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Emotion in psychogenic nonepileptic seizures: Responses to affective pictures

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ABSTRACT

We examined emotional responses to standard affective pictures in 18 psychogenic nonepileptic seizure (PNES) patients. Given reports of trauma and posttraumatic stress symptoms (PTS) in many PNES patients, comparison groups were seizure-free individuals high and low in PTS (*PTS-high*, *PTS-low*; $n=18$ per group). Patients with psychogenic nonepileptic seizures (1) reported more emotional intensity to neutral and pleasant pictures than PTS-low and more intensity to neutral pictures than PTS-high, and (2) showed less positive emotional behavior to pleasant pictures than PTS-high. Groups did not differ in pleasantness/unpleasantness ratings, negative emotional behavior, cardiac interbeat interval, or respiratory sinus arrhythmia (RSA) reactivity to the pictures. Patients with psychogenic nonepileptic seizures reported more general emotion regulation difficulties and showed lower baseline RSA than PTS-low but not PTS-high. In sum, intense emotional experience and diminished positive emotional behavior characterized PNES patients' emotional responses.

1. Introduction

The idea that unresolved emotional distress manifests in somatic symptoms is found from Freud to modern notions of stress and health (see [1] for review). One such symptom is psychogenic non-epileptic seizures (PNES). Approximately 5 to 22% of patients seeking treatment for seizures suffer from PNES, in which the patient appears to be having a seizure but electrophysiological abnormalities are absent [2,3]. Without identifiable medical origin, PNES typically is conceptualized as a conversion, dissociative, and/or posttraumatic stress reaction (see [4] for a review). Although from its early conceptions through current models, PNES has been described as closely tied to emotions [5,6] and even as "caused purely by the emotions" [7], much remains to be learned about PNES patients' actual emotional responses. The goal of the present study was to investigate PNES patients' subjective, physiological, and behavioral responses to standard affective stimuli.

In recent years researchers have begun studying emotion and emotion-related cognitive processes in patients with PNES more systematically. Studies of attention indicate that compared with epilepsy patients or controls, PNES patients show heightened responses to novel stimuli and fail to disregard task-irrelevant stimuli [8,9]. Such patterns have been identified in other psychiatric populations (e.g., posttraumatic stress disorder [PTSD]) and may be associated with heightened vigilance or responsivity to environmental stimuli more broadly (discussed in [8,9]). Bakvis and colleagues [10] found that PNES patients showed an attentional bias for subliminally presented negative emotional stimuli (angry faces), but not positive emotional stimuli (happy faces). In a subsequent study, Bakvis and colleagues [11] found that PNES patients were slower to "approach" the negative stimuli (i.e., angry faces) than controls, based on arm movements signaling approach versus avoidance. Therefore, despite potentially greater pre-attentive processing of negative emotional stimuli, from a behavioral perspective, PNES patients may be more likely than controls to avoid such stimuli [11]. These laboratory-based findings are consistent with self-report results indicating that compared with epilepsy patients or healthy controls, PNES patients experience more stress (both perceptions and actual number of stressful life events) but are more likely to deny the experience of psychological stress, to favor somatic rather than psychological explanations, and to engage in avoidance rather than problem-focused coping strategies [12–14].

Studies investigating physiological correlates of stress or emotion-related responses have found higher basal cortisol levels in PNES patients than healthy controls [10,11,15], which also predict greater attention [16] and slower "approach" [11] to angry faces. Patients with psychogenic nonepileptic seizures have shown lower heart rate variability (HRV) during baseline conditions than controls [10,17] although they do not differ from epilepsy patients [17]. High-frequency HRV (or respiratory sinus arrhythmia [RSA]) indexes parasympathetic nervous system influences on the heart [18] and is associated with self-soothing, calming, and inhibition of arousal [19].

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Many emotion-related responses observed in patients with PNES, such as heightened vigilance, greater attention to threatening stimuli, greater avoidance behavior, and lower RSA, have also been observed in other clinical disorders, such as depression, borderline personality disorder, and PTSD [8,20–26]. This is perhaps not surprising, given that common affective processes or vulnerabilities may underlie many disorders [27,28]. In particular, trauma is often a shared characteristic among these disorders, including PNES. Very high proportions of PNES patients report trauma [29,30], which is considered a risk factor for PNES [31], and PNES has been hypothesized to develop as an expression of, or mechanism for coping with, trauma-related stress or emotional upset [7,32–34]. Indeed, Bakvis and colleagues [10] found that attentional bias for angry faces was associated with PNES patients' (but not controls') reports of past sexual trauma, and in another study, reports of past sexual trauma were associated with elevated basal cortisol [15]. Despite theoretical explanations and data linking trauma and PNES, surprisingly few studies have directly compared individuals with PNES to seizure-free individuals with posttraumatic stress symptoms. Such comparisons are critical for identifying aspects of emotional processes unique to PNES versus those common among individuals with prior trauma exposure.

Therefore, in the current study we compared emotional responses among PNES patients (nearly all of whom reported prior trauma and elevated posttraumatic stress symptoms) and seizure-free individuals with prior trauma exposure and higher or lower levels of posttraumatic stress symptoms (*PTS-high* and *PTS-low*, respectively). Participants viewed pleasant, neutral, and unpleasant pictures from the International Affective Picture System (IAPS; [35]). We measured emotional experience (ratings of valence [pleasantness/unpleasantness] and arousal [calm/intense]), emotional facial behavior (positive and negative), and cardiovascular responses (cardiac interbeat interval and respiratory sinus arrhythmia) to the pictures. We also examined baseline cardiovascular responses and general self-reported emotion regulation difficulties.

Individuals with posttraumatic stress symptoms but not PNES show emotional responses including heightened negative emotional experience and physiological arousal [36], flattening of emotional behavior relative to emotional experience [37], and general emotion regulation difficulties [38] or vulnerabilities (e.g., low baseline RSA; [20]). Many PNES patients, including those in our sample, experience nonepileptic seizures in addition to "typical" posttraumatic stress manifestations of reexperiencing, arousal, and avoidance [29,30]. Furthermore, studies describe PNES patients as high in distress and low in psychological or emotional insight [12–14], which we suspect may be associated with less differentiated emotional states. This led us to expect that PNES patients' subjective emotional reactivity might be more negative and more intense, yet more blunted in its expression, compared to non-seizure participants with posttraumatic stress symptoms, even those with high symptom levels.

We hypothesized that in response to standard affective pictures, compared with the PTS-high or PTS-low groups, PNES patients would (1) report more unpleasant emotional experience (i.e., lower valence ratings) and greater emotional intensity; (2) display less of the expected valence-congruent emotion (i.e., less positive emotional behavior to pleasant slides and less negative emotional behavior to unpleasant slides); and (3) show greater cardiovascular activation (i.e., shorter cardiac interbeat intervals, reflecting faster heart rate) and lower heart rate variability (i.e., lower RSA). In addition, given previous research suggesting that PNES is associated with greater perceived stress and potentially maladaptive approaches for coping with this stress (e.g., avoidant coping [12,13]), we expected that PNES patients would report experiencing more emotion regulation difficulties per the Difficulties in Emotion Regulation Scale [39] than the other groups. We also expected PNES patients would show lower baseline RSA than the other groups, given that in previous research, PNES patients showed lower baseline RSA than controls [10,17].

2. Method

2.1. Participants

Participants were 18 PNES patients (nearly all of whom reported prior trauma), 18 seizure-free individuals with relatively elevated posttraumatic stress symptom levels (PTS-high), and 18 seizure-free individuals with relatively lower posttraumatic symptom levels (PTS-low). The latter two groups were closely matched in demographic background to the PNES group (see Table 1).

2.1.1. PNES patients

PNES patients were recruited from the epilepsy monitoring unit of Barrow Neurological Institute, St. Joseph's Hospital and Medical Center (Phoenix, AZ). Board-certified clinical neurophysiologists/epileptologists diagnosed PNES using video-EEG monitoring. Additional inclusion

Table 1
Sample characteristics by group.

	PNES ($n=18$)	PTS-high ($n=18$)	PTS-low ($n=18$)
Sex (n)			
Female	15	13	15
Male	3	5	3
Age (years)	42.6 (11.8)	40.7 (12.3)	43.2 (12.6)
Age of PNES onset (years)	35.1 (14.9)	–	–
Race/ethnicity (n)			
White/European American	12	10	11
Hispanic/Latino (a)	2	3	5
Black/African American	2	3	1
Asian/Asian American	0	1	0
Multiethnic	2	1	1
Marital status (n)			
Single	11	13	14
Married	7	5	4
Number of years of education	13.2 (2.0)	14.3 (2.5)	14.9 (2.2)
Income level (n)			
Lower/lower-middle	8	11	9
Middle	9	4	6
Upper-middle/upper	1	3	3
PTSD Symptom Checklist (PCL-S)[a]	59.9_a (12.2)	53.8_a (11.9)	30.7_b (6.3)
Trauma type reported (n)[a]			
Abuse/assault	3	10	10
Injury/hospitalization	3	3	1
Death of a loved one	3	2	2
Car accident	2	1	1
Combat experience	0	2	2
Natural disaster	0	0	1
Event not specified	6	0	1
No traumatic event	1	0	0
SCL-90-R—Global Severity Index	1.5_a (0.8)	1.3_a (0.5)	0.5_b (0.4)
SCL-90-R—symptom subscales			
Anxiety	14.9_a (9.3)	11.8_a (8.3)	5.4_b (5.5)
Depression	21.9_a (11.4)	23.1_a (11.1)	10.8_b (9.7)
Hostility	6.4_a (5.7)	5.1_a (3.9)	2.2_b (2.3)
Interpersonal sensitivity	11.3_a (9.2)	12.5_a (7.2)	5.0_b (4.1)
Obsessive–compulsive	20.6_a (10.5)	15.8_a (6.7)	6.6_b (5.9)
Paranoia	8.5_a (6.0)	7.8_a (5.3)	2.9_b (3.1)
Phobic anxiety	7.0_a (7.2)	5.4_a (4.7)	1.4_b (2.6)
Psychoticism	11.1_a (9.0)	11.3_a (7.2)	1.8_b (2.1)
Somatization	24.4_a (12.4)	11.8_b (5.1)	6.8_b (4.6)
Psychotropic medication[b] (n)			
Antiepileptic	10_a	0_b	0_b
Antidepressant	8_a	3_a	5_a
Antianxiety	7_a	1_b	$2_{a,b}$

Values are group means (*SD*), unless otherwise noted. Within a row, means with different subscripts are significantly different from each other, $p<.05$. PNES = psychogenic nonepileptic seizures. PTS = posttraumatic stress symptoms. SCL-90-R = Symptom Checklist-90—Revised.

[a] For the PCL-S, $n=10$ for the PNES group. Two additional PNES participants spontaneously described trauma experiences, and this information is included in the trauma categorization.

[b] For participants taking multiple medications, medications were counted in each respective category.

criteria were age greater than 18 and ability to converse appropriately with study personnel. Participants with comorbid epileptic and nonepileptic seizures, unclear diagnoses, severe sensory impairments, or severe psychiatric conditions (e.g., active psychosis, substance abuse) were not considered for enrollment into the study. Of the patients who were informed about the study and expressed interest in being contacted by the PI, 18 participated (60%), 3 were unable to participate (e.g., for geographic reasons) but participated in telephone interviews (reported elsewhere), 7 were unreachable by phone or did not follow up, and 2 decided they were not interested before hearing about the details of the study. Of note, prior trauma exposure was not one of the inclusion criteria; however, all but one patient reported having experienced one or more traumatic events (i.e., a past event that elicited helplessness, horror, or fear) spontaneously or when asked, and all of those assessed reported elevated posttraumatic stress symptoms (see below).

2.1.2. Seizure-free, trauma-exposed participants

Trauma-exposed individuals were recruited from the community via flyers and word of mouth. Inclusion criteria were identical to PNES, with the addition that those with a history of any seizures or neurological conditions were excluded. Prior trauma exposure was determined by a telephone screen and the PTSD Symptom Checklist—Specific Event version (PCL-S). PCL-S scores for seizure-free, trauma-exposed individuals ranged from 19 to 76. Categorization into the PTS-high and PTS-low groups was based on a median split (median = 40). A PCL-S score over 44 may be considered diagnostic of PTSD [40]. Notably, most participants in our PTS-high group scored above 44 (exceptions were two at 43 and one at 42). The PCL-S range in the PTS-high group (42 to 76) was comparable to that of PNES participants (41 to 78), whereas scores for the PTS-low group ranged from 19 to 38. Our group categorization provided a conservative test of our hypotheses that PNES patients would differ in their emotional responses from our two comparison groups because all participants experienced some degree of elevated psychiatric symptoms.

2.2. Procedure

Participants completed one 2-hour laboratory session. All procedures were approved by the university's committee for protection of human subjects and participants provided informed consent per APA standards. Electrodes for physiological recordings were attached and participants sat quietly for a 3-minute resting baseline. Participants then viewed 60 emotional pictures (described below) on a computer monitor, each for 5 s.[1] Each image was preceded by a 1.5-second fixation (a plus-sign) and followed by two rating screens, one for emotional valence (pleasantness/unpleasantness) and one for emotional intensity (calm/intense). Participants entered ratings via keyboard. Inter-trial intervals (blank screen) averaged 7 s. Participants were video recorded throughout picture viewing. Lastly, participants completed questionnaires, were debriefed, and were paid $65.

2.3. Stimulus materials and measures

2.3.1. Emotional pictures

Participants viewed 60 pictures from the International Affective Picture System (IAPS; [35]): 20 pleasant pictures (e.g., puppies), 20 unpleasant pictures (e.g., pointed gun), and 20 neutral pictures (household objects; e.g., chair).[2] Four additional pictures not included in the analyses (two neutral, one pleasant, and one unpleasant) were presented for adaptation to the procedure.

Pictures were selected using normative ratings of pleasantness/unpleasantness made on a 0–10 scale [41]. Normative group means indicated that the pictures we selected for the present study were clearly pleasant ($M = 7.4$, $SD = 0.5$), neutral ($M = 4.9$, $SD = 0.2$), or unpleasant ($M = 2.6$, $SD = 0.9$), $ts > 11.11$, $ps < .001$. The pictures also differed significantly in normative ratings of intensity or arousal (0–10 scale), such that unpleasant pictures were rated as most emotionally intense ($M = 6.5$, $SD = 0.8$), followed by pleasant pictures ($M = 4.9$, $SD = 1.1$), and then neutral pictures ($M = 2.6$, $SD = 0.4$), $ts > 4.94$, $ps < .01$.

2.3.2. Emotional experience ratings

After viewing each image, participants provided self-report ratings of emotional valence (pleasantness/unpleasantness) and intensity – two key dimensions of affective experience – using Lang's [42] self-assessment manikin (SAM). The SAM uses cartoon figures representing affect along two dimensions: valence, for which figures display affect ranging from unpleasant (frowning, unhappy) to pleasant (smiling, happy; [41]), and intensity, for which figures display arousal states ranging from calm (close-eyed, calm) to intense (wide-eyed, excited; [41,43]). We included corresponding numeric values ranging from 1 to 5 along with the cartoon figures.

2.3.3. Emotional behavior

Trained research assistants watched digital video recordings of each participant's face and upper torso and coded positive and negative emotional behavior. A positive emotion score of “1” was assigned if the participant displayed any positive emotional behavior and a “0” if no positive emotional behavior was displayed. The same procedure was followed for negative emotion. In making their ratings, coders used intuitive judgments (see [44] for a validation of this procedure) and specific facial behaviors (e.g., genuine smiles, laughter, brow furrowing, nose wrinkles). Coding was done for the last 3 s of picture viewing for the 51 pictures (17 per valence) with startle noises (see footnote 1). To determine interrater reliability among coders, a subset of videos (15%) was coded by two or more raters. Across rater pairs/groups, average measure intraclass correlations ranged from .73 to .89. Given low base rates of behavior, our final analyses considered whether participants showed any positive emotional behavior (coded as 1 versus 0) or negative emotional behavior (coded as 1 versus 0) during picture viewing.

2.3.4. Cardiac interbeat interval (IBI) and respiratory sinus arrhythmia (RSA)

IBI and RSA were acquired and processed using hardware and software from MindWare Technologies Ltd. (8-slot *Bionex* unit, *Biolab* software v2.0–5.0). Quik-Trace diaphoretic foam spot electrodes for electrocardiography (ECG) were attached to each participant's neck and torso in a modified Lead II placement [45]. Spot electrodes for impedance cardiography were applied to the back, neck, and chest in a tetrapolar configuration [46]. Signals were digitized at 1000 Hz, then edited, verified, and scored. Cardiac interbeat interval was derived based on the time in ms between successive peaks of the R-wave of the ECG. Respiratory sinus arrhythmia was derived as described by Berntson and colleagues [47] using spectral analysis.

[1] White noise bursts were presented through headphones intermittently during and after the pictures. Noise presentation was identical for all participants and did not interact significantly with group membership in influencing the dependent measures reported here. Due to technical issues, other data related to these noise bursts (i.e., electromyographic data) are not analyzable and therefore not reported. Because behavioral data were based on pictures with startle noises, analyses with the other dependent measures (self-report and physiology) were re-computed for just these pictures. These analyses yielded the same pattern of findings as reported here.

[2] IAPS identification numbers for pictures used: unpleasant: 7380, 3053, 3530, 1070, 1050, 9080, 6260, 3060, 1120, 3080, 6230, 9300, 6350, 7360, 3110, 1300, 6510, 3130, 1930, and 9320; neutral: 7004, 7006, 7010, 7025, 7002, 7035, 7040, 7041, 7009, 7050, 7030, 7060, 7080, 7090, 7150, 7175, 7217, 7233, 7034, and 7235; pleasant: 4660, 5660, 2530, 7230, 4670, 1710, 5760, 7330, 7350, 4680, 5000, 2070, 2340, 4651, 7400, 5780, 5830, 5891, 7470, and 4651. Four initial pictures: 7000 (neutral), 5260 (pleasant), 9290 (unpleasant), and 6150 (neutral).

To obtain baseline IBI and RSA, data were ensemble averaged within 1-minute epochs during the 3-minute baseline rest period, and these three epochs were averaged. To obtain IBI responses to the pictures, average IBI for the 5-second picture viewing was computed for each picture. These scores were then averaged for the pleasant, unpleasant, and neutral pictures, respectively. To obtain IBI reactivity, IBI change scores were computed by subtracting mean IBI during the 3-minute initial resting baseline from mean IBI during picture viewing for each valence.

RSA reactivity scores were derived differently. Because more reliable estimates of RSA are obtained from longer time intervals [48], we averaged RSA across the entire picture viewing period, which lasted 20.9 min on average ($SD = 4.5$ min). This resulted in one RSA value that was used in the analyses, as opposed to the 60 values (one for each picture based on a 5-second interval) used for the IBI analyses. We then computed RSA reactivity scores for each participant by subtracting baseline RSA from average RSA during the picture presentation.

2.3.5. Demographics

Participants completed a questionnaire regarding age, race/ethnicity, occupation, education, income, and relationship status.

2.3.6. PTSD Symptom Checklist for DSM-IV—Specific Event version (PCL-S; [49])

For the PCL-S, participants list a specific traumatic event and, with reference to the event, rate how much they have been bothered by 17 PTSD-related symptoms (e.g., repeated disturbing memories, thoughts, or images of the stressful experience) in the past month. Ratings are made on a 1 to 5 scale (anchored by *not at all*, *a little bit*, *moderately*, *quite a bit*, and *extremely*) and summed into one total score. The PCL-S is correlated with the Clinician-Administered PTSD Scale ($r = .93$; [50]) and has been used in previous research on PTS symptoms and emotion regulation [38]. In our sample, reliability was $\alpha = .92$. Initially in our protocol the PCL-S was not administered to PNES participants; therefore, PCL-S data are available for only 10 of the 18 PNES participants.

2.3.7. Symptom Checklist-90—Revised (SCL-90-R; [51])

The SCL-90-R is a valid and reliable measure of psychiatric distress [52,53]. Participants use a 5-point Likert-type scale (0 = *not at all*, 1 = *a little bit*, 2 = *moderately*, 3 = *quite a bit*, 4 = *extremely*) to rate how much discomfort they experienced during the past week due to each of 90 problems (e.g., spells of terror or panic). This measure yields the Global Severity Index (average of all 90 items) and nine primary symptom subscale scores (see Table 1). In our sample, reliability was $\alpha = .98$ for the Global Severity Index, and reliabilities ranged from $\alpha = .79$ to $\alpha = .90$ for the symptom subscales.

2.3.8. Difficulties in Emotion Regulation Scale (DERS; [39])

The DERS is a reliable and valid 36-item measure that assesses emotion regulation difficulties, encompassing "the awareness, understanding, and acceptance of emotions, and the ability to act in desired ways regardless of emotional state" [39]. Participants rate how often each item applies, using a 5-point scale: 1 = *almost never* (0–10%), 2 = *sometimes* (11–35%), 3 = *about half the time* (36–65%), 4 = *most of the time* (66–90%), 5 = *almost always* (91–100%). Sample items include, "When I'm upset, my emotions feel overwhelming," and "I have difficulty making sense out of my feelings." Higher scores indicate greater emotion regulation difficulties. In our sample, reliability for the DERS total score was $\alpha = .94$.

3. Results

3.1. Preliminary analyses

Information about demographics, prior trauma, self-reported psychological symptoms, and current use of psychotropic medication is presented by group in Table 1. Groups did not differ with respect to any of our demographic measures.

3.1.1. Traumatic stress symptoms

Groups did not differ in type of previous traumatic experiences reported, $\chi^2(10, N = 46) = 9.41$, $p = .494$. As expected per our group categorization, however, groups differed in reports of severity of posttraumatic stress symptoms, $F(2, 43) = 35.15$, $p < .001$. Patients with psychogenic nonepileptic seizures and PTS-high each reported more posttraumatic stress symptoms than PTS-low, $ts > 6.83$, $ps < .001$, and PNES and PTS-high did not differ from one another, $t(26) = 1.53$, $p = .134$. Notably, greater posttraumatic stress symptom severity per the PCL-S was associated with greater general psychological distress, $r(44) = .78$, $p < .001$, and greater self-reported emotion regulation difficulties, $r(44) = .66$, $p < .001$, but was not significantly related to any of our dependent emotion measures, $rs \leq .29$, $ps > .11$.

3.1.2. Psychological symptoms

There were group differences in the overall psychological distress (per the SCL-90-R Global Severity Index), $F(2, 51) = 13.62$, $p < .001$; PNES and PTS-high each reported more psychological distress than PTS-low, $ts \geq 2.10$, $ps \leq .041$, but PNES and PTS-high did not differ from one another, $t(34) = 1.29$, $p = .202$. Patients with psychogenic nonepileptic seizures and PTS-high also reported more psychological symptoms based on specific symptom subscales than PTS-low, $ts \geq 2.10$, $ps < .041$, for all subscales except somatization, where PTS-high and PTS-low did not differ, $t(34) = 1.82$, $p = .076$. Patients with psychogenic nonepileptic seizures and PTS-high did not differ in psychological symptoms per specific subscales, $ts < 1.21$, $ps > .234$, except that PNES participants reported significantly more somatic symptoms, $t(34) = 4.63$, $p < .001$ than PTS-high.

3.1.3. Medication use

Groups differed significantly in their use of antiepileptic medication, $\chi^2(2, N = 54) = 24.55$, $p < .001$; 10 of the 18 PNES participants, but none of the PTS-high or PTS-low participants were taking antiepileptic medication. Consistent with a PNES diagnosis, patients reported that antiepileptic medications were not effective in ameliorating their seizures; however, they had not yet been weaned from these medications and may have been continuing on them for mood stabilization purposes. Groups also differed in their use of antianxiety medication (i.e., benzodiazepines or buspirone), $\chi^2(2, N = 54) = 7.61$, $p = .022$; PNES participants were more likely to be taking antianxiety medication than PTS-high participants, $\chi^2(1, N = 36) = 5.79$, $p = .016$ (PNES versus PTS-low, $\chi^2[1, N = 36] = 3.70$, $p = .054$). There were no significant group differences in their use of antidepressant medication (i.e., selective serotonin reuptake inhibitors [SSRIs], tricyclic antidepressants, bupropion, venlafaxine, trazodone, or duloxetine), $\chi^2(2, N = 54) = 3.38$, $p = .185$.

To examine possible effects of medication use on our dependent measures, we re-computed our primary analyses (described below) including medication use as an additional factor. We did this for antianxiety medication use and then for antiepileptic medication use. There was one effect of antianxiety medication: participants taking antianxiety medication showed more negative emotional behavior to unpleasant pictures than participants not taking antianxiety medication; however, group differences in negative emotional behavior were non-significant (as reported below), regardless of whether antianxiety medication was included in the model. Antianxiety medication use did not interact significantly with group for any of the measures.

Only participants from the PNES group were taking antiepileptic medication. Use of this medication predicted significantly lower SCL-90-R somatization scores, but did not predict any of our primary dependent measures (i.e., emotional intensity, emotional behavior, cardiac interbeat interval, or respiratory sinus arrhythmia); therefore, the use of antiepileptic medication cannot account for group differences in these measures where found.

3.1.4. Emotion ratings to standard stimuli: manipulation check

To determine whether the affective pictures evoked the intended responses in our participants, we conducted two separate repeated-measures ANOVAs with image valence (pleasant, unpleasant, neutral) as the repeated factor and ratings of pleasantness and intensity as dependent measures.

The main effect of image valence was significant for ratings of pleasantness, $F(2, 50)=183.13$, $p<.001$, $\eta_p^2=.88$, and intensity, $F(2, 50)=67.35$, $p<.001$, $\eta_p^2=.73$. Pair-wise comparisons revealed the expected patterns whereby participants provided the highest pleasantness ratings to pleasant ($M=4.0$, $SD=0.5$), followed by neutral ($M=3.0$, $SD=0.5$), and then unpleasant pictures ($M=1.9$, $SD=0.8$), and the highest intensity ratings to unpleasant ($M=3.5$, $SD=1.0$), followed by pleasant ($M=2.5$, $SD=1.0$), and then neutral pictures ($M=1.8$, $SD=0.8$), all $ps<.001$. Thus, the pattern of ratings across our full sample replicated that of normative ratings.

3.2. Emotional experience to affective pictures

To test the hypotheses that PNES participants would report more negative emotion and greater emotional intensity to the affective pictures than PTS-high or PTS-low participants, planned comparisons were conducted between groups (i.e., PNES vs. PTS-high, and PNES vs. PTS-low). We used this targeted approach rather than following a traditional hierarchical analytic strategy, given the advantages of direct hypothesis testing (see [54] for a discussion).

3.2.1. Emotional valence ratings

Contrary to our predictions, planned contrasts showed no significant differences in pleasantness ratings to the pictures for PNES versus PTS-high participants, $t(31)=.37$, $p=.710$, $d=.13$, or PNES versus PTS-low participants, $t(33)=.53$, $p=.597$, $d=.18$ (see Table 2). Exploratory post-hoc comparisons for the neutral, pleasant, and unpleasant pictures also failed to show significant differences in pleasantness ratings for PNES participants versus PTS-high or PTS-low participants.

3.2.2. Emotional intensity ratings

Consistent with our predictions, PNES participants reported more intensity to the pictures than either PTS-high participants, $t(31)=2.99$, $p=.004$, $d=1.07$, or PTS-low participants, $t(33)=3.68$, $p=.001$, $d=1.28$. Based on follow-up post-hoc comparisons for the neutral, pleasant, and unpleasant pictures (using Bonferroni correction), we found that PNES participants reported more intensity to neutral pictures than either PTS-high, $t(31)=3.13$, $p=.009$, $d=1.12$, or PTS-low participants, $t(33)=3.26$, $p=.006$, $d=1.13$. In responding to pleasant pictures, PNES participants reported significantly more intensity than PTS-low participants, $t(34)=2.76$, $p=.024$, $d=.95$, but did not differ from PTS-high participants, $t(34)=2.29$, $p=.079$, $d=.79$. Emotional intensity ratings did not differ significantly between groups for unpleasant pictures (see Table 2).

3.3. Emotional behavior to affective pictures

We conducted planned comparisons to test the hypothesis that PNES participants would show less target emotional behavior (i.e., less positive emotional behavior to the pleasant pictures and less negative emotional behavior to the unpleasant pictures) than PTS-high or PTS-low participants. We found that fewer PNES than PTS-high participants displayed positive emotional behavior to pleasant pictures, $\chi^2(1, N=25)=7.67$, $p=.006$, and PNES and PTS-low did not differ, $\chi^2(1, N=26)=2.48$, $p=.116$. Patients with psychogenic nonepileptic seizures did not differ from PTS-high or PTS-low in negative emotional behavior to the unpleasant pictures, $\chi^2(1, N=25)=.013$, $p=.910$, and $\chi^2(1, N=26)=.722$, $p=.395$, respectively (see Table 2).

Table 2
Mean (*SD*) emotional experience, emotional behavior, and cardiovascular responses to pictures and general emotion regulation indicators by group.

	PNES	PTS-high	PTS-low
Pleasantness ratings			
Pleasant pictures	4.0 (0.4)	4.0 (0.5)	4.0 (0.4)
Neutral pictures	3.1 (0.3)	3.0 (0.4)	3.1 (0.2)
Unpleasant pictures	1.8 (0.7)	1.7 (0.4)	1.8 (0.7)
Intensity ratings			
Pleasant pictures	3.1_a (1.0)	$2.3_{a,b}$ (0.9)	2.2_b (1.0)
Neutral pictures	2.2_a (0.8)	1.5_b (0.6)	1.5_b (0.7)
Unpleasant pictures	3.8 (0.9)	3.5 (1.0)	3.3 (1.1)
Emotional behavior			
Positive to pleasant pictures	5	11	9
Negative to unpleasant pictures	10	9	8
IBI reactivity			
Pleasant pictures	−3.9 (33.8)	11.1 (24.2)	3.2 (28.3)
Neutral pictures	−4.5 (32.4)	8.0 (23.7)	5.2 (23.8)
Unpleasant pictures	−3.0 (31.4)	18.4 (25.7)	5.8 (21.7)
RSA reactivity (across all pictures)	0.1 (0.4)	0.0 (0.4)	0.1 (0.5)
Baseline RSA	4.7_a (1.5)	$5.0_{a,b}$ (1.5)	5.7_b (1.4)
Difficulties in Emotion Regulation Scale—total score	87.1_a (20.7)	92.1_a (25.3)	68.2_b (18.0)

Within a row, means with different subscripts are significantly different, $p<.05$. All other values do not differ between groups. PNES = psychogenic nonepileptic seizures. PTS = posttraumatic stress symptoms. IBI = cardiac interbeat interval. RSA = respiratory sinus arrhythmia. Pleasantness and intensity ratings were made on a scale from 1 to 5 (very unpleasant to very pleasant, and very calm to very intense, respectively). Emotional behavior was coded as 0 (behavior absent) or 1 (behavior present). IBI and RSA reactivity scores were computed as response to pictures minus response during initial resting baseline. For self-report measures (pleasantness ratings, intensity ratings, and Difficulties in Emotion Regulation Scale scores), $n=18$ per group; for behavioral measures, $n=13$ for PNES and PTS-low and $n=12$ for PTS-high; for cardiovascular measures, $n=17$ for PNES and $n=18$ for PTS-high and PTS-low.

3.4. Cardiovascular responses to affective pictures

We conducted planned comparisons to test the hypothesis that PNES participants would show greater cardiovascular reactivity to the pictures (i.e., picture viewing minus baseline), than PTS-high or PTS-low. Contrary to this hypothesis, PNES patients did not differ from the other groups in cardiac interbeat interval to the pictures: PNES versus PTS-low, $t(33)=0.97$, $p=.338$, $d=.34$; PNES versus PTS-high, $t(33)=1.84$, $p=.071$, $d=.64$. Post-hoc comparisons for the neutral, pleasant, and unpleasant pictures (using Bonferroni correction) also failed to show group differences ($ts<2.39$, $ps\geq.062$). With respect to RSA reactivity (i.e., change from baseline to picture viewing), PNES also did not differ from PTS-high, $t(32)=0.52$, $p=.603$, $d=.18$, or PTS-low, $t(32)=0.03$, $p=.973$, $d=.01$ (see Table 2).

3.5. Indicators of emotion regulation

3.5.1. Reported emotion regulation difficulties

Groups differed significantly in their reports of overall emotion regulation difficulties per the Difficulties in Emotion Regulation Scale, $F(2, 51)=6.10$, $p=.004$, $\eta_p^2=.19$. Patients with psychogenic nonepileptic seizures and PTS-high each reported more overall emotion regulation difficulties than PTS-low: PNES versus PTS-low, $t(34)=2.62$, $p=.012$, $d=.90$; PTS-high versus PTS-low, $t(34)=3.31$, $p=.002$, $d=1.14$. Patients with psychogenic nonepileptic seizures and PTS-high did not differ, $t(34)=0.69$, $p=.490$, $d=.24$ (see Table 2).

3.5.2. Baseline RSA

During the initial resting baseline, PNES patients showed lower RSA than PTS-low, $t(33)=2.05$, $p=.046$, $d=.71$, but did not differ from PTS-high, $t(33)=0.51$, $p=.611$, $d=.18$ (see Table 2).

3.6. Supplemental analysis: emotion predicting group membership

We used logistic regression to determine whether our three significant dependent measures – emotional intensity to neutral pictures, emotional intensity to pleasant pictures, and positive emotional behavior to pleasant pictures – could serve as predictors to differentiate individuals with PNES from the other groups. Participants with psychogenic nonepileptic seizures were coded as having a positive diagnosis. Sensitivity and specificity estimates were determined by the correspondence between each participant's a priori classification (i.e., NES versus PTS-high or NES versus PTS-low) and his/her model-based classification (case = predicted probability of positive diagnosis ≥ 0.5; non-case = predicted probability of positive diagnosis < 0.5). We then performed an ROC analysis of specificities and sensitivities based on additional cut-points. For NES versus PTS-high, sensitivity = 0.85, specificity = 0.92, and positive and negative predictive values = 0.92 and 0.85, respectively. Area under the curve (AUC) from the ROC analysis was .97 (95% CI = 0.90, 1.00). For NES versus PTS-low, sensitivity = 0.77, specificity = 0.69, positive and negative predictive values = 0.71 and 0.75, respectively, and AUC = .85 (95% CI = 0.70, 1.00). Area under the curve values suggest that the predictors provide very good to excellent diagnostic value for both comparisons.

4. Discussion

This study was a systematic investigation of emotion in individuals with psychogenic nonepileptic seizures (PNES). Given the high prevalence of trauma reported by many PNES patients, including those in our sample, comparison groups were seizure-free, trauma-exposed individuals with relatively higher and lower levels of posttraumatic stress symptoms (*PTS-high* and *PTS-low* groups). Self-ratings of emotional experience, positive and negative emotional facial behavior, and cardiovascular responses (cardiac interbeat interval and respiratory sinus arrhythmia) were measured in response to standard stimuli widely used in the emotion literature (pleasant, neutral, and unpleasant pictures from the International Affective Picture System). We found that PNES patients (1) reported more emotional intensity in response to neutral and pleasant pictures than PTS-low and more intensity to neutral pictures than PTS-high, and (2) showed less positive emotional behavior to pleasant pictures than PTS-high. The groups did not differ in valence ratings (pleasantness/unpleasantness), negative emotional behavior, cardiac interbeat interval, or RSA reactivity to the pictures. In terms of emotion regulation, PNES patients reported more overall emotion regulation difficulties and showed lower baseline RSA than PTS-low. Finally, PNES patients reported more clinical symptoms on all subscales of the SCL-90-R than PTS-low. Patients with psychogenic nonepileptic seizures and PTS-high did not differ on these emotion regulation or symptom measures, with the important exception that PNES patients reported more somatic symptoms than PTS-high.

4.1. Greater emotional intensity in PNES

In our sample, greater intensity of emotional experience emerged as a key characteristic of PNES patients' emotional responses. Greater intensity for PNES patients was apparent for neutral and pleasant, but not unpleasant, pictures. Previous research similarly has found emotion-related differences between psychiatric patient groups and controls under neutral, ambiguous, or positive conditions, but not in more definitively negative or threatening contexts [36,55–60]. Furthermore, a study of PNES patients found that patients showed attentional bias for angry faces during baseline conditions, but not conditions of social evaluative threat [10]. Individuals with clinical disorders such as PTSD and borderline personality are theorized to demonstrate heightened vigilance in “safe” situations because aversive experiences from their past have conditioned them to prepare for threats in their current environment [36,57,61]. Similarly, in previous research PNES patients have failed to habituate to or filter out irrelevant stimuli in laboratory settings, which was posited to have implications for greater vigilance or responsivity to environmental stimuli more broadly [8,9].

The fact that PNES patients perceived the neutral and pleasant affective pictures as more intense is perhaps not surprising, given that subjective feeling states may arise in large part from somatic or visceral sensations [62,63], as well as from interpretation of possibly unrelated sensations [64,65]. Heightened attention to physiological arousal has been implicated in several clinical disorders, most notably anxiety—whereby simply anticipating physiological arousal is sufficient to induce changes in neural and subjective experience [66]. Attention to physical symptoms has been proposed as an integral contributor to the development and maintenance of medically unexplained symptoms in general [32] and to PNES in particular [4]. Given that PNES patients tend to attribute psychological stress or distress to somatic causes [13], it follows that they might experience and describe emotions in more global or visceral terms. Our findings of greater intensity ratings among PNES patients lend support to this idea, in addition to the fact that greater somatization was the only SCL-90-R subscale differentiating PNES from PTS-high. Notably, emotional intensity ratings may have been particularly likely to reflect somatic attunement in our study, because they were based on a pictorial scale that emphasized somatic states (ranging from calm, indicated by closed eyes and a small dot in the middle of the figure's torso, to intense, indicated by wide eyes and a large irregular pointed shape taking up the entire torso).

Unexpectedly, PNES participants did not endorse feeling greater negativity to emotional pictures, and in fact we found no evidence for any differences among our groups in hedonic evaluation. A previous study similarly found that in response to IAPS images, women with sexual assault-related PTSD reported greater intensity than controls but the groups did not differ in valence ratings [37]. Although null results must be interpreted with caution, they nevertheless suggest that PNES patients are not deficient in their ability to experience positive and negative emotional states in a differentiated way. Instead, heightened intensity may be a more appropriate characterization of emotional experience in this group.

4.2. Diminished positive emotional behavior in PNES

We hypothesized that PNES patients would show less valence-congruent emotion (i.e., less positive emotion to pleasant slides and less negative emotion to unpleasant slides) than the PTS groups. This was based on theories and some empirical evidence suggesting that PNES patients attempt to avoid emotion and emotional expression [11,32,67]. This hypothesis was supported for positive emotion, with the PNES group showing less positive behavior during pleasant pictures than PTS-high. Diminished positive emotion characterizes a number of clinical disorders, perhaps most notably major depressive disorder [68]. Our findings suggest that expression of positive affect may be diminished in PNES also. Although this feature has not been previously described as characteristic of PNES patients, it may have important implications. For example, a blunting of positive affective expression could contribute to difficulties in interactions with family members, health care providers, and others. It also is important to point out that these displays were coded around the time of the startle, and so PNES patients may be showing a selective inability to up-regulate positive affect in the presence of an aversive stimulus, whereas a “pure” positive emotional context may not have yielded group differences.

Finally, we did not find group differences in negative emotional behavior to unpleasant pictures. As noted earlier, group differences in emotion often are more likely to emerge in positive than negative contexts. With respect to behavior, the strong action tendencies and organizing functions evoked by negative emotions [65] may minimize the opportunity to observe group differences. Nevertheless, taken together, our findings suggest a selective blunting of positive, rather than negative, emotional displays in PNES.

4.3. General emotion regulation in PNES

In addition to examining emotional responses to pictures (i.e., emotional reactivity) we examined two indicators of more general emotion regulation: reported emotion regulation difficulties and baseline RSA. On the Difficulties in Emotion Regulation Scale, which assesses participants' self-reported ability to handle feelings of emotional upset and to be aware of and accepting of emotions, PNES participants reported more difficulties than PTS-low, but did not differ from PTS-high. Similarly, PNES patients showed lower baseline RSA, which has been described as reflecting a "biological vulnerability to emotion dysregulation" (e.g., [21]) than PTS-low, but did not differ from PTS-high. In previous research, PNES patients showed lower baseline RSA than controls [10,17], but did not differ from epilepsy patients [17]. To the best of our knowledge, studies have not assessed self-reported difficulties in emotion regulation as measured here. Our data therefore provide some evidence of emotion dysregulation in PNES based on self-report and physiological indicators. Notably, this is the case for baseline physiological responding, but not reactivity to emotional stimuli, a pattern observed among individuals with borderline personality disorder [21]. Furthermore, previous research similarly failed to find differences between PNES patients and controls or epilepsy patients in autonomic nervous system activity as measured by salivary α-amylase [15] or skin conductance and IBI responses [69].

4.4. Limitations

Our findings should be considered in light of several limitations. First, the small sample size results in reduced statistical power, and coupled with self-selection into the study, limits generalizability. Although we conducted planned contrasts and used Bonferroni correction, the large number of comparisons relative to the sample size risks Type I error. Second, although a strength of our study is that our PNES sample did not include those with mixed epileptic and nonepileptic seizures, we did not examine potential heterogeneity between PNES participants [70]. For example, it would be interesting to determine whether emotional response patterns differ between the different semiologies of PNES. This could not be done in the present sample, given both the small sample size and the fact that nearly all patients reported hypermotor/convulsive symptoms (e.g., "body shakes" or "twitching/shaking") and loss of awareness/consciousness (e.g., "black out"), with only one reporting a primarily hypomotor/catatonic state. Also, we studied a subset of patients who reported trauma and elevated levels of clinical distress, but this is not the case for all PNES patients. Current theories and data point to the importance of considering subtypes of PNES [4,70], and therefore empirical assessment of emotional responding in these different subtypes would be useful in future research. Third, although including individuals with elevated posttraumatic stress symptoms was an important starting point and ultimately served as a good way of identifying individuals with psychological distress more broadly, certainly trauma or PTSD is by no means the only relevant comparison group for PNES. We also did not have formal psychiatric diagnoses, which would be of interest given that these disorders may be associated with different patterns of emotional functioning. Finally, we measured emotional experience using a dimensional approach (i.e., ratings of pleasantness versus unpleasantness), thus capturing basic hedonic evaluations [71], but a discrete approach assessing specific emotions (e.g., anger versus fear) for both experience and behavior may yield group differences not apparent here [72]. The present emotion assessment was advantageous in that it evoked real-time emotions and measured three different facets of emotional responses. Nevertheless, a more complete assessment of emotional reactivity and regulation, including experimental manipulations of emotion regulation, would build on our understanding of emotion and emotion regulatory processes in PNES.

4.5. Implications

Although it is widely assumed that individuals with PNES have disruptions in emotional processing or emotion regulation, only relatively recently have empirical studies been conducted to determine the nature of these disruptions. Our findings based on emotional responses to standard stimuli reveal that individuals with PNES do not necessarily experience greater negativity than those without PNES, but rather greater intensity of emotional experience – especially in neutral contexts – and in fact may show blunted responses to positive emotional stimuli. Such findings are consistent with poor "gating" of sensory experiences, perhaps resulting in inappropriate prioritization of emotional responding [73]. Findings also may suggest a dissociation among emotion components in PNES, whereby subjective aspects of emotion are heightened but behavioral displays are blunted. This would be consistent with a pattern of emotion suppression [74,75]. It also is congruent with the idea that PNES patients may show signs of both "hyperarousal" and "hypoarousal," which has been noted with respect to PTSD (both within persons and regarding subtypes of responders; [37,76,77]).

At the same time, we believe that our data contribute to a growing body of evidence suggesting that the emotion dysregulation in PNES is not entirely different in kind than that typifying other clinical or neurological conditions. We speculate that PNES patients potentially are perceived as more dysregulated than other groups, however, because their symptom manifestation (apparent seizures) may be particularly troubling and misunderstood by observers and health care providers [78].

It is difficult to disentangle in this study whether simply being exposed to prior trauma accounted for some of the similarities among all three groups, and whether PNES and PTS-high participants showed certain emotional similarities because of a shared underlying trauma-related process, shared processes not related to trauma, or distinct processes. Our data nevertheless support notions that interpretation of distress in somatic terms may be a key differentiating factor between PNES and other disorders such as PTSD. A potential biological vulnerability toward affect dysregulation, evidenced by low baseline RSA as found here and previously [10,17], and elevated basal cortisol as found previously [10,11,15], may leave PNES patients particularly vulnerable to experiencing sensations that in turn are interpreted as symptoms [4,32]; however, we note that such vulnerabilities themselves are not unique to PNES (e.g., [21,79]). In addition, behavioral inhibition – and perhaps surprisingly for positive emotion in particular – may also be an important characteristic of PNES patients' emotional responses and target for intervention.

Rapid advances are being made in designing interventions for PNES based on etiologic models (e.g., [80]). The emotional responses we observed in PNES patients may offer potential for informing differential diagnosis efforts and may help contribute to an understanding of *why* certain interventions have been successful in treating PNES. For example, cognitive–behavioral interventions, which include strategies such as monitoring symptom triggers, re-interpreting physical sensations, and increasing relaxation [30,81], have reduced or eliminated nonepileptic attacks and lowered other symptoms of psychopathology in PNES patients [30,82]. From an emotion perspective, such interventions perhaps are effective at least in part because they reduce emotional intensity to daily life situations (e.g., through cognitive reappraisal) and increase parasympathetic responding (e.g., through relaxation training). In addition, our findings yield new possibilities for intervention. Lowering PNES patients' stress and improving their mood may unto itself result in greater expression of positive emotion; in addition, interventions that directly target enhanced positive affective expression may benefit PNES patients and improve their social relationships.

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