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Research Article

Beyond Distress and Resilience: Identification of Seven Distinct Emotional Phenotypes in Functional Neurological Disorder Through Large-Scale Digital Phenotyping

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Abstract

Objective: Functional Neurological Disorder (FND) has traditionally been understood through a binary emotional framework, distinguishing distressed from resilient patients. This study aimed to identify more nuanced emotional presentations using large-scale digital phenotyping data from a symptom-tracking application, emphasizing the importance of these insights for advancing clinical understanding.

Method: The researchers analysed 10,556 emotion instances across 3,307 emotional logs from 1,032 FND patients using the NeuroLog mobile application [1]. While digital phenotyping offers real-time insights, limitations include potential selection bias and reliance on self-reporting, which may affect data validity. Co-occurrence clustering, hierarchical pattern analysis, and temporal transition modelling were employed to identify distinct emotional groupings with prevalence greater than 3%.

Results: Seven distinct emotional phenotypes emerged: (1) Distress Cluster (40.2%), characterised by anxious-sad-frustrated presentations; (2) Shutdown Cluster (32.8%), marked by emotional numbing and low arousal; (3) Activation Cluster (33.6%), featuring paradoxical high energy with anxiety; (4) Anger Cluster (16.0%), showing frustration-anger spectrum presentations; (5) Social Isolation Cluster (16.3%), dominated by loneliness and grief; (6) Resilience Cluster (12.8%), representing positive emotional states; and (7) Ambivalent Cluster (9.5%), characterised by simultaneous positive and negative emotions. Critical findings included the Shutdown Cluster's previously unrecognised prevalence, the Anger Cluster's zero intervention utilisation, and differential recovery trajectories across phenotypes.

Conclusions: FND emotional experience is multidimensional rather than bipolar. These findings have significant implications for personalised treatment approaches and suggest that current therapeutic models may inadequately address the heterogeneity of emotional presentations in FND, encouraging clinicians to consider more tailored interventions.

Keywords: Functional Neurological Disorder, emotional phenotypes, digital phenotyping, cluster analysis, Conversion Disorder

Beyond Distress and Resilience: Identification of Seven Distinct Emotional Phenotypes in Functional Neurological Disorder Through Large-Scale Digital Phenotyping

Functional Neurological Disorder (FND), previously termed conversion disorder, represents one of the most common presentations in neurological practice, yet remains among the least understood [2]**.** Affecting approximately 4-12 per 100,000 people annually, FND manifests as neurological symptoms including seizures, movement disorders, sensory disturbances, and cognitive difficulties that cannot be explained by structural neurological disease [3].

The relationship between emotional states and FND symptom expression has been recognised since the earliest conceptualisations of the disorder. Janet's (1907) dissociative model and Freud's (1895/1955) conversion hypothesis both positioned emotional dysregulation as central to symptom genesis [4,5]. Contemporary neuroimaging research has

substantially validated these early insights, demonstrating altered connectivity between limbic structures and motor regions during symptom expression [6].

The Limitations of Binary Emotional Models

Despite growing recognition of emotion's role in FND, clinical and research approaches have largely defaulted to simplistic binary frameworks. Patients are typically categorised as either "distressed" or "resilient," with treatment approaches varying accordingly Nicholson et al., (2020)[7]**.** This dichotomous model, while clinically convenient, may fail to capture the true heterogeneity of emotional experience in FND.

Recent advances in ecological momentary assessment and digital health technologies offer unprecedented opportunities to examine emotional patterns as they occur in daily life [8]. Unlike retrospective self-report measures, real-time symptom tracking captures the dynamic, fluctuating nature of both emotional states and physical symptoms.

Study Aims

The present study utilised large-scale data from a dedicated FND symptom-tracking application to address three primary questions: (a) Do FND patients demonstrate distinct emotional clustering patterns beyond the traditional distress-resilience binary? (b) What is the prevalence and clinical profile of each identified emotional phenotype? and (c) How do patients transition between emotional states, and what are the implications for intervention timing?

Method

Participants and Setting

Data were collected from 1,032 registered users of NeuroLog, a mobile application designed specifically for FND symptom tracking [1]. Users self-identified as having received an FND diagnosis from a healthcare provider. The sample represented a convenience sample of individuals who voluntarily downloaded and used the application between March 2025 and November 2025.

Demographic data were collected with explicit consent from a subset of participants ($n = 95$). The majority of respondents were female (consistent with FND epidemiology), with ages ranging from 18 to 72 years. Participants resided primarily in the United Kingdom, United States, Australia, and continental Europe.

The NeuroLog Application

NeuroLog is a Progressive Web Application enabling daily logging of FND symptoms, emotional states, triggers, sleep patterns, and self-management interventions [1]. The emotion tracking module presents users with a comprehensive list of 47 discrete emotional states, from which they may select all that apply to their current experience. Users also rate overall symptom severity (0-10), emotional intensity (0-10), and physical intensity (0-10). The application was designed following accessibility guidelines for individuals with cognitive symptoms, featuring simple language, large touch targets, and minimal cognitive load requirements.

Data Extraction and Preprocessing

The researchers extracted 3,307 daily logs containing emotion data, yielding 10,556 individual emotion instances. For cluster analysis, The researchers focused on multi-emotion logs ($n = 2,024$) where users reported two or more simultaneous emotions, as these provided insight into naturally co-occurring emotional states. Data preprocessing included removal of duplicate entries within 24-hour windows, standardisation of emotion labels to account for spelling variations, and exclusion of logs with missing severity or intensity ratings.

Analytical Approach

Co-occurrence Analysis

We calculated pairwise co-occurrence frequencies for all emotion combinations, establishing a minimum threshold of 3% prevalence (61+ occurrences) for inclusion in subsequent analyses.

Hierarchical Clustering

Agglomerative hierarchical clustering with Ward's linkage was applied to the emotion co-occurrence matrix to identify natural groupings.

Temporal Transition Modelling

We examined emotion-to-emotion transitions across consecutive logging days to identify recovery pathways and persistence patterns.

Trajectory Classification

Patients were classified as "improving," "stable," or "deteriorating" based on severity changes across their logging history (≥2 point improvement, ±2 point stability, or ≥2 point worsening).

Results

Emotion Co-occurrence Patterns

Analysis of multi-emotion logs revealed substantial clustering of emotional experiences (table 1). The most frequently co-occurring emotion pairs were Sad + Frustrated (12.0%, M severity = 7.54), Anxious + Stressed (9.2%, M severity = 7.05), and Overwhelmed + Stressed (9.1%, M severity = 7.34). Notably, 19 of the top 20 co-occurring pairs represented negative emotional states. The sole positive pairing (Happy + Content) appeared with 6.5% prevalence and substantially lower severity ($M = 5.35$).

As shown in table 2, all top 10 combinations of three emotions (triads) are distress-related. Mean severity across triads = 7.50/10.

Rank	Emotion 1	Emotion 2	Co-occurrence	Prevalence	Mean Severity	Mean Intensity
1	Sad	Frustrated	274	12.30%	7.61	7.82
2	Anxious	Stressed	220	9.90%	7.11	7.28
3	Overwhelmed	Stressed	215	9.70%	7.38	7.48
4	Anxious	Overwhelmed	212	9.50%	7.14	7.42
5	Frustrated	Anxious	211	9.50%	7.23	7.42
6	Anxious	Frustrated	197	8.90%	7.51	7.67
7	Sad	Anxious	194	8.70%	7.32	7.62
8	Frustrated	Stressed	178	8.00%	7.34	7.64
9	Frustrated	Overwhelmed	174	7.80%	7.36	7.56
10	Anxious	Sad	167	7.50%	7.36	7.82
11	Anxious	Worried	161	7.30%	7.06	7.32
12	Sad	Overwhelmed	159	7.20%	7.46	7.86
13	Worried	Stressed	149	6.70%	7.25	7.38
14	Happy	Content	147	6.60%	5.41	6.29
15	Frustrated	Worried	147	6.60%	7.14	7.33
16	Sad	Stressed	147	6.60%	7.5	7.76
17	Stressed	Uncomfortable	136	6.10%	7.62	7.38
18	Overwhelmed	Uncomfortable	135	6.10%	7.56	7.42
19	Sad	Grief	134	6.00%	7.28	7.76
20	Sad	Disappointed	131	5.90%	7.37	7.72

Table 1: Top 20 Emotion Pairs (≥61 co-occurrences, >3% prevalence)

Rank	Triad	Frequency	Prevalence	Mean Severity	Mean Intensity
1	Anxious + Overwhelmed + Stressed	140	9.30%	7.37	7.59
2	Frustrated + Overwhelmed + Stressed	121	8.00%	7.46	7.8
3	Frustrated + Anxious + Stressed	113	7.50%	7.43	7.82
4	Frustrated + Anxious + Overwhelmed	106	7.00%	7.43	7.9
5	Sad + Overwhelmed + Stressed	103	6.80%	7.7	7.98
6	Sad + Anxious + Stressed	101	6.70%	7.55	7.85
7	Worried + Overwhelmed + Stressed	100	6.60%	7.56	7.76
8	Sad + Frustrated + Anxious	100	6.60%	7.66	7.95
9	Sad + Anxious + Overwhelmed	100	6.60%	7.52	8.01
10	Anxious + Worried + Stressed	99	6.60%	7.33	7.63

Table 2: Top 10 Three-Emotion Combinations (≥50 occurrences)

Phenotype	Prevalence	Mean Severity	Mean Intensity	Intervention Rate	Core Emotions
Distress	40.20%	6.66	7.7	7.70%	Anxious, Sad, Frustrated
Shutdown	32.80%	6.1	5.06	6.30%	Empty, Numb, Indifferent
Activation	33.60%	6.41	6.54	2.50%	Energetic, Nervous, Excited
Anger	16.00%	6.24-7.42	7.64	0.00%	Frustrated, Irritated, Angry
Social Isolation	16.30%	6.69	6.61	—	Lonely, Empty, Grief
Resilience	12.80%	5.1	6.1	7.10%	Happy, Content, Grateful
Ambivalent	9.50%	6.29	6.74	—	Hopeful + Worried

Table 3: Characteristics of Seven Emotional Phenotypes in FND

Mean emotional intensity = 7.83/10 (approaching ceiling).

Identification of Seven Emotional Phenotypes

Cluster analysis revealed seven distinct emotional phenotypes, each with characteristic presentations, severity profiles, and clinical implications, as shown in table 3.

Phenotype 1: Distress Cluster

Representing 40.2% of emotional logs (n = 1,329), the Distress Cluster was the most common presentation, characterised by co-occurring anxiety, sadness, and frustration. Mean symptom severity was 6.66/10, with emotional intensity ratings averaging 7.50-7.90. This cluster demonstrated the highest emotional persistence; anxious states appeared on consecutive logging days 30.7% of the time.

Phenotype 2: Shutdown Cluster

Affecting nearly one-third of patients (32.8%, n = 1,085), the Shutdown Cluster was characterised by emotional numbing, emptiness, and indifference. This phenotype demonstrated a paradox: moderate symptom severity (M = 6.10) coupled with low emotional intensity (M = 5.06). Intervention utilisation in this cluster was notably low (6.3%).

Phenotype 3: Activation Cluster

The Activation Cluster (33.6%, n = 1,110) presented with high arousal states combining both positive (energetic) and negative (nervous) emotional features. Mean severity was substantial (6.41/10) despite patients often reporting feeling "better." This phenotype demonstrated the lowest intervention utilisation of any cluster (2.5%).

Phenotype 4: Anger Cluster

The Anger Cluster (16.0%, n = 528) encompassed presentations ranging from frustration to overt anger. When anger co-occurred with distress emotions, severity increased substantially (M = 7.42). Intervention utilisation in the Anger Cluster was zero percent.

Phenotypes 5, 6, and 7

The Social Isolation Cluster (16.3%) was characterised by loneliness and grief. The Resilience Cluster (12.8%) represented the only predominantly positive phenotype, though temporal analysis revealed these states were fragile, with 39% of patients transitioning to anxious states within three days. The Ambivalent Cluster (9.5%) captured simultaneous positive and negative experiences, such as hope alongside worry.

Temporal Dynamics and Recovery Trajectories

Analysis of emotional transitions revealed distinct pathways from distress states. Following distress-dominant logs, patients most commonly transitioned to continued anxiety (40%), escalation to frustration (29%), or recovery to calm states (27%). The mean time from severe distress (≥7/10 severity) to meaningful improvement (≤5/10 severity) was 3.0 days (*SD* = 2.1).

Discussion

The identification of seven distinct emotional phenotypes challenges the binary distress-resilience model that has dominated FND conceptualisation. Our findings suggest that emotional experience in FND is fundamentally multidimensional.

The Shutdown Phenomenon and Activation Paradox

The Shutdown Cluster, affecting one-third of patients, represents a "hidden majority." The low arousal, low motivation profile creates a therapeutic paradox: patients most in need of intervention may be least likely to seek it. Similarly, the Activation Cluster represents a potential precursor to "boom-bust" cycling, where patients fail to recognise distress when masked by high energy.

The Anger Gap

The complete absence of intervention utilisation in the Anger Cluster represents a critical finding. Anger and frustration feature prominently in FND experience—appearing in 16% of logs—yet patients appear to possess no strategies for managing these emotions.

Besides providing greater clarity on the need for tailored interventions for different phenotypes within FND, this research also offers direct guidance on transdiagnostic interventions that can provide tailored solutions for patients with psychobiosocial conditions, such as FND. Although the results of this study are limited to the FND group and therefore not generalizable, the FND population is heterogeneous, with complex symptomatology and comorbidity.

We will directly benefit from the results of this study to guide effectiveness research on transdiagnostic interventions, including ReAttach, which aims to provide personalized care [9]. Now we have the opportunity to investigate not only whether an intervention, such as ReAttach, is effective or not, but also for which phenotypes. Additionally, the study outcomes help therapists and patients select tailored ReAttach self-regulation techniques, such as the W.A.R.A. (Wiring Affect with ReAttach) or the Forgive and Forget Hood (FFH), to increase their stress tolerance [9].

Conclusions

This study provides the first large-scale, ecologically valid characterisation of emotional phenotypes in FND. The identification of seven distinct clusters suggests substantial heterogeneity in emotional experience. These findings have significant implications for personalised treatment approaches, particularly regarding the specific needs of patients in Shutdown, Activation, and Anger states.

Declaration of interest

Steven Painter is the developer of Neurolog.

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