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Personality profiles differ between patients with epileptic seizures and patients with psychogenic non-epileptic seizures

Michelle Leong[a], Albert D Wang[a], David Trainor[b], Ben Johnstone[c], Genevieve Rayner[d,e,f,g], Tomas Kalincik[a,h], Izanne Roos[a,h], Patrick Kwan[c,f,g,h], Terence J O'Brien[c,f,g,h], Dennis Velakoulis[b,i], Charles B Malpas[a,e,f,g,h,*]

[a] Clinical Outcomes Research Unit (CORe), Department of Medicine, Royal Melbourne Hospital, The University of Melbourne, Parkville, Victoria, 3010, Australia
[b] Department of Psychiatry, Royal Melbourne Hospital, Parkville, Victoria, 3050, Australia
[c] Department of Medicine, Royal Melbourne Hospital, The University of Melbourne, Parkville, Victoria, 3010, Australia
[d] Department of Medicine, Austin Health, The University of Melbourne, Victoria, 3010, Australia
[e] Melbourne School of Psychological Sciences, The University of Melbourne, Parkville, Victoria, 3010, Australia
[f] Department of Neuroscience, Monash University, Clayton, Victoria, 3800, Australia
[g] Department of Neurology, Alfred Health, Melbourne, Victoria, 3004, Australia
[h] Department of Neurology, Royal Melbourne Hospital, Parkville, Victoria, 3010, Australia
[i] Department of Psychiatry, University of Melbourne, Parkville, Victoria, 3010 Australia

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ABSTRACT

Purpose: Psychogenic non-epileptic seizures (PNES) and epileptic seizures (ES) are often difficult to differentiate, leading to incorrect or delayed diagnosis. The aim of the study was to determine whether patients of these two diagnostic groups possess different personality profiles, and whether they could be used to efficiently screen for PNES in clinical settings.

Methods: Collection of data was conducted on 305 patients who completed the NEO-Five Factor Inventory questionnaire during a Video EEG Monitoring admission to the Royal Melbourne Hospital between 2002–2017. Personality differences were investigated using Bayesian linear mixed effects models, with receiver operating characteristic curve analysis computed to evaluate diagnostic accuracy.

Results: The 'openness to experience' domain ($BF_{10} = 21.55$, $d = -0.43$ [95% CI -0.71, -0.17]) and the 'aesthetic interest' facet ($B_{10} = 7.98$, $d = -0.39$ [95% CI -0.66, -0.12]) were the only personality factors demonstrating strong evidence for a group difference, with patients with PNES having higher scores compared to the ES group. ES patients had lower scores on these measures compared to the normal population, while PNES patients did not. Both openness to experience and aesthetic interest showed poor sensitivities (53%, 46% respectively) and specificities (69%, 46% respectively) for classifying PNES and ES patients.

Conclusion: While openness and aesthetic interests differ greatly between PNES and ES groups, low sensitivity and specificity suggests their use is limited in a clinical setting. Nevertheless, these findings open up new avenues of research using modern personality models to further understand patients with epilepsy and related presentations.

1. Introduction

Psychogenic non-epileptic seizures (PNES) are episodes of abnormal limb movements that resemble epileptic seizures (ES), but are not associated with organic aetiologies, and presumably manifest due to psychological distress [1]. Similarities in presentation to ES mean that patients with PNES are often misdiagnosed with epilepsy, resulting in multiple financial, social, emotional and health implications [2–6].

A notable area of research has been the differential psychological profiles of PNES and ES patients. For example, a body of research has demonstrated different rates of personality disorders in these two groups. There is evidence that PNES is more commonly associated with cluster B personality disorders (e.g. borderline, histrionic) [7–14], while ES is more often associated with cluster C disorders (e.g. avoidant, obsessive-compulsive) [7,13,15]. It is possible, however, that some patients experience 'subthreshold' personality features that are not severe enough to cause functional impairment and to be diagnosed as a personality disorder [13]. It is therefore possible that personality assessment that includes coverage of the less pathological range of personality traits might reveal differential profiles between PNES and ES patients.

Along this line, multiple psychological questionnaires have been utilised to investigate these differences with significant results. Numerous studies using the Minnesota Multiphasic Personality Inventory (MMPI) highlighted an increase in hypochondriasis (Hs) and hysteria (Hy) scales in PNES groups [16–21]. The Personality Assessment Inventory (PAI) has also been used extensively in PNES and ES research with the Somatic-Conversion (SOM-C) and Non-epileptic seizure indicator (NES indicator) being used to differentiate PNES and ES patients [22–24]. Additionally, the Dimensional Assessment of Personality Pathology- Basic Questionnaire (DAPP-BQ) has shown PNES patients to be elevated in emotional dysregulation in comparison to epileptic and healthy controls [25]. While these measures assess some aspects of personality, they also focus on common symptoms of psychiatric disorders (such as depression, or anxiety). For example, while the MMPI does include the assessment of some personality characteristics, the psychopathological variables make it hard to determine personality correlations between patients with ES and PNES. Furthermore, the PAI's clinical scales have been derived based on DSM criteria [26]. Relatively little research has used modern models of non-pathological personality traits such as the five-factor model (FFM). The FFM is a statistically-derived model that describes personality along five domains, including neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness [27].

Few notable studies using the five-factor model in the differentiation of PNES and ES has been performed thus far. In the process of cluster analysing PNES using the Revised NEO Personality Inventory (NEO PI-R), Cragar et al. [28] compared the PNES patients to an epilepsy control group and found that PNES patients scored higher on neuroticism and on the agreeableness facet of modesty and lower on the extraversion facet of gregariousness and on the agreeableness facet of trust compared to epilepsy controls. Although these findings are relevant, the study sizes were small and personality differences between PNES and epilepsy were not the focus of the study, but rather a secondary finding. A study investigating personality traits between patients with PNES and psychogenic movement disorder (PMD), also reported patients with PNES having greater levels of neuroticism compared to healthy controls [29]. More recently, Vilyte et al. reported no differences in FFM traits between patients with PNES and ES in a small sample of South African patients [30]. Lack of clinically focused, high-quality research in this area shows the need for a more in-depth study using the modern personality models.

This large retrospective study aimed to utilise the FFM model of personality to determine profile differences between patients with PNES and ES admitted to a specialist VEM unit in a large tertiary centre. It also aimed to directly investigate the classification accuracy of these differences in a clinical setting, which has often been overlooked in previous research. Following Cragar et al., we hypothesised that PNES patients would score higher on neuroticism, and lower on extraversion compared to patients with ES.

2. Methods

2.1. Participants

This was a retrospective case control study. Data were collected from patients as part of routine psychological care who were admitted to the Royal Melbourne Hospital (RMH), Australia, VEM unit between the years 2002-2017. The RMH is a major epilepsy centre in Australia and utilises the use of VEM and a multidisciplinary team involving epileptologists, psychiatrists, EEG scientists, and neuropsychologists in diagnosing epilepsy. Inclusion criteria for the current study included patients who had completed the NEO Five-Factor Inventory (NEO-FFI) questionnaire during their VEM admission and those who had a 6th grade reading level of English and above. Exclusion criteria included patients who were under the age of 17 and patients with 10 or more responses missing. Of the 344 patients who were initially recruited, 8 patients were underage and 31 had missing responses, leading to 305 patients being finally included in the study. This study received approval from the Melbourne Health Ethics Committee (MH HREC# QA2012044). All data are available at http://doi.org/10.17605/OSF. IO/T3A9G.

2.2. Clinical diagnosis

Diagnosis of the patients admitted for VEM was determined at a large multidisciplinary meeting consisting of EEG scientists, epileptologists, neuropsychologists, and psychiatrists. Neuropsychiatric assessments, neurological examinations, and imaging was also heavily considered in making the final diagnosis. A diagnosis of Epilepsy was made when a patient met the International League Against Epilepsy (ILAE) criteria of epilepsy [31,32], while a diagnosis of PNES was made based on abnormal movements in the absence of EEG changes [33]. This definition included 'swoon' attacks (when the patients sinks to the floor and becomes unresponsive) [34]. Patients were classified into 4 main categories: ES, PNES, ES + PNES and non-diagnostic. Patients were categorised as non-diagnostic when a definite diagnosis could not be made or if they had a condition which did not meet either ES or PNES criteria. Conditions reported were migraines, postural hypotension, anxiety, cardiac syncope, arrhythmia, alcohol excess, post-traumatic stress disorder (PTSD), benign paroxysmal positional vertigo (BPPV) and sick sinus syndrome. For patients with ES, the type of epilepsy was also classified according to the ILAE classification of epilepsies [35]. Specifically, the focal epilepsies, temporal lobe epilepsy (TLE) and extra-temporal lobe epilepsy (extra-TLE), and generalised epilepsy. Laterality of seizure focus was also recorded for TLE patients. The NEO-FFI results were not known to the VEM team and did not inform the diagnosis of PNES.

2.3. Personality assessment

The NEO-FFI is a 60-item self-administered measure of personality that describe an individual's degree of standing across five higher order factors: neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness [27]. These domains and their definitions are included in Table A1 in the Supplementary material. The five factors were identified via the factor analysis of all the trait adjectives found in English and other natural languages [36] and has received widespread empirical support [27,37,38]. Construct validity and internal consistency studies have shown the NEO-FFI to be a valid and reliable psychometric tool for the assessment of personality [27]. Furthermore, the five-factor model has shown to have good cross-cultural

replicability [39] and real-life applicability by demonstrating its ability to predict numerous important life outcomes [27]. The NEO-FFI scores are calculated in the form of a normalised score, providing an indication as to where an individual lies on a spectrum compared to the general population [27].

Facet scores were also computed for each of the 5 domains. While domain scores allow for a global picture of an individual's personality, facets allow for a deeper understanding of the individual [27]. We computed scores for the 13 facets derived via an analysis performed by Saucier [40]. Table A2 in Supplementary material illustrates the domains and its facets.

2.4. Statistical analysis

All analyses were performed JASP [41] and R [42]. Bayesian linear mixed effects models were used to determine differences in personality profiles between the PNES and ES groups. Separate analyses were conducted for TLE and non-TLE groups, as well as laterality in TLE patients. For all analyses, the null model included gender and age as predictors of personality and the alternative model contained these predictors plus the relevant personality domains and diagnostic group (e.g. PNES vs ES). The statistical importance of each term was determined using a model averaging approach. Specifically, the Bayes factor of inclusion (BF_{inc}) was computed for each term which represents the sum of the posterior model probabilities for all models containing the term divided by the sum of posterior probabilities for all models not containing the term. Higher interactions are excluded. A $BF_{inc} > 3$ was taken to indicate evidence for an effect, while $BF_{inc} < 1/3$ was taken as evidence for the null hypothesis. BFs between 1/3 and 3 were taken to indicate insensitivity to either hypothesis. Follow-up Bayesian independent sample T-tests were computed to identify specific domain differences between the groups, with BFs interpreted as described above. Effect sizes were reported for all group comparisons in the form of Cohen's [43] *d*, with 95% credible intervals. Receiver operating characteristic (ROC) curve were computed to generate sensitivities and specificities of individual domains and facets in order to determine usefulness in a clinical setting.

3. Results

3.1. Sample characteristics

Full diagnosis and demographic variables are described in Table 1. Of the 305 patients who met eligibility criteria, 122 (40%) were diagnosed with ES, 14 (5%) with both ES and PNES, and 90 (30%) with PNES. The remaining 79 (25%) patients were classified as either 'non-diagnostic', or were diagnosed with an alternative, non-epileptic or non-psychogenic cause of their presentation. Only the ES and PNES patients were included in the main statistical analyses. Of the ES patients, 23 (17%) had extra-temporal focal epilepsy, 74 (54%) had TLE, 31 (23%) had generalised epilepsy, and 8 (6%) had probable focal epilepsy of unspecified or unclear focus. Mean age was 38.79 (SD 15.33, range 17–92) and the majority of participants were female (*n* = 202, 66%). There was no relationship between gender and VEM diagnosis ($BF_{10} = 0.02$).

Psychiatric comorbidity was common with 113 (37%) patients having a history of any major psychiatric disorder, and 12 (4%) patients having a history of borderline personality disorder. PNES participants were more likely to have a history of depression ($BF_{10} = 4.66$), current depression ($BF_{10} = 5.91$), or any current major psychiatric disorder ($BF_{10} = 16.95$). There was no evidence for a relationship between diagnostic category and history of any major psychiatric disorder ($BF_{10} = 1.52$), history of anxiety disorder ($BF_{10} = 2.23$), current anxiety disorder ($BF_{10} = 1.36$), or history of borderline personality disorder ($BF_{10} = 2.87$).

3.2. Comparison of PNES and ES patients to population normative data

A Bayesian liner mixed effects model was computed to determine whether there were differences between personality domains and facets in the combined PNES and ES cohort. There was strong evidence for an effect of domain ($BF_{inc} > 100$). As shown in Fig. 1, the highest scores were observed for neuroticism (*M* = 0.49, *SD* = 0.97), followed by openness (*M* = −0.13, SD = 1.10), agreeableness (*M* = -0.22, *SD* = 1.20), extraversion (*M* = −0.23, *SD* = 1.03), and conscientiousness (*M* = −0.58, *SD* = 1.04). There was strong evidence that the levels of neuroticism were higher when compared to normal population ($BF_{10} \geq 100$). Levels of extraversion ($BF_{10} = 10.84$) and consciousness ($BF_{10} \geq 100$) were significantly lower than the normal population.

3.3. Comparison of epilepsy and PNES groups

A Bayesian linear mixed effects model was computed to determine differences in personality domains between diagnostic groups (PNES and ES). While there was strong evidence for a main effect of domain ($BF_{inc} > 100$), there was no evidence for a main effect of diagnostic group ($BF_{inc} = 1.86$). There was, however, evidence for diagnostic group by domain interaction ($BF_{inc} = 9.92$). This indicates that the two diagnostic groups had different personality profiles. Follow-up Bayesian independent samples T-tests were performed to investigate which specific domains differed between groups (see Table 2 and Fig. 1). Openness to experience was the only domain found with a strong evidence for a group difference ($BF_{10} = 21.55$, *d* = −0.43 [95% CI −0.71, −0.17]). Patients in the PNES group reported greater openness to experience compared to patients in the ES group. The null hypothesis was supported for the agreeableness domain ($BF_{10} = 0.21$, *d* = 0.11 [95% CI −0.16, 0.38]), while the evidence was insensitive for the domains of neuroticism, extraversion and conscientiousness.

A focused analysis was performed on the three facets of the openness domain (see Table 2). There was evidence for group differences on the aesthetic interest facet ($BF_{10} = 7.98$, *d* = −0.39 [95% CI −0.66, −0.12]), with PNES patients reporting higher scores compared to ES patients. The evidence for the facets of intellectual interests and unconventionality was insensitive. No evidence for a group difference was observed for the remaining facets, and the null hypothesis was supported for the facets of sociability, activity, nonantagonistic orientation, prosocial orientation, goal striving, and dependability.

To investigate this further, Bayesian single sample *t*-test were performed to compare each group to the general population in terms of levels of openness to experience. Patients in the ES group reported lower openness to experience ($BF_{10} = 94.07$, *d* = −0.34 [95% CI −0.52, −0.160]) and aesthetic interests ($BF_{10} > 100$, *d* = −0.58 [95% CI −0.77, −0.39]). In contrast, patients in the PNES group had scores on openness to experience ($BF_{10} = 0.23$, *d* = 0.12 [95% CI −0.09, 0.32]) and aesthetic interests ($BF_{10} = 0.21$, *d* = −0.11, [95% CI −0.32, 0.09]) that were not different to the general population.

3.4. Comparison of all diagnostic groups

A Bayesian linear mixed effects model was computed to determine differences in personality domains between all four diagnostic groups (PNES, ES, ES + PNES and non-diagnostic). While there was strong evidence for a main effect of domain ($BF_{inc} > 100$), the null hypothesis was supported for the main effect of diagnostic group ($BF_{inc} < .01$). The null hypothesis was also supported for the domain by diagnostic group interaction ($BF_{inc} = 0.02$). Examination of the means for these groups confirmed that the addition of the ES + PNES and non-diagnostic groups diluted the statistical effects.

Table 1
Sample characteristics.

	Diagnostic group – Mean (SD)			
	ES (n = 122)	PNES (n = 90)	ES & PNES (n = 14)	Non-Diagnostic (n = 79)
Age, years	38.87 (14.73)	35.28 (12.70)	36.21 (11.91)	43.13 (18.37)
Females, N (%)	80 (65.57)	62 (68.89)	11 (78.57)	49 (62.03)
Males, N (%)	42 (34.43)	28 (31.11)	3 (21.43)	30 (37.97)
Domains				
Neuroticism	0.39 (0.85)	0.63 (1.11)	0.88 (0.90)	0.22 (1.19)
Extraversion	−0.13 (1.03)	−0.35 (1.02)	−0.26 (1.31)	−0.19 (1.28)
Openness	−0.34(0.98)	0.15 (1.19)	−0.15 (0.94)	−0.15 (1.03)
Agreeableness	−0.16 (1.19)	−0.30 (1.21)	−0.43 (1.21)	−0.15 (1.45)
Conscientiousness	−0.47 (1.05)	−0.73 (1.01)	−1.11 (1.15)	−0.56 (1.31)
Facets				
Negative affect	0.35 (0.75)	0.57 (0.95)	0.66 (0.73)	0.25 (1.01)
Self-reproach	0.58 (1.01)	0.81 (1.27)	1.16 (1.06)	0.37 (1.33)
Positive affect	0.02 (0.92)	−0.16 (1.02)	0.02 (0.93)	−0.13 (1.01)
Sociability	0.26 (0.93)	0.14 (0.85)	0.12 (1.31)	0.16 (1.15)
Activity	−0.20 (0.83)	−0.35 (1.01)	−0.33 (0.94)	−0.07 (1.08)
Aesthetic interests	−0.57 (0.96)	−0.14 (1.17)	−0.35 (0.90)	−0.54 (1.00)
Intellectual interests	−0.33 (0.84)	−0.10 (0.90)	−0.09 (0.70)	−0.34 (0.95)
Unconventionality	−0.38 (0.89)	−0.06 (0.93)	−0.16 (1.01)	−0.01 (0.88)
Nonantagonistic orientation	−0.41 (1.04)	−0.57 (1.11)	−0.52 (0.90)	−0.57 (1.11)
Prosocial orientation	−0.15 (1.32)	−0.14 (1.14)	−0.62 (1.61)	−0.25 (1.33)
Orderliness	−0.27 (1.00)	−0.58 (0.97)	−0.58 (1.06)	−0.42 (1.10)
Goal striving	−0.04 (0.93)	−0.08 (0.99)	−0.50 (1.12)	0.01 (1.02)
Dependability	−0.55 (1.10)	−0.72 (0.91)	−1.33 (1.01)	−0.60 (1.37)

Note: ES = Epileptic Seizures. PNES = Psychogenic non-epileptic seizures. Non-diagnostic = Patients for whom a diagnosis could not be determined, or for whom a diagnosis of other non-epileptic events was given.

3.5. Comparison of TLE and non-TLE

A Bayesian linear mixed effects model was computed to determine differences in personality domains between the ES patients with TLE and the non-TLE ES patients. There was strong evidence for a main effect of domain ($BF_{inc} > 100$). The null hypothesis was supported for the main effect of group (TLE vs non-TLE; $BF_{inc} = 0.11$) and the group by domain interaction ($BF_{inc} = 0.10$).

3.6. Comparison of left and right TLE patients

Of the 70 TLE patients, 3 patients with bilateral TLE were excluded from the analysis, leaving 37 Left TLE and 26 Right TLE patients. A Bayesian linear mixed effects model was computed to determine differences in personality domains between left and right TLE patients. The evidence was insensitive to the main effect of domain in this smaller sub-grouping ($BF_{inc} = 2.36$). The null hypothesis was support for the main effect of laterality ($BF_{inc} = 0.17$) and the laterality by domain interaction ($BF_{inc} = 0.05$).

3.7. Diagnostic accuracy

Receiver operating characteristic (ROC) curves were computed to determine whether personality scores accurately classified PNES and ES patients (Fig. 2 and 3). As shown in Table 3, the openness to experience domain had an area under the curve (AUC) greater than .50, which suggests that it performs better than chance at classifying diagnostic group. The sensitivity (53%) and specificity (69%), however, were low. Similar results were seen for the aesthetic interests facet in terms of sensitivity (46%) and specificity (74%). None of the other personality domains produced high sensitivity or specificity metrics.

4. Discussion

In this study, we investigated differences in personality profiles between patients with PNES and ES using the five-factor model of personality. Our primary finding was that patients with PNES and ES differed in their personality profiles. Specifically, patients in the PNES group exhibited higher scores on the openness to experience domain, which measures such personality facets as propensity for fantasy, aesthetics interests, openness to feelings, and acceptance of new ideas. Follow-up analyses showed that the strongest evidence was for the aesthetic interests facet. Patients with ES had lower scores on these variables compared to the general population, while PNES patients did not differ from normative data. While these differences were large and supported by strong statistical evidence, the sensitivity and specificity for the openness and aesthetic interests scores were poor, which suggests that their use as psychometric screening instruments for PNES might be limited. Further analysis of the data revealed no differences between personality profiles in TLE and non-TLE patients, and no differences in personality profiles between patients with left or right TLE.

Our finding of elevation in openness and aesthetic interests in PNES patients is not entirely consistent with the previous literature. In a secondary analysis performed by Cragar et al., PNES patients scored higher in the domain of neuroticism compared to ES patients, while differences in the domain of openness were also found to be insignificant [28]. This discrepancy could be accounted for by several factors. One potential factor is the use of the NEO PI-R that was used in Cragar's study as opposed to the NEO-FFI. The NEO PI-R assessment allows for personality to be described across 30 facet scales in addition to the 5 domains [27]. This might permit more comprehensive coverage of personality, accounting for differences in results. The NEO-FFI was used in our study due to time constraints and has been shown to be both a reliable and adequate measurement of a global assessment of personality - the main focus of our study [27]. Results for neuroticism, conscientiousness and extraversion were also insensitive in our study. It is possible that our statistical power was insufficient to determine the results for these specific domains. If true, however, the effect sizes are likely to be small and of questionable clinical significance. Nevertheless, the finding of an elevation of openness is novel and adds to the body of research reinforcing the association between personality profiles and diagnostic groups.
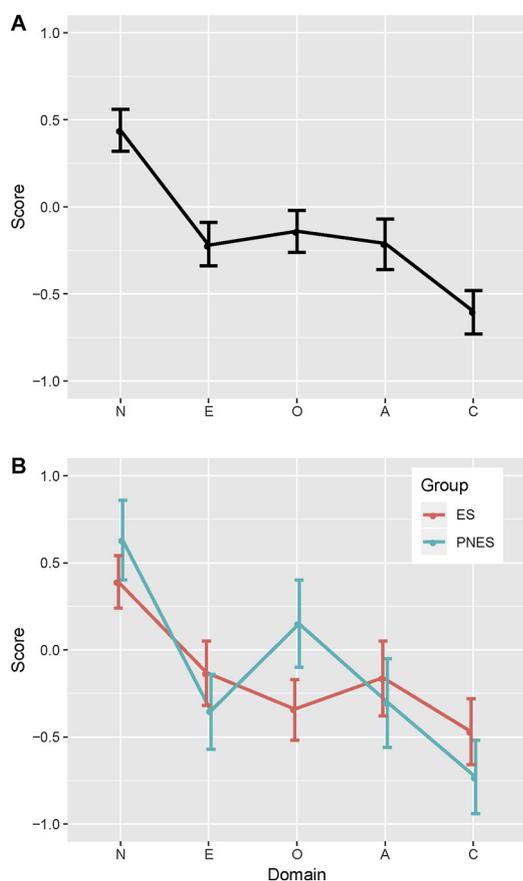
Fig. 1. Distribution of personality scores in the combined PNES and ES cohort. The dotted line shows the mean for the general population. As shown in A, participants had higher scores on neuroticism, and lower scores in extraversion and conscientiousness compared to the general population. As shown in B, the two groups had comparable scores for all domains except openness to experience, on which the PNES group had high scores compared to the ES group. Scores for the ES group were below the mean for the general population.

One explanation for the elevation of openness and aesthetic interests might be related to the association of both openness and ES with cognition. Openness is one of the more challenging of the five personality factors to describe, due to the wide variety of traits that it seems to encompass [44]. There has been a great deal of contention in the literature regarding naming this specific factor, with other contenders being intellect and culture [44]. McCrae and Costa who coined the term openness described it as essentiality traits relating to the exploration of the world from a cognitive point of view [44]. It is, therefore, the factor that has the greatest correlation with cognitive ability amongst the five factors of personality [44,45]. Particularly in cognitive domains such as working memory, latent inhibition and implicit learning [44]. Epilepsy also has been known to have a strong association with cognition, with chronic epileptic patients having higher degrees of cognitive impairment [46]. There is evidence that patients who have poor seizure control, longer seizure duration, and earlier onset of disease are more adversely affected cognitively [46]. Given that this is most representative of our VEM cohort, it is possible that observed lower openness scores might be partly reflective of prevalent cognitive impairment in this group. However, it is important to note that this finding is speculative and provides a clear direction for future research.

Our study showed no differences in personality profiles and laterality which is consistent with a previous study in the literature using the same five-factor model [47]. In contrast, two other studies in the literature have shown to contradict these findings [48,49]. These studies found that patients with left TLE were more dependent and less composed, whereas patients with right TLE were found to have the tendency to underestimate their own problems. However, these studies were not performed using the five-factor model making them difficult to be used as studies for comparison. Further research using modern personality theory, such as the five-factor model, is warranted.

The strengths of our study include the use of a large sample size, gold standard VEM diagnosis, and the exclusion of non-diagnostic and mixed groups of patients. This method of patient sampling produces a high level of certainty regarding classification and allows for well-defined phenotypes, greatly increasing the accuracy of the data. Our study also has an advantage over most in the area of statistical analysis. The use of Bayesian statistics allows us to overcome the limitations of null

Table 2
Comparison between diagnostic groups (PNES and ES).

	Mean (SD)		BF_{10}	BF_{01}	d [95% CI]
	ES	PNES			
Domains					
Neuroticism	0.39 (0.85)	0.63 (1.11)	0.68	1.48	−0.23 [−0.50, 0.03]
Extraversion	−0.13 (1.03)	−0.35 (1.02)	0.47	2.12	0.20 [−0.06, 0.47]
Openness	−0.34 (0.98)	0.15 (1.19)	**21.55**	0.05	−0.43 [−0.71, −0.17]
Agreeableness	−0.16 (1.19)	−0.30 (1.21)	0.21	**4.79**	0.11 [−0.16, 0.38]
Conscientiousness	−0.47 (1.05)	−0.73 (1.01)	0.68	1.47	0.23 [−0.03, 0.50]
Facets					
Negative affect	0.35 (0.75)	0.57 (0.95)	0.77	1.31	−0.25 [−0.51, 0.02]
Self-reproach	0.58 (1.01)	0.81 (1.27)	0.42	2.40	−0.19 [−0.46, 0.08]
Positive affect	0.02 (0.92)	−0.16 (1.02)	0.37	2.74	0.18 [−0.08, 0.45]
Sociability	0.26 (0.93)	0.14 (0.85)	0.23	**4.39**	0.12 [−0.14, 0.39]
Activity	−0.20 (0.83)	−0.35 (1.01)	0.30	**3.36**	0.15 [−0.11, 0.42]
Aesthetic interests	−0.57 (0.96)	−0.14 (1.17)	**7.98**	0.13	−0.39 [−0.66, −0.12]
Intellectual interests	−0.33 (0.84)	−0.10 (0.90)	0.88	1.13	−0.26 [−0.52, 0.02]
Unconventionality	−0.38 (0.89)	−0.06 (0.93)	2.99	0.33	−0.33 [−0.60, −0.07]
Nonantagonistic orientation	−0.41 (1.04)	−0.57 (1.11)	0.26	**3.85**	−0.14 [−0.13, 0.40]
Prosocial orientation	−0.15 (1.32)	−0.14 (1.14)	0.15	**6.60**	−0.01 [−0.28, 0.26]
Orderliness	−0.27 (1.00)	−0.58 (0.97)	1.81	0.55	0.30 [0.03, 0.57]
Goal striving	−0.04 (0.93)	−0.08 (0.99)	0.16	**6.29**	0.04 [−0.22, 0.30]
Dependability	−0.55 (1.10)	−0.72 (0.91)	0.29	**3.51**	0.15 [−0.12, 0.42]

Note: ES = Epileptic Seizures. PNES = Psychogenic non-epileptic seizures. BF_{10} = Bayes Factor for the alternative hypothesis. BF_{01} = Bayes Factor for the null hypothesis. d = Cohen's d and 95% credible intervals. $BF_{10} > 3$ considered evidence for an effect of the domain or facet. $BF_{01} > 3$ considered evidence for the null hypothesis.
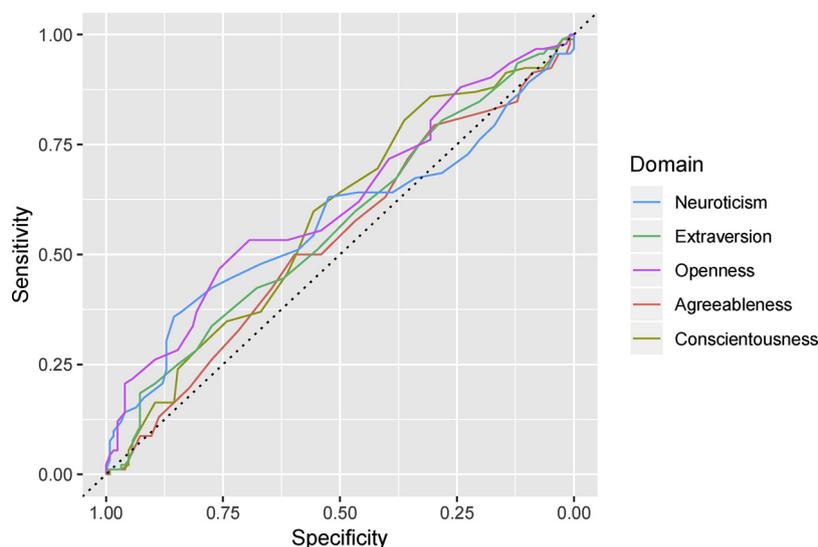
Fig. 2. Receiver operating characteristic (ROC) curves for personality score domains in terms of classification of PNES and ES.

hypothesis significance testing which has come under considerable criticism [50]. The built-in power analysis enables us to gather evidence for the null. For example, in our study, the domain agreeableness was revealed to support the null hypothesis, indicating that there are no differences in agreeableness between ES and PNES patients. To our knowledge, our study has also been the first to directly investigate the classification accuracy of the five-factor model in a clinical setting. While conventional statistical methods are used to identify group differences no matter how small, they do not address the clinically important question whether they assist in diagnosis. This is important to consider as often group differences and clinical classification are not aligned. Our study demonstrated considerable group differences present in the domain of openness and facet of aesthetic interests, however, they did not perform sufficiently well to facilitate clinical use of the NEO-FFI for diagnostic purposes.

The main limitation of our study is the absence of other clinical information (for example, the number of years since first seizure-like event, length and frequency of seizures, and anti-epileptic drugs (AEDs)) in the collected patient data. Some of these variables have been used in combination with other psychometric testing in the past to increase PNES classification accuracy [19,20,26]. However, this study was a clinical audit and it was necessary to limit the investigation to

personality data and limited demographics. Further research should investigate the incremental validity of using other commonly collected variables in combination with the NEO-FFI. Another limitation is the possible social desirability bias associated with self-report questionnaires and the characteristic nature of some PNES patients. Future research should aim to control for such bias by conducting comparison of self-reports with observer ratings as suggested by McCrae and Costa [51].

The novel finding of elevated openness and aesthetic interests in PNES patients compared to ES patients may provide a new avenue for management strategies in PNES patients. Currently, management in PNES patients involves a mixture of antidepressants and psychotherapy [52,53]. Evidence for these strategies is limited and remains a large gap in the literature. Patients who tend to score higher on the domain of openness have been shown to be more receptive to unconventional forms of therapy such as imagery techniques [27]. Whilst no studies have investigated the relation between the facet of aesthetic interests and therapy, people who score higher on this facet have a greater appreciation for art and may be more suited to creative therapeutic modalities, such as art and music therapy. To our knowledge, there is no research studying the benefits of art and music therapy in PNES patients, therefore, this presents a direction for future research.
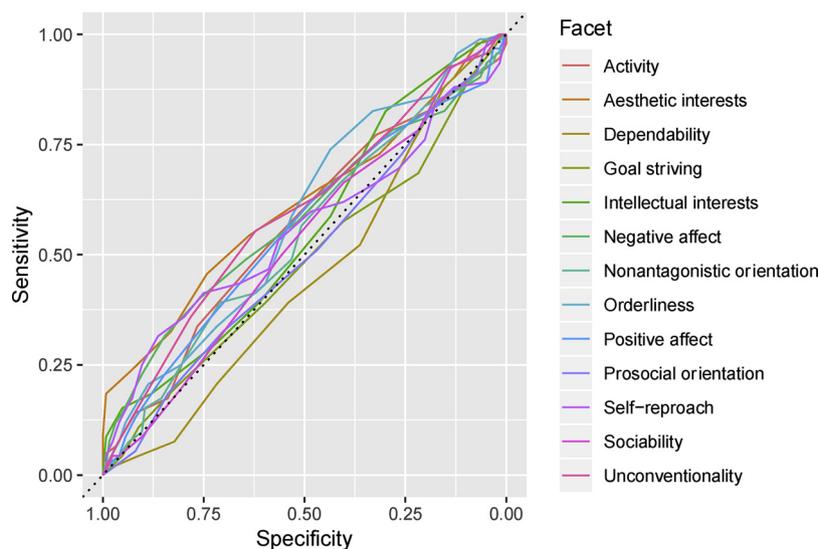

Fig. 3. Receiver operating characteristic (ROC) curves for personality score facets in terms of classification of PNES and ES.

Table 3
Classification performance for personality domain and facet scores.

Psychometric marker	AUC [95%CIs]	Threshold	Sensitivity	Specificity	PPV	NPV
Domains						
Neuroticism	.57 [.49, .65]	> 1.20	.36	.85	.65	.64
Extaversion	.56 [.49, .64]	< −1.40	.18	.93	.65	.61
Openness	**.62 [.54, .69]**	> 0.08	.53	.69	.56	.67
Agreeableness	.53 [.45, .61]	< −0.40	.50	.60	.48	.62
Conscientiousness	.59 [.50, .66]	< −0.01	.80	.36	.48	.71
Facets						
Negative affect	.58 [.50, .66]	> 1.08	.32	.85	.60	.62
Self-reproach	.55 [.48, .64]	> 1.66	.32	.86	.63	.63
Positive affect	.56 [.48, .63]	< 0.19	.62	.48	.47	.63
Sociability	.53 [.45, .61]	< 0.51	.66	.40	.45	.62
Activity	.56 [.48, .64]	< −0.41	.52	.59	.48	.62
Aesthetic interests	**.61 [.53, .69]**	> 0.10	.46	.74	.57	.65
Intellectual interests	.55 [.48, .63]	> −0.87	.83	.30	.47	.70
Unconventionality	**.59 [.52, .69]**	> −0.13	.55	.62	.52	.65
Nonantagonistic orientation	.54 [.46, .62]	< −1.02	.39	.71	.50	.61
Prosocial orientation	.50 [.42, .58]	> −3.02	.99	.04	.43	.83
Orderliness	**.58 [.51, .66]**	< −0.01	.74	.44	.49	.69
Goal striving	.48 [.40, .56]	> 1.19	.11	.91	.48	.58
Dependability	.44 [.37, .52]	> −1.79	.88	.15	.44	.63

Note: AUC = area under the curve. CIs = 95% credible intervals. Threshold is the optimal cut-off for classifying PNES patients. PPV = positive predictive value. NPV = negative predictive value.

However, it is important to note that PNES patients are a heterogenous group with different psychological profiles and defence mechanisms [9,54], and therapy should ultimately be tailored to the individual.

5. Conclusion

Overall, our findings show that patients with ES exhibit lower openness to experience and aesthetic interest compared to patients with PNES and compared to the general population. These findings open up new avenues of research using modern personality models to further understand patients with epilepsy and related presentations.

Declaration of Competing Interest

All authors have no competing interests to declare.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.seizure.2019.10.011.

References

[1] LaFrance Jr WC, Baker GA, Duncan R, Goldstein LH, Reuber M. 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 2013;54:2005–18.

[2] de Timary P, Fouchet P, Sylin M, Indriets JP, de Barsy T, Lefèbvre A, et al. Non-epileptic seizures: delayed diagnosis in patients presenting with electroencephalographic (EEG) or clinical signs of epileptic seizures. Seizure 2002;11:193–7.

[3] Magee JA, Burke T, Delanty N, Pender N, Fortune GM. The economic cost of nonepileptic attack disorder in Ireland. Epilepsy Behav 2014;33:45–8.

[4] Nowack WJ. Epilepsy: a costly misdiagnosis. Clin Electroencephalogr 1997;28:225–8.

[5] Whitaker JN. The confluence of quality of care, cost-effectiveness, pragmatism, and medical ethics in the diagnosis of nonepileptic seizures: a provocative situation for neurology. Arch Neurol 2001;58:2066–7.

[6] Karterud HN, Knizek BL, Nakken KO. Changing the diagnosis from epilepsy to PNES: patients' experiences and understanding of their new diagnosis. Seizure 2010;19:40–6.

[7] Galimberti CA, Ratti MT, Murelli R, Marchioni E, Manni R, Tartara A. Patients with psychogenic nonepileptic seizures, alone or epilepsy-associated, share a psychological profile distinct from that of epilepsy patients. J Neurol 2003;250:338–46. https://doi.org/10.1007/s00415-003-1009-0.

[8] Scévola L, Teitelbaum J, Oddo S, Centurión E, Loidl CF, Kochen S, et al. Psychiatric disorders in patients with psychogenic nonepileptic seizures and drug-resistant epilepsy: a study of an Argentine population. Epilepsy Behav 2013;29:155–60. https://doi.org/10.1016/j.yebeh.2013.07.012.

[9] Beghi M, Negrini PB, Perin C, Peroni F, Magaudda A, Cerri C, et al. Psychogenic non-epileptic seizures: so-called psychiatric comorbidity and underlying defense mechanisms. Neuropsychiatr Dis Treat 2015;11:2519.

[10] Kanner AM, Schachter SC, Barry JJ, Hersdorffer DC, Mula M, Trimble M, et al. Depression and epilepsy, pain and psychogenic non-epileptic seizures: clinical and therapeutic perspectives. Epilepsy Behav 2012;24:169–81. https://doi.org/10.1016/j.yebeh.2012.01.008.

[11] Hovorka J, Nežádal T, Herman E, Nečmcová I, Bajacˇek M. Psychogenic non-epileptic seizures, prospective clinical experience: diagnosis, clinical features, risk factors, psychiatric comorbidity, treatment outcome. Epileptic Disord 2017;9:7.

[12] Tojek TM, Lumley M, Barkley G, Mahr G, Thomas A. Stress and other psychosocial characteristics of patients with psychogenic nonepileptic seizures. Psychosomatics 2000;41:221–6. https://doi.org/10.1176/appi.psy.41.3.221.

[13] Lacey C, Cook M, Salzberg M. The neurologist, psychogenic nonepileptic seizures, and borderline personality disorder. Epilepsy Behav EB 2007;11:492–8.

[14] Harden CL, Jovine L, Burgut FT, Carey BT, Nikolov BG, Ferrando SJ. A comparison of personality disorder characteristics of patients with nonepileptic psychogenic pseudoseizures with those of patients with epilepsy. Epilepsy Behav EB 2009;14:481–3. https://doi.org/10.1016/j.yebeh.2008.12.012.

[15] Krishnamoorthy ES, Brown RJ, Trimble MR. Personality and psychopathology in nonepileptic attack disorder and epilepsy: a prospective study. Epilepsy Behav EB 2001;2:418–22.

[16] Cragar DE, Berry DT, Fakhoury TA, Cibula JE, Schmitt FA. A review of diagnostic techniques in the differential diagnosis of epileptic and nonepileptic seizures. Neuropsychol Rev 2002;12:31–64.

[17] Wilkus RJ, Dodrill CB, Thompson PM. Intensive EEG monitoring and psychological studies of patients with pseudoepileptic seizures. Epilepsia 1984;25:100–7.

[18] Derry PA, McLachlan RS. The MMPI-2 as an adjunct to the diagnosis of pseudo-seizures. Seizure 1996;5:35–40.

[19] Storzbach D, Binder LM, Salinsky MC, Campbell BR, Mueller RM. Improved prediction of nonepileptic seizures with combined MMPI and EEG measures. Epilepsia 2000;41:332–7. https://doi.org/10.1111/j.1528-1157.2000.tb00164.x.

[20] Schramke CJ, Valeri A, Valeriano JP, Kelly KM. Using the Minnesota Multiphasic Inventory 2, EEGs, and clinical data to predict nonepileptic events. Epilepsy Behav 2007;11:343–6. https://doi.org/10.1016/j.yebeh.2007.06.011.

[21] Owczarek K, Jedrzejczak J. Patients with coexistent psychogenic pseudoepileptic and epileptic seizures: a psychological profile. Seizure 2001;10:566–9.

[22] Thompson AW, Hantke N, Phatak V, Chaytor N. The Personality Assessment Inventory as a tool for diagnosing psychogenic nonepileptic seizures. Epilepsia 2010;51:161–4. https://doi.org/10.1111/j.1528-1167.2009.02151.x.

[23] Marc Testa S, Lesser RP, Krauss GL, Brandt J. Personality Assessment Inventory among patients with psychogenic seizures and those with epilepsy. Epilepsia 2011;52:e84–8. https://doi.org/10.1111/j.1528-1167.2011.03141.x.

[24] Wagner MT, Wymer JH, Topping KB, Pritchard PB. Use of the Personality Assessment Inventory as an efficacious and cost-effective diagnostic tool for none-pileptic seizures. Epilepsy Behav EB 2005;7:301–4.

[25] Reuber M, Pukrop R, Bauer J, Derfuss R, Elger CE. Multidimensional assessment of personality in patients with psychogenic non-epileptic seizures. J Neurol Neurosurg Psychiatry 2004;75:743–8.

[26] Hill SW, Gale SD. Predicting psychogenic nonepileptic seizures with the Personality Assessment Inventory and seizure variables. Epilepsy Behav EB 2011;22:505–10. https://doi.org/10.1016/j.yebeh.2011.08.001.

[27] Costa PT, MacCrae RR. Revised NEO personality inventory (NEO PI-R) and NEO five-factor inventory (NEO-FFI): professional manual. Psychological Assessment Resources, Incorporated; 1992.

[28] Cragar DE, Berry DTR, Schmitt FA, Fakhoury TA. Cluster analysis of normal per-sonality traits in patients with psychogenic nonepileptic seizures. Epilepsy Behav 2005;6:593–600. https://doi.org/10.1016/j.yebeh.2005.03.007.

[29] Ekanayake V, Kranick S, LaFaver K, Naz A, Frank Webb A, LaFrance WCJ, et al. Personality traits in psychogenic nonepileptic seizures (PNES) and psychogenic movement disorder (PMD): neuroticism and perfectionism. J Psychosom Res 2017;97:23–9. https://doi.org/10.1016/j.jpsychores.2017.03.018.

[30] Vilyte G, Pretorius C. Personality traits, illness behaviors, and psychiatric co-morbidity in individuals with psychogenic nonepileptic seizures (PNES), epilepsy, and other nonepileptic seizures (oNES): differentiating between the conditions. Epilepsy Behav 2019;98:210–9.

[31] Fisher RS, Boas WVE, Blume W, Elger C, Genton P, Lee P, et al. Epileptic seizures and epilepsy: definitions proposed by the International League Against Epilepsy (ILAE) and the International Bureau for Epilepsy (IBE). Epilepsia 2005;46:470–2.

[32] Fisher RS, Acevedo C, Arzimanoglou A, Bogacz A, Cross JH, Elger CE, et al. ILAE official report: a practical clinical definition of epilepsy. Epilepsia 2014;55:475–82.

[33] Association AP. Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub; 2013.

[34] Betts T, Boden S. Diagnosis, management and prognosis of a group of 128 patients with non-epileptic attack disorder. Part II. Previous childhood sexual abuse in the aetiology of these disorders. Seizure 1992;1:27–32.

[35] Berg AT, Berkovic SF, Brodie MJ, Buchhalter J, Cross JH, van Emde Boas W, et al. Revised terminology and concepts for organization of seizures and epilepsies: report of the ILAE Commission on Classification and Terminology, 2005–2009. Epilepsia 2010;51:676–85.

[36] John O. The "Big Five" factor taxonomy: dimensions of personality in the natural language and in questionnaires. Handb. Personal. Res.. 1990. p. 66–100.

[37] McCrae RR. The five-factor model and its assessment in clinical settings. J Pers Assess 1991;57. https://doi.org/10.1207/s15327752jpa5703_2. 399–314.

[38] Digman J. Personality structure:emergence of the five-factor model. Annu Rev Clin Psychol 1990;41:417–40.

[39] McCrae RR. NEO-PIR data from 36 cultures. Five-factor model personal. Cult.. Springer; 2002. p. 105–25.

[40] Saucier G. Replicable item-cluster subcomponents in the NEO five-factor inventory. J Pers Assess 1998;70:263–76.

[41] JASP Team. JASP(Version 0.9.2)[Computer software]. 2019.

[42] R Core Team. R: a language and environment for statistical computing. 2019.

[43] Cohen J. Statistical power analysis for the behavioral sciences. Routledge; 2013.

[44] DeYoung CG. Openness/Intellect: a dimension of personality reflecting cognitive exploration. APA Handb Personal Soc Psychol Personal Process Individ Differ 2014;4:369–99.

[45] Zillig LMP, Hemenover SH, Dienstbier RA. What do we assess when we assess a Big 5 trait? A content analysis of the affective, behavioral, and cognitive processes represented in Big 5 personality inventories. Pers Soc Psychol Bull 2002;28:847–58.

[46] Elger CE, Helmstaedter C, Kurthen M. Chronic epilepsy and cognition. Lancet Neurol 2004;3:663–72.

[47] Swinkels WAM, Van Emde Boas W, Kuyk J, Van Dyck R, Spinhoven P. Interictal Depression, Anxiety, Personality Traits, and Psychological Dissociation in Patients with Temporal Lobe Epilepsy (TLE) and Extra-TLE: INTERICTAL PSYCHOPATHOLOGY IN TLE AND EXTRA-TLE. Epilepsia 2006;47:2092–103. https://doi.org/10.1111/j.1528-1167.2006.00808.x.

[48] Bear DM, Fedio P. Quantitative analysis of interictal behavior in temporal lobe epilepsy. Arch Neurol 1977;34:454–67.

[49] Feddersen B, Herzer R, Hartmann U, Gaab MR, Runge U. On the psychopathology of unilateral temporal lobe epilepsy. Epilepsy Behav EB 2005;6:43–9.

[50] Wasserstein RL, Lazar NA. The ASA's statement on p-values: context, process, and purpose. Am Stat 2016;70:129–33.

[51] McCrae RR, Costa PT. Validation of the five-factor model of personality across in-struments and observers. J Pers Soc Psychol 1987;52:81–90.

[52] LaFrance WC, Keitner GI, Papandonatos GD, Blum AS, Machan JT, Ryan CE, et al. Pilot pharmacologic randomized controlled trial for psychogenic nonepileptic sei-zures. Neurology 2010;75:1166–73. https://doi.org/10.1212/WNL. 0b013e3181f4d5a9.

[53] Goldstein LH, Chalder T, Chigwedere C, Khondoker MR, Moriarty J, Toone BK, et al. Cognitive-behavioral therapy for psychogenic nonepileptic seizures: a pilot RCT. Neurology 2010;74:1986–94. https://doi.org/10.1212/WNL.0b013e3181e39658.

[54] Marchetti RL, Kurcgant D, Neto JG, von Bismark MA, Marchetti LB, Fiore LA. Psychiatric diagnoses of patients with psychogenic non-epileptic seizures. Seizure 2008;17:247–53.