuracy (Bogaerts, Van Eylen, Li, et al, 2010; Schaefer et al, 2012). Theoretically, such factors could, if coupled with a context that affords the development and activation of seizure programs, be sufficient to give rise to PNES without any contribution from trauma, stress or psychopathology. Exploring this possibility is an intriguing question for future research.

TREATMENT IMPLICATIONS

Although the model outlined above is primarily described in cognitive terms, and is compatible with a cognitive behavioural approach, it does not suggest that cognitive interventions are the only (or necessarily the most appropriate) way of addressing the various predisposing, precipitating and perpetuating factors that contribute to PNES. Indeed, emotional inhibition and the tendency to represent affective states as physical experiences, which we identify as important vulnerability factors for PNES, are key psychodynamic concepts that may be best tackled using interventions from that tradition. For example, creating a safe therapeutic environment that enables the individual to recognize, tolerate and accept the broader emotional dimension to their physical symptoms may be particularly important for these individuals (e.g., Howlett & Reuber, 2009). Psychodynamic and interpersonal methods may also be useful in cases where unhelpful, but potentially unacknowledged, patterns of relating are driving stress/arousal (or vice versa) and thereby PNES. In many cases, however, there is also likely to be a need for more directive interventions that enable patients to develop strategies (e.g., relaxation, grounding, distraction) for managing hyper- and hypo-arousal and traumatic material.

Alongside tackling emotional regulation and representation where appropriate, the focus of treatment according to our model is on identifying and addressing factors that are activating the seizure scaffold and compromising attentional functioning. This includes tackling the circumstances that give rise to negative affect, chronic stress and heightened threat processing; dismantling aspects of the seizure scaffold more generally (e.g., beliefs concerning the meaning of attacks) and replacing them with healthier mental representations; and enhancing top-down control of the seizure scaffold,

perhaps using attention training or neurorehabilitation techniques. Simply explaining the diagnosis to patients may be sufficient to reduce arousal, alter coping and re-structure the scaffold (Duncan, Razvi, & Mulhern, 2011; Mayor et al., 2012). Whilst many of the interventions used to address these factors are likely to already be in use with PNES patients, the proposed model offers a framework for making systematic decisions about which interventions are most likely to help someone with PNES, without declaring allegiance to any particular "school" or "model" of therapy. In addition, the model suggests a number of avenues for clinical development, including the use of mindfulness, hypnotic suggestion and imagery techniques (see e.g., Brown, 2013a).

CONCLUSION

The label PNES is a neurological diagnosis of convenience, in most cases meant to denote that a patient's seizures are not related to epileptic discharges in the brain but are instead considered to have a "psychological" cause. The patients to whom this diagnostic label is given make up a highly heterogeneous group in terms of background, personality profiles, comorbidities, response to treatment and outcomes. Most previous accounts of the nature of PNES have dealt with this heterogeneity by describing a broad range of predisposing, precipitating and perpetuating factors without identifying necessary and sufficient features that explain the pathogenesis of the disorder.

In keeping with our previous Integrative Cognitive Model (ICM) of other medically unexplained symptoms we suggest that the preconscious activation of a rogue mental representation, the seizure scaffold, by internal or external triggers is common to all PNES (with the exception of those that result from patients' willed action, for instance in the context of factitious disorder). These rogue representations consist of cognitive-emotional-behavioural action programs that combine elements of inherent schemata (such as how to respond to fear) with the results of learning and experience across multiple contexts. Activation of the scaffold may or may not be associated with abnormal arousal, emotion or cognitive processing, accounting for the wide range of different PNES manifestations.

This model is in keeping with the findings of original studies documenting increased levels of previous trauma, heightened anxiety, arousal and avoidance in some but not all patients with PNES. It allows for PNES occurring in states of hypo- and hyper-arousal, as well as from a normal resting state. We believe the theory described here represents a major advance in our understanding of PNES, enabling existing theories and empirical findings to be integrated within a single overarching framework, thereby accounting for a number of hitherto unexplained aspects of PNES.

Whilst our model uses the language of cognitive psychology, we do not wish to suggest that the most successful treatment will focus specifically on cognitions. Cognitive restructuring may be

helpful for individual cases but other psychotherapeutic treatment options may be more appropriate to address relevant targets, such as increasing patients' tolerance of traumatic memories, other seizure triggers and arousal, helping them regulate their emotions more effectively, or changing interpersonal patterns of behaviour likely to foster recurrence or hinder recovery.

Aside from explaining existing findings in this area, a key strength of our account is that it makes a number of testable predictions, for instance that primary sensory processing should be normal during PNES, that PNES do not invariably occur in a state of autonomic arousal, that PNES manifestations and experience are likely to change over a patients' lifetime, and that PNES manifestations can be affected by patient expectations. These hypotheses will need to be tested in future studies involving sufficiently large groups of patients with PNES to capture the heterogeneity of this disorder.

REFERENCES

Al Marzooqi, S. M., Baker, G. A., Reilly, J., & Salmon, P. (2004). The perceived health status of people with psychologically derived non-epileptic attack disorder and epilepsy: a comparative study. Seizure, 13(2), 71-75.

Almis, B. H., Cumurcu, B. E., Unal, S., Ozcan, A. C., & Aytas, O. (2013). The neuropsychological and neurophysiological profile of women with pseudoseizure. Comprehensive Psychiatry, 54, 649-657.

American Psychiatric Association (2013). Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM–5), Washington, DC, American Psychiatric Publishing.

Alper, K., Devinsky, O., Perrine, K., Luciano, D., Vazquez, B., Pacia, S., & Rhee, E. (1997). Dissociation in epilepsy and conversion nonepileptic seizures. Epilepsia, 38, 991-997.

Alper, K., Devinsky, O., Perrine, K., Vazquez, B., & Luciano, D. (1995). Psychiatric classification of nonconversion nonepileptic seizures. Archives of Neurology, 52(2), 199-201.

Angus-Leppan, H. (2008). Diagnosing epilepsy in neurology clinics: A prospective study. Seizure, 17, 431-436.

Austin, M.-P., Mitchell, P., & Goodwin, G. M. (2001). Cognitive deficits in depression: Possible implications for functional neuropathology. British Journal of Psychiatry, 178, 200-206.

Bakvis, P., Roelofs, K., Kuyk, J., Edelbroek, P. M., Swinkels, W. A. M., & Spinhoven, P. (2009). Trauma, stress, and preconscious threat processing in patients with psychogenic nonepileptic seizures. [Research Support, Non-U.S. Gov't]. Epilepsia, 50(5), 1001-1011.

Bakvis, P., Spinhoven, P., Putman, P., Zitman, F. G., & Roelofs, K. (2010). The effect of stress induction on working memory in patients with psychogenic nonepileptic seizures. Epilepsy & Behavior, 19(3), 448-454.

Bakvis, P., Spinhoven, P., Zitman, F. G., & Roelofs, K. (2011). Automatic avoidance tendencies in patients with psychogenic non-epileptic seizures. Seizure, 20, 628-634.

Barrett, L. F., & Bar, M. (2009). See it with feeling: Affective predictions during object perception. Philosophical Transactions of the Royal Society B: Biological Sciences, 364, 1325-1334.

Barry, J. J., Atzman, O., & Morrell, M. J. (2000). Discriminating between epileptic and nonepileptic events: the utility of hypnotic seizure induction. Epilepsia, 41(1), 81-84.

Baslet, G. (2011). Psychogenic non-epileptic seizures: a model of their pathogenic mechanism. Seizure, 20(1), 1-13.

Bautista, R. E. D., Gonzales-Salazar, W., & Ochoa, J. G. (2008). Expanding the theory of symptom modeling in patents with psychogenic nonepileptic seizures.Epilepsy & Behavior,13,407-409.

Bell, V., Oakley, D. A., Halligan, P. W., & Deeley, Q. (2011). Dissociation in hysteria and hypnosis: evidence from cognitive neuroscience. Journal of Neurology, Neurosurgery and Psychiatry, 82, 332-339.

Benbadis, S. R., Allen, H. W., & Hauser, W. A. (2000). An estimate of the prevalence of psychogenic non-epileptic seizures. Seizure, 9, 280-281.

Benbadis, S. R., Johnson, K., Anthony, K., Caines, G., Hess, G., Jackson, C., . . . Tatum, W. O. t. (2000). Induction of psychogenic nonepileptic seizures without placebo. Neurology, 55(12), 1904-1905.

Bernstein, E., & Putnam, F. W. (1987). Development, reliability, and validity of a dissociation scale. Journal of Nervous and Mental Disease, 174, 727–735.

Binder, L. M., Salinsky, M. C., & Smith, S. P. (1994). Psychological correlates of psychogenic seizures. Journal of Clinical & Experimental Neuropsychology, 16(4), 524-530.

Bodde, N. M. G., Brooks, J. L., Baker, G. A., Boon, P. A. J. M., Hendriksen, J. G. M., Mulder, O. G., & Aldenkamp, A. P. (2009). Psychogenic non-epileptic seizures--definition, etiology, treatment and prognostic issues: a critical review. Seizure, 18(8), 543-553.

Bogaerts, K., Van Eylen, L., Li, W., Bresseleers, J., Van Diest, I., De Peuter, S., Stans, L., Decramer, M., & Van den Bergh, O. (2010b). Distorted symptom perception in patients with medically unexplained symptoms. Journal of Abnormal Psychology, 119, 226.

Bowman, E. S. (2006). Why conversion seizures should be classified as a dissociative disorder. Psychiatric Clinics of North America, 29, 185-211.

Bowman, E. S., & Markand, O. N. (1996). Psychodynamics and psychiatric diagnoses of pseudoseizure subjects. American Journal of Psychiatry, 153(1), 57-63.

Breuer, J., & Freud, S. (1893-1895/1955). Studies on hysteria. In J. Strachey & A. Strachey (Eds.), The standard edition of the complete psychological works of Sigmund Freud (Vol. II). London: Hogarth Press and the Institute of Psycho-Analysis.

Brown, R. J. (2002a). The cognitive psychology of dissociative states. Cognitive Neuropsychiatry, 7, 221-235.

Brown, R. J. (2002b). Epilepsy, dissociation and nonepileptic seizures. In M. R. Trimble & B. Schmitz (Eds.), The Neuropsychiatry of Epilepsy (pp. 189-209). Cambridge, UK: Cambridge University Press.

Brown, R. J. (2004). Psychological mechanisms of medically unexplained symptoms: An integrative conceptual model. Psychological Bulletin, 130, 793-812.

Brown, R. J. (2006). Different types of "dissociation" have different psychological mechanisms. Journal of Trauma and Dissociation, 7, 7-28.

Brown, R. J. (2013a). Dissociation and somatoform disorders. In F. Kennedy, H. Kennerley & D. Pearson (Eds.), Cognitive behavioural approaches to the understanding and treatment of dissociation (pp. 133-147). London: Routledge.

Brown, R. J. (2013b). Explaining the unexplained. The Psychologist, 26, 868-872.

Brown, R. J. (In press). Dissociation. In M. Hallett, A. Carson & J. Stone, Functional Neurological Disorders (Handbook of Clinical Neurology). Amsterdam: Elsevier.

Brown, R. J., & Lewis-Fernández, R. (2011). Culture and conversion disorder: Implications for DSM-5. Psychiatry, 74(3), 187-206.

Brown, R. J., & Oakley, D. A. (2004). An integrative cognitive theory of hypnosis and high hypnotizability. In M. Heap, R. J. Brown & D. A. Oakley (Eds.), The Highly Hypnotizable Person: Theoretical, Experimental and Clinical Issues (pp. 152-186). London: Brunner-Routledge.

Brown, R.J. & Reuber, M. (2016). Psychological and psychiatric aspects of psychogenic non-epileptic seizures (PNES): A systematic review. Clinical Psychology Review, 45, 157-182.

Brown, R. J., Bouska, J. F., Frow, A., Kirkby, A., Baker, G. A., Kemp, S., . . . Reuber, M. (2013). Emotional dysregulation, alexithymia, and attachment in psychogenic nonepileptic seizures. Epilepsy & Behavior, 29(1), 178-183.

Chen, J., Tsuchiya, M., Kawakami, N., & Furukawa, T. A. (2009). Non-fearful vs. fearful panic attacks: a general population study from the National Comorbidity Survey. Journal of Affective Disorders, 112, 273-278.

Coffey, E., Berenbaum, H., & Kerns, J.G. (2003) The dimensions of emotional intelligence, alexithymia and mood awareness: Associations with personality and performance on an emotional Stroop task. Cognition and Emotion, 17, 671–679.

Cragar, D. E., Berry, D. T. R., Schmitt, F. A., & Fakhoury, T. A. (2005). Cluster analysis of normal personality traits in patients with psychogenic nonepileptic seizures. Epilepsy & Behavior, 6(4), 593-600.

Cronje, G., & Pretorius, C. (2013). The coping styles and health-related quality of life of South African patients with psychogenic nonepileptic seizures. Epilepsy & Behavior, 29, 581-584.

Derakshan, N., & Eysenck, M. W. (2009). Anxiety, processing efficiency and cognitive performance: New developments from attentional control theory. European Psychologist, 14, 168-176.

Derogatis LR, Lipman RS, Rickels K, Uhlenhuth EH, Covi L. The Hopkins symptom check-list (HSCL): A self-report symptom inventory. Behavioral Science, 19, 1-15.

Dimaro, L. V., Dawson, D. L., Roberts, N. A., Brown, I., Moghaddam, N. G., & Reuber, M. (2014). Anxiety and avoidance in psychogenic nonepileptic seizures: The role of implicit and explicit anxiety. Epilepsy & Behavior, 33, 77-86.

Dixit, R., Popescu, A., Bagic, A., Ghearing, G., & Hendrickson, R. (2013). Medical comorbidities in patients with psychogenic nonepileptic spells (PNES) referred for video-EEG monitoring. Epilepsy and Behavior, 28(2), 137-140.

Driver-Dunckley, E., Stonnington, C. M., Locke, D. E. C., & Noe, K. (2011). Comparison of psychogenic movement disorders and psychogenic nonepileptic seizures: is phenotype clinically important? Psychosomatics, 52(4), 337-345.

Duncan, R., & Oto, M. (2008). Predictors of antecedent factors in psychogenic nonepileptic attacks: multivariate analysis. Neurology, 71, 1000-1005.

Duncan, R., Oto, M., Martin, E., & Pelosi, A. (2006). Late onset psychogenic nonepileptic attacks. Neurology, 66(11), 1644-1647.

Duncan, R., Razvi, S., & Mulhern, S. (2011). Newly presenting psychogenic nonepileptic seizures: incidence, population characteristics, and early outcome from a prospective audit of a first seizure clinic. Epilepsy & Behavior, 20(2), 308-311.

Edwards, M.J., Adams, R.A., Brown, H., Pareés, I., Friston, K.J. (2012). A Bayesian account of 'hysteria'. Brain, 135, 3495-512

Elliott, J. O., & Charyton, C. (2014). Biopsychosocial predictors of psychogenic non-epileptic seizures. Epilepsy Research, 108(9), 1543-1553.

Fiszman, A., Alves-Leon, S. V., Nunes, R. G., D'Andrea, I., & Figueira, I. (2004). Traumatic events and posttraumatic stress disorder in patients with psychogenic nonepileptic seizures: a critical review. Epilepsy & Behavior, 5(6), 818-825.

Frances, P. L., Baker, G. A., & Appleton, P. L. (1999). Stress and avoidance in Pseudoseizures: testing the assumptions. Epilepsy Research, 34(2-3), 241-249.

Galimberti, C. A., Ratti, M. T., Murelli, R., Marchioni, E., Manni, R., & Tartara, A. (2003). Patients with psychogenic nonepileptic seizures, alone or epilepsy-associated, share a psychological profile distinct from that of epilepsy patients. Journal of Neurology, 250(3), 338-346.

Gheorghiu, V.A., & Reyher, J. (1982). The Effect of Different Types of Influence on an "Indirect-Direct" Form of a Scale of Sensory Suggestibility. American Journal of Clinical Hypnosis, 24(3), 191-199.

Goldstein, L. H., Deale, A. C., Mitchell-O'Malley, S. J., Toone, B. K., & Mellers, J. D. C. (2004). An evaluation of cognitive behavioral therapy as a treatment for dissociative seizures: a pilot study. Cognitive & Behavioral Neurology, 17(1), 41-49.

Goldstein, L. H., Drew, C., Mellers, J., Mitchell-O'Malley, S., & Oakley, D. A. (2000). Dissociation, hypnotizability, coping styles and health locus of control: characteristics of pseudoseizure patients. Seizure, 9(5), 314-322.

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.

Gul, A., & Ahmad, H. (2014). Cognitive deficits and emotion regulation strategies in patients with psychogenic nonepileptic seizures: a task-switching study. Epilepsy & Behavior, 32, 108-113.

Guz, H., Doganay, Z., Ozkan, A., Colak, E., Tomac, A., & Sarisoy, G. (2003). Conversion disorder and its subtypes: a need for a reclassification. Nordic Journal of Psychiatry, 57(5), 377-381.

Harden, C. L. (1997). Pseudoseizures and dissociative disorders: a common mechanism involving traumatic experiences. Seizure, 6(2), 151-155.

Hariri, A. R. (2009). The neurobiology of individual differences in complex behavioral traits. Annual Review of Neuroscience, 32, 225-247.

Hathaway, S. R., & McKinley, J. C. (1940). A multiphasic personality schedule (Minnesota): I. Construction of the schedule. Journal of Psychology, 10, 249-254.

Hendrickson, R., Popescu, A., Dixit, R., Ghearing, G., & Bagic, A. (2014). Panic attack symptoms differentiate patients with epilepsy from those with psychogenic nonepileptic spells (PNES). Epilepsy and Behavior, 37, 210-214.

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, 158-62.

Holmes, A. & Wellman, C. L. (2009). Stress-induced prefrontal reorganization and executive dysfunction in rodents. Neuroscience and Biobehavioral Reviews, 33, 773-83.

Howlett, S., & Reuber, M. (2009). An Augmented Model of Brief Psychodynamic Interpersonal Therapy for Patients with Nonepileptic Seizures. Psychotherapy, 46(1), 125-138.

Janet, P. (1889). *L'automatisme* psychologique [Psychological automatisms]. Paris: Alcan.

Jawad, S. S., Jamil, N., Clarke, E. J., Lewis, A., Whitecross, S., & Richens, A. (1995). Psychiatric morbidity and psychodynamics of patients with convulsive pseudoseizures. Seizure, 4(3), 201-206.

Kaplan, M. J., Dwivedi, A. K., Privitera, M. D., Isaacs, K., Hughes, C., & Bowman, M. (2013). Comparisons of childhood trauma, alexithymia, and defensive styles in patients with psychogenic non-epileptic seizures vs. epilepsy: Implications for the etiology of conversion disorder. Journal of Psychosomatic Research, 75(2), 142-146.

Kretschmer, E. (1944). Hysterie, Reflex und Instinkt [Hysteria, Reflex and Instinct]. Leipzig: Georg Thieme Verlag.

Kotsopoulos, I. A. W., de Krom, M. C. T. F. M., Kessels, F. G. H., Lodder, J., Troost, J., Twellaar, M., . . . Knottnerus, A. J. (2003). The diagnosis of epileptic and non-epileptic seizures. Epilepsy Research, 57(1), 59-67.

Kristensen, O., & Alving, J. (1992). Pseudoseizures--risk factors and prognosis. A case-control study. Acta Neurologica Scandinavica, 85(3), 177-180.

Kuyk, J., Spinhoven, P., & van Dyck, R. (1999). Hypnotic recall: a positive criterion in the differential diagnosis between epileptic and pseudoepileptic seizures. Epilepsia, 40, 485-491.

Kuyk, J., Van Dyck, R., & Spinhoven, P. (1996). The case for a dissociative interpretation of pseudoepileptic seizures. Journal of Nervous & Mental Disease, 184(8), 468-474.

LaFrance, W. C., Jr., Baker, G. A., Duncan, R., Goldstein, L. H., & Reuber, M. (2013). Minimum requirements for the diagnosis of psychogenic nonepileptic seizures: a staged approach: a

report from the International League Against Epilepsy Nonepileptic Seizures Task Force. Epilepsia, 54(11), 2005-2018.

Lanius, R. A., Brand, B., Vermetten, E., Frewen, P. A., & Spiegel, D. (2012). The dissociative subtype of posttraumatic stress disorder: rationale, clinical and neurobiological evidence, and implications. Depression and Anxiety, 29, 1-8.

Lanius, R. A., Vermetten, E., Loewenstein, R. J., Brand, B., Schmahl, C., Bremner, J. D., & Spiegel, D. (2010). Emotion modulation in PTSD: Clinical and neurobiological evidence for a dissociative subtype. American Journal of Psychiatry, 167, 640-647.

Litwin, R., & Cardeña, E. (2000). Demographic and seizure variables, but not hypnotizability or dissociation, differentiated psychogenic from organic seizures. Journal of Trauma & Dissociation, 1(4), 99-122.

Ludwig, L., Whitehead, K., Sharpe, M., Reuber, M., Stone, J. (2015). Differences in illness perceptions between patients with non-epileptic seizures and functional limb weakness. Journal of psychosomatic research, 79, 246-9.

Martinez-Taboas, A. (2005). Psychogenic seizures in an Espiritismo context: The role of culturally sensitive psychotherapy. Psychotherapy, 42(1), 6-13.

Mayor, R., Brown, R. J., Cock, H., House, A., Howlett, S., Singhal, S., . . . Reuber, M. (2012). Short-term outcome of psychogenic non-epileptic seizures after communication of the diagnosis. Epilepsy & Behavior, 25(4), 676-681.

McGonigal, A., Oto, M., Russell, A. J., Greene, J., & Duncan, R. (2002). Outpatient video EEG recording in the diagnosis of non-epileptic seizures: a randomized controlled trial of simple suggestion techniques. Journal of Neurology, Neurosurgery & Psychiatry, 72, 549-551.

McKenzie, P. S., Oto, M., Graham, C. D., & Duncan, R. (2011). Do patients whose psychogenic non-epileptic seizures resolve, 'replace' them with other medically unexplained symptoms? Medically unexplained symptoms arising after a diagnosis of psychogenic non-epileptic seizures. Journal of Neurology, Neurosurgery & Psychiatry, 82(9), 967-969.

Mokleby, K., Blomhoff, S., Malt, U. F., Dahlstrom, A., Tauboll, E., & Gjerstad, L. (2002). Psychiatric comorbidity and hostility in patients with psychogenic nonepileptic seizures compared with somatoform disorders and healthy controls. Epilepsia, 43(2), 193-198.

Moore, P. M., & Baker, G. A. (1997). Non-epileptic attack disorder: a psychological perspective. Seizure, 6(6), 429-434.

Morey, L. C. (1991). The Personality Assessment Inventory professional manual. Odessa, Florida: Psychological Assessment Resources.

Myers, L., Matzner, B., Lancman, M., Perrine, K., & Lancman, M. (2013). Prevalence of alexithymia in patients with psychogenic non-epileptic seizures and epileptic seizures and predictors in psychogenic non-epileptic seizures. Epilepsy & Behavior, 26(2), 153-157.

Nijenhuis, E. R. (2004). Somatoform Dissociation: Phenomena, Measurement and Theoretical Issues. Norton.

Nijenhuis, E. R., Spinhoven, P., Van Dyck, R., Van Der Hart, O., & et al. (1996). The development and psychometric characteristics of the Somatoform Dissociation Questionnaire (SDQ-20). Journal of Nervous and Mental Disease, 184, 688-694.

Nijenhuis, E. R. Vanderlinden, J. & Spinhoven, P. (1998). Animal defensive reactions as a model for trauma-induced dissociative reactions. Journal of Traumatic Stress, 11, 243-60.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz & D. Shapiro (Eds.), Consciousness and self-regulation (Vol. 4, pp. 1–18). New York: Plenum Press.

Oakley, D. A. (1999). Hypnosis and conversion hysteria: A unifying model. Cognitive Neuropsychiatry Vol 4(3) Aug 1999, 243-265.

Pechtel, P., & Pizzagalli, D. A. (2011). Effects of early life stress on cognitive and affective function: an integrated review of human literature. Psychopharmacology, 214, 55-70.

Polak, A. R., Witteveen, A. B., Reitsma, J. B., & Olff, M. (2012). The role of executive function in posttraumatic stress disorder: A systematic review. Journal of Affective Disorders, 141,11-21.

Ponnusamy, A., Marques, J. L. B., & Reuber, M. (2012). Comparison of heart rate variability parameters during complex partial seizures and psychogenic nonepileptic seizures. Epilepsia, 53(8), 1314-1321.

Pouretemad, H. R., Thompson, P. J., & Fenwick, P. B. (1998). Impaired sensorimotor gating in patients with non-epileptic seizures. Epilepsy Research, 31(1), 1-12.

Reinsberger, C., Perez, D. L., Murphy, M. M., & Dworetzky, B. A. (2012). Pre- and postictal, not ictal, heart rate distinguishes complex partial and psychogenic nonepileptic seizures. Epilepsy & Behavior, 23(1), 68-70.

Reuber, M. (2009). The etiology of psychogenic non-epileptic seizures: toward a biopsychosocial model. Neurologic Clinics, 27(4), 909-924.

Reuber, M., Chen, M., Jamnadas-Khoda, J., Broadhurst, M., Wall, M., Gru□newald, R.A., Howell, S.J., Koepp, M., Parry, S., Sisodiya, S., Walker, M., & Hesdorffer, D. (In press). Value of patient-reported symptoms in the diagnosis of transient loss of consciousness. Neurology.

Reuber, M., Fernandez, G., Bauer, J., Helmstaedter, C., & Elger, C. E. (2002). Diagnostic delay in psychogenic nonepileptic seizures. Neurology, 58(3), 493-495.

Reuber, M., Fernandez, G., Bauer, J., Singh, D. D., & Elger, C. E. (2002). Interictal EEG abnormalities in patients with psychogenic nonepileptic seizures. Epilepsia, 43, 1013-1020.

Reuber, M., House, A. O., Pukrop, R., Bauer, J., & Elger, C. E. (2003). Somatization, dissociation and general psychopathology in patients with psychogenic non-epileptic seizures. Epilepsy Research, 57(2-3), 159-167.

Reuber, M., Howlett, S., Khan, A., & Grunewald, R. A. (2007). Non-epileptic seizures and other functional neurological symptoms: predisposing, precipitating, and perpetuating factors. Psychosomatics, 48(3), 230-238.

Reuber, M., Jamnadas-Khoda, J., Broadhurst, M., Grunewald, R., Howell, S., Koepp, M., . . . Walker, M. (2011). Psychogenic nonepileptic seizure manifestations reported by patients and witnesses. Epilepsia, 52(11), 2028-2035.

Reuber, M., Pukrop, R., Bauer, J., Derfuss, R., & Elger, C. E. (2004). Multidimensional assessment of personality in patients with psychogenic non-epileptic seizures. Journal of Neurology, Neurosurgery & Psychiatry, 75(5), 743-748.

Reuber, M., Pukrop, R., Bauer, J., Helmstaedter, C., Tessendorf, N., & Elger, C. E. (2003). Outcome in psychogenic nonepileptic seizures: 1 to 10-year follow-up in 164 patients. Annals of Neurology, 53(3), 305-311.

Reuber, M., Qurishi, A., Bauer, J., Helmstaedter, C., Fernandez, G., Widman, G., & Elger, C. E. (2003). Are there physical risk factors for psychogenic non-epileptic seizures in patients with epilepsy? Seizure, 12(8), 561-567.

Roberts, N. A., Burleson, M. H., Weber, D. J., Larson, A., Sergeant, K., Devine, M. J., . . . Wang, N. C. (2012). Emotion in psychogenic nonepileptic seizures: responses to affective pictures. Epilepsy & Behavior, 24(1), 107-115.

Robinson, O. J., Letkiewicz, A. M., Overstreet, C., Ernst, M., & Grillon, C. (2011). The effect of induced anxiety on cognition: Threat of shock enhances aversive processing in healthy individuals. Cognitive, Affective, & Behavioral Neuroscience, 11, 217-227.

Robson, C., Drew, P., Walker, T., Reuber, M. (2012). Catastrophising and normalising in patient's accounts of their seizure experiences. Seizure, 21(10), 795-801.

Roelofs, K., & Spinhoven, P. (2007). Trauma and medically unexplained symptoms: Towards an integration of cognitive and neuro-biological accounts. Clinical Psychology Review, 27, 798-820.

Roelofs, K., van Galen, G. P., Eling, P., Keijsers, G. P. J., & Hoogduin, C. A. L. (2003). Endogenous and exogenous attention in patients with conversion paresis. Cognitive Neuropsychology, 20, 733–745.

Ruocco, A. C. (2005). The neuropsychology of borderline personality disorder: a meta-analysis and review. Psychiatry Research, 137, 191-202.

Schaefer, M., Egloff, B., & Witthöft, M. (2012). Is interoceptive awareness really altered in somatoform disorders? Testing competing theories with two paradigms of heartbeat perception. Journal of Abnormal Psychology, 121, 719-724. Seneviratne, U., Reutens, D., & D'Souza, W. (2010). Stereotypy of psychogenic nonepileptic seizures: insights from video-EEG monitoring. Epilepsia, 51(7), 1159-1168.

Sharpe, D., & Faye, C. (2006). Non-epileptic seizures and child sexual abuse: a critical review of the literature. Clinical Psychology Review, 26(8), 1020-1040.

Sierra, M. & Berrios, G.E. (1998). Depersonalization: neurobiological perspectives. Biological Psychiatry, 44, 898-908

Sierra, M. & David, A. S. (2007). Depersonalization disorder: A selective impairment of awareness. Consciousness and Cognition, 20(1), 99-108

Shallice, T., & Cooper, R. P. (2011). The Organisation of Mind. Oxford: Oxford University Press.

Sirven, J. I., & Glosser, D. S. (1998). Psychogenic nonepileptic seizures: theoretic and clinical considerations. Neuropsychiatry, Neuropsychology, & Behavioral Neurology, 11, 225-235.

Slater, J. D., Brown, M. C., Jacobs, W., & Ramsay, R. E. (1995). Induction of pseudoseizures with intravenous saline placebo. Epilepsia, 36(6), 580-585.

Stone, J., Binzer, M., & Sharpe, M. (2004). Illness beliefs and locus of control: a comparison of patients with pseudoseizures and epilepsy. Journal of Psychosomatic Research, 57, 541-547.

Stone, J., & Carson, A. (2013). The unbearable lightheadedness of seizing: wilful submission to dissociative (non-epileptic) seizures. Journal of Neurology, Neurosurgery and Psychiatry, 84, 822-824.

Stone, J., Carson, A., Aditya, H., Prescott, R., Zaubi, M., Warlow, C. & Sharpe, M. (2008). The role of physical illness injury in motor and sensory conversion symptoms: A systematic and narrative review. Journal of Psychosomatic Research, 66, 383-390.

Stone, J., Sharpe, M., & Binzer, M. (2004). Motor conversion symptoms and pseudoseizures: a comparison of clinical characteristics. Psychosomatics, 45(6), 492-499.

Strutt, A. M., Hill, S. W., Scott, B. M., Uber-Zak, L., & Fogel, T. G. (2011). A comprehensive neuropsychological profile of women with psychogenic nonepileptic seizures. Epilepsy & Behavior, 20(1), 24-28.

Taylor, G. J., Bagby, R. M., & Parker, J. D. A. (1997). Disorders of Affect Regulation: Alexithymia in Medical and Psychiatric Illness. Cambridge University Press.

Testa, S. M., & Brandt, J. (2010). Do patients with psychogenic nonepileptic seizures have positive covert attitudes toward sickness? Epilepsy & Behavior, 19(3), 323-327.

Testa, S. M., Krauss, G. L., Lesser, R. P., & Brandt, J. (2012). Stressful life event appraisal and coping in patients with psychogenic seizures and those with epilepsy. Seizure, 21, 282-287.

Tojek, T. M., Lumley, M., Barkley, G., Mahr, G., & Thomas, A. (2000). Stress and other psychosocial characteristics of patients with psychogenic nonepileptic seizures. Psychosomatics, 41(3), 221-226.

Truelove-Hill, M. & Yadon, C. A. (2015). Auditory sensory gating and performance on the Delis–Kaplan Executive Function System. Journal of Cognitive Psychology, 27, 909-920.

Uliaszek, A. A., Prensky, E., & Baslet, G. (2012). Emotion regulation profiles in psychogenic non-epileptic seizures. Epilepsy & Behavior, 23(3), 364-369.

Van der Kruijs, S. J., Vonck, K. E., Langereis, G.R., Feijs, L. M., Bodde, N. M., Lazeron, R. H., Carrette, E., Boon, P. A., Backes, W. H., Jansen, J. F., Aldenkamp, A. P. & Cluitmans, P. J. (2016). Autonomic nervous system functioning associated with psychogenic nonepileptic seizures: Analysis of heart rate variability. Epilepsy & Behavior, 54, 14-19.

Van den Bergh, O., Witthöft, M., Petersen, S. & Brown, R.J. (submitted). Symptoms and the body: Taking the inferential leap.

Van den Bergh, O., Stegen, K. & Van de Woestijne, K.P. (1997). Learning to have psychosomatic complaints: Conditioning of respiratory behavior and complaints in psychosomatic patients. Psychosomatic Medicine, 59, 13-23.

Van den Bergh, O., Winters, W., Devriese, S., & Van Diest, I. (2002). Learning subjective health complaints. Scandinavian Journal of Psychology, 43, 147-152.

Van IJzendoorn, M. H., & Schuengel, C. (1996). The measurement of dissociation in normal and clinical populations. Clinical Psychology Review, 16, 365-382.

von Fabeck, F. R. (2010). Zur Dynamik narrativer Re-Konstruktionen im Behandlungsverlauf dissoziativer Patienten Bielefeld, Bielefeld. Retrieved from http://pub.uni-bielefeld.de/publication/2540577

Willment, K., Hill, M., Baslet, G., & Loring, D. W. (2015). Cognitive Impairment and Evaluation in Psychogenic Nonepileptic Seizures: An Integrated Cognitive-Emotional Approach. Clinical EEG and Neuroscience, 46, 42− 53.

Whitehead, K., Kandler, R., & Reuber, M. (2013). Patients' and neurologists' perception of epilepsy and psychogenic nonepileptic seizures. Epilepsia, 54(4), 708-717.

Wolf, L. D., Hentz, J. G., Ziemba, K. S., Kirlin, K. A., Noe, K. H., Hoerth, M. T., . . . Locke, D. E. C. (2015). Quality of life in psychogenic nonepileptic seizures and epilepsy: The role of somatization and alexithymia. Epilepsy and Behavior, 43, 81-88.

Yiend, J., (2010). The effects of emotion on attention: A review of attentional processing of emotional information. Cognition & Emotion, 24, 3-47.

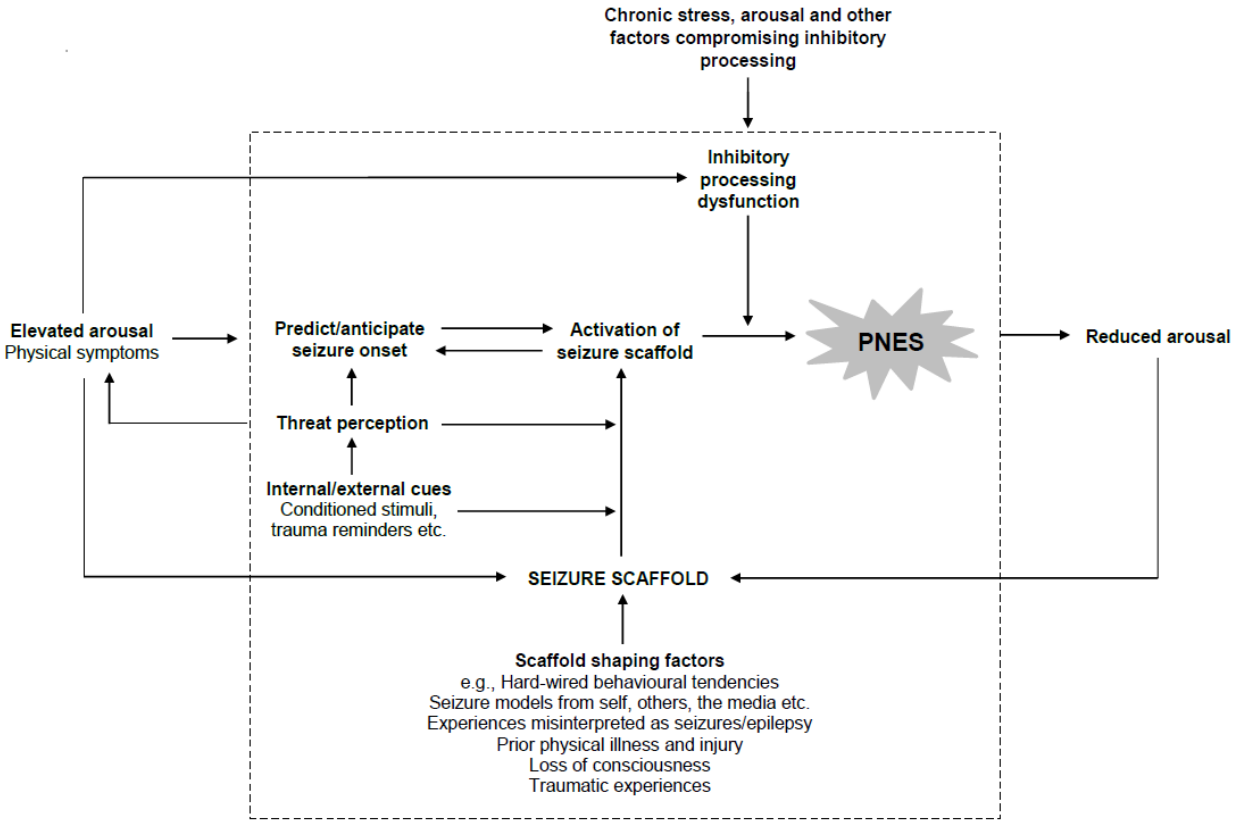


FIGURE LEGENDS

FIGURE 1: Hypothesized sequence of events in PNES. Essential components of the process are represented in the dashed area. Although hyper- and hypo-arousal (arousal levels not appropriate to the patient's current environment and internal state) are frequently present in PNES, and may give rise to high-level processing dysfunction, abnormal arousal is not an essential aspect of the PNES generation process. For example, strong activation of the seizure scaffold in the presence of an inhibitory processing dysfunction may be sufficient to trigger an attack even in the absence of heightened arousal. The figure focuses on how rather than why PNES arise. Recognised risk factors for PNES such as a history of traumatisation, emotional dysregulation, alexithymia, psychopathology and heightened suggestibility will confer vulnerability to the processes depicted, but are neither necessary nor sufficient in this account.

Table 1: Key strengths and limitations of main models of PNES

Model	Key strengths	Key limitations
1. PNES as the activation of dissociated material	• Explains increased rate of childhood trauma in patients with PNES and apparent clinical relevance of traumatic events	• Many patients with PNES do not report a history of potentially traumatising events • Only a minority of patients with PNES meet criteria for PTSD
	• Explains elevated scores on trait dissociation measures	• Trait dissociation findings are mixed • Some patients with PNES don't report significant dissociation or flashbacks • Scores on trait dissociation measures may pertain to different aspects of dissociation
	• Predicts elevated suggestibility seen in some studies, as well as apparent utility of suggestion methods for eliciting PNES • Explains perceived involuntariness of attacks, unusual motor activity and potentially loss of consciousness	• Suggestibility findings are mixed and not all patients score in suggestible range
2. PNES as hard-wired responses, such as "panic without panic"	• Explains why PNES are relatively stereotyped and could potentially account for phenomenology and semiology	• Stereotyping less marked than in epilepsy and significant variations are apparent between and within individuals • Number of seizure categories inconsistent with a single hard-wired response
	• Panic without panic is consistent with ictal unreality, disconnection and detachment in many patients with PNES • Panic without panic explains why many patients with PNES report physical symptoms of arousal at the time of their attacks but not explicit anxiety • Panic without panic predicts increased scores on trait dissociation measures	• Panic without panic does not explain perceived involuntariness, loss of consciousness, unresponsiveness and unusual motor activity • Many PNES occur without apparent arousal, anxiogenic triggers or panic symptoms • Scores on trait dissociation measures may pertain to different aspects of dissociation
3. PNES as physical manifestation of emotional distress	• Explains apparent disparity between increased physical symptom reports and low explicit anxiety	• Does not explain key aspects of PNES semiology and phenomenology
	• Consistent with evidence for defensiveness, avoidance, alexithymia and emotional processing deficits in some studies	• Findings on defensiveness, avoidance, alexithymia and emotional processing deficits are inconsistent • A significant proportion of patients deny emotional distress; claims that this is evidence of denial are circular
4. PNES as learned behaviours	• Explains motor features and unresponsiveness seen in some PNES • Explains increased prevalence of PNES in patients with previous epilepsy • Explains link between PNES and prior history of physical illness, injury and loss of consciousness	• Account of semiology and phenomenology seems to imply deliberate simulation/deceit • Unclear whether it can account for PNES that arise in the absence of obvious seizure models and that have changed little over time • Cannot explain why very similar PNES-behaviours have been observed across different cultures • It is often difficult to identify reinforcers/gains for PNES, making it difficult to explain symptom onset and resistance to extinction

HIGHLIGHTS

- Current models of PNES can account for some but not all of the available data
- Automatic activation of seizure representations in memory may be a unifying process
- Suppression of arousal and distress are typical maintaining factors for PNES
- Inhibitory dysfunction, often arising from chronic stress, is a key vulnerability
- Trauma exposure is common but neither necessary nor sufficient for PNES to occur

ENDNOTES

[i]The term "physical" is used here to denote demonstrable medical pathology, such as that associated with brain injury or disease. It should not be taken as implying that PNES do not have a physical substrate in the brain or, conversely, that "psychological" factors are not relevant for understanding epilepsy. Our emphasis on the psychological aspects of PNES reflects the widely held view that this level of explanation is currently the most helpful for understanding these conditions. We are not suggesting that physical factors are irrelevant or that PNES will not eventually be described in physiological terms. Indeed, some "physical" problems such as a previous diagnosis of epilepsy or a history of head injury are well recognised as risk factors for developing PNES; these are incorporated into our account below.

[ii] In other words, predicted by the cognitive system; this is not necessarily conscious.