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Altered microstate dynamics in Functional Neurological Disorder☆

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ABSTRACT

Background: Functional Neurological Disorder (FND) presents with disabling and heterogeneous motor, sensory, and cognitive symptoms despite the absence of gross structural pathology. A key question is whether symptoms reflect disruptions in the intrinsic organization of brain networks. Electroencephalography (EEG) offers a high temporal resolution view of ongoing dynamics, making it a powerful means to probe such mechanisms.

Methods: We applied a seven-class microstate decomposition to resting-state EEG from 39 patients with FND and 47 matched healthy controls to characterize the temporal dynamics of brain activity. Microstate were labelled A-G according to established topographies. Symptom severity was assessed with the Simplified-Functional Movement Disorder Rating Scale, and correlations were tested. Logistic regression was used to assess group discrimination, with accuracy quantified by the area under the curve.

Results: Compared to controls, patients with FND exhibit significantly reduced duration of microstate G, associated with sensorimotor integration. This alteration correlated negatively with symptom severity scores and moderately discriminated groups. Transition probabilities analyses uncovered distinct patterns among microstates A, B and C, suggesting both an exaggerated shift from arousal-related to visual imagery networks and resistance to engage in self-referential processing.

Conclusions: Our findings provide the first direct evidence of disrupted resting-state microstate organization across a heterogeneous FND cohort.

1. Introduction

Functional Neurological Disorder (FND) stands as one of the most compelling challenges in neuropsychiatry, presenting with a spectrum of neurological symptoms, such as motor disturbances, sensory changes, and non-epileptic seizures (Aybek and Perez, 2022; Espay et al., 2018). Recent theoretical advances have reframed FND from a diagnosis of exclusion to a disorder rooted in the dynamic dysfunction of brain networks, implicating alterations in domains such as motor control, emotional regulation, and the sense of agency (Edwards et al., 2012; Perez et al., 2021). Notably, growing evidence highlights the centrality of disrupted sensory processing and the integration of somatosensory information in the pathophysiology of FND (Monsa et al., 2018; Rossi et al., 2025).

Electroencephalography (EEG) offers a non-invasive window into the temporal dynamics of brain activity with high temporal resolution; however, conventional spectral analyses often provide only a static or averaged perspective, potentially overlooking the rapid and transient reconfigurations of large-scale neural networks that underpin complex behaviors and subjective experiences (Chivu et al., 2024; Khanna et al., 2015; Li et al., 2020). Microstate analysis has emerged as a transformative approach in this context: by segmenting the continuous EEG signal into sequences of brief, quasi-stable topographical patterns – microstates – it enables the investigation of the brain's millisecond-level functional states and their temporal organization (Michel and Koenig, 2018; Van de Ville et al., 2010). Beyond their topographical definition, the seven microstates (A–G) have been associated with discrete functional aspects based on converging evidence from EEG–fMRI studies and source localization analyses: microstate A to subjects' arousability and auditory processing, B to visual perception, self-visualization and

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autobiographical memory, C to mind-wandering and self-referential mentation, D to executive functioning, including working memory, E to interoceptive and emotional information processing, F to personally significant information processing, and G to somatosensory network activity (Tarailis et al., 2024). Unlike traditional methods, microstate analysis captures the fleeting transitions and dynamic interplay between neural networks, offering a more nuanced understanding of brain function in both health and disease (Asha, 2024; Schiller et al., 2024; Vass et al., 2025).

Nevertheless, to date, EEG microstate analysis has not been systematically applied to resting-state activity across heterogeneous presentations of FND. Few previous studies have investigated microstate dynamics in functional (psychogenic) seizures, often focusing on ictal or peri-ictal periods and reporting transient reductions in microstate duration during dissociative events, albeit in different microstate classes (Kučikienė et al., 2025; Kučikienė et al., 2024; Catania et al., 2025). While informative, these studies address a specific FND subtype and capture state-dependent alterations linked to seizure expression rather than the intrinsic organization of resting brain dynamics. Given the growing conceptualization of FND as a disorder of large-scale network functioning that extends beyond episodic symptom expression, investigating resting-state microstate dynamics across a broader FND population, including also sensory-motor subtypes, may offer complementary insights into trait-like alterations of brain network organization (Kleinert et al., 2024). The present study addresses this gap by examining resting-state EEG microstates to investigate the temporal dynamics in individuals with FND and matched healthy controls.

2. Materials and methods

2.1. Participants

Ninety-two adults were enrolled, of which 45 patients with mixed FND and 47 healthy controls (HC); For this study, 6 FND participants were excluded (N = 2 due to symptom exacerbation preventing completion, N = 2 for poor EEG quality, N = 1 for technical issues, and N = 1 as a statistical outlier in microstate analysis), resulting in a final sample of 39 FND (29 female; mean age = 38.5±11.6 years) and 47 HC (34 female; mean age = 37.8±13.1 years). Groups did not differ significantly in age or sex distribution (see Table 1). Patients were recruited from the Clinical Neurology Unit, Cantonal Hospital Fribourg and the Psychosomatic Medicine Unit, Inselspital Bern; controls via flyers, word-of-mouth, and online ads. All participants were >18 years, capable of informed consent, and FND diagnoses met DSM-5/ICD-11 criteria (F44.4–F44.7), encompassing motor, cognitive, or mixed symptom presentations. Exclusion criteria encompassed comorbid major psychiatric disorders, brain surgery or implants, substance abuse, inability to comply, and pregnancy. Patients' symptom severity was assessed with the Simplified-Functional Movement Disorder Rating Scale (S-FMDRS). The data presented here is part of a larger study (Stoffel et al., 2025; Stoffel et al., 2026; Stoffel et al., 2025), conducted at the University of Fribourg, approved by the Ethics Committee of the Canton of Bern (2023-00469) and registered on ClinicalTrials.gov (NCT06084325).

Table 1

Demographic and clinical characteristics of the sample. Summary of demographic and clinical characteristics for patients with Functional Neurological Disorder (FND) and healthy controls (HC), including age, sex distribution, and symptom severity. Group comparisons were performed using Welch's t-tests for continuous variables and chi-square tests for categorical variables.

	HC (*n* = 47)	**FND** (*n* = 39)	**Statistics**
Age, mean (SD), years, [range]	37.8 (13.1), [18–67]	38.5 (11.6), [18–64]	Welch's t (83.68) = 0.24, p = 0.81, d = 0.05
Sex (females/males)	34/13	29/10	X^2 (1,86) = 0.04, p = 0.88
Antidepressants, benzodiazepines, antipsychotics, or antiseizure medications (yes/no)	12/47	28/39	
Symptom type °	*NA*	15 motor 23 weakness 16 sensory 1 mixed 3 cognitive	
Disease severity (S-FMDRS, median, SD)	*NA*	6.0 (5.4)	

2.2. EEG acquisition and preprocessing

Resting-state EEG was acquired with a 64-channel Biosemi Active-Two system at a sampling rate of 2048 Hz for 6 minutes, alternating between 20 seconds eyes-open and 40 seconds eyes-closed, thus leading to 4 minutes of eyes-closed retained for analysis. The alternation between open and closed eyes was intended to minimize fluctuations in vigilance state (Schiller et al., 2019). Preprocessing was carried out using a customized MATLAB toolbox (EEGpal), based on EEGLab 2023.1 (Delorme and Makeig, 2004), available at https://github.com/DePrettoM/EEGpal. Signals were band-pass filtered between 0.3 and 40 Hz; bad channels and bridged ones were identified via visual inspection. Independent component analysis (ICA) was then performed, and artefactual components were identified and removed using the ICLabel algorithm. Subsequently, bad channels were interpolated and data were re-referenced to the average of all electrodes. The continuous EEG was then segmented into 2000 ms epochs for further analysis.

2.3. Microstates analysis

Microstate analysis was performed in MATLAB using the MICROSTATELAB toolbox (Nagabhushan Kalburgi et al., 2024). Peaks of Global Field Power (GFP) were used to extract EEG topographies, clustered via a modified k-means algorithm to define subject-specific microstate classes. Although the four-class solution remains the most commonly adopted configuration in EEG microstate research, recent literature has increasingly highlighted the potential functional relevance of additional microstates beyond the canonical four, particularly when investigating large-scale network dynamics. (Tarailis et al., 2024; Tarailis et al., 2021). In the present study, a seven-class microstate configuration was therefore adopted to avoid collapsing potentially distinct functional patterns, especially those related to sensorimotor and integrative processes. The internal consistency and topographic stability of microstate solutions ranging from four to seven classes were evaluated using the MICROSTATELAB toolbox by inspecting the mean shared variance between individual-level and group-level maps. Across all tested solutions, microstate maps exhibited high shared variance (mean shared variance across the four solutions = 94.59%). Individual maps underwent hierarchical clustering – first to yield group-mean maps and then to derive grand-mean templates – ensuring one-to-one correspondence across levels and maximizing shared variance. Maps were then sorted, labeled and reordered according to established conventions using the template-matching procedure implemented in the toolbox, which quantifies spatial similarity between the derived group-level microstate maps and reference template (Nagabhushan Kalburgi et al., 2024; Custo et al., 2017), accounting for 94.79% of global variance with no outliers detected by the toolbox. Finally, templates were back-fitted to each subject's continuous EEG by assigning, at every time point, the microstate class whose topography exhibited the highest spatial correlation. For each microstate class, we derived mean duration, occurrence rate (per second), coverage (percentage of recording time), mean GFP, and explained variance (per class and overall). We also extracted transition probabilities: both raw, reflecting the empirical percentage of direct transitions from microstate class X to Y among all transitions, and adjusted, indicating deviations from chance levels and thus the relative propensity or resistance for each class-to-class transition.

2.4. *Statistical analysis*

To account for potential differences in the temporal dynamics of individual microstate configurations, we examined group effects on the different microstate parameters (mean duration, occurrence rate, coverage, mean GFP, explained variance) for each class using independent samples *t*-tests. Bonferroni correction was applied separately for each parameter across the 7 microstate classes, resulting in an adjusted significance threshold of $\alpha = 0.05/7 \approx 0.007$ per test. This approach was chosen to preserve sensitivity to parameter-specific effects; however, we acknowledge that considering all microstate parameters jointly would define a larger family of tests and would have required more conservative correction strategies. Results with *p*-values below this threshold were considered statistically significant, and logistic regression analyses were conducted to test whether significantly different parameters predicted group membership. For parameters showing significant group differences, correlations with the S-FMDRS symptom severity score were also examined in patients only.

To further assess whether the results depended on the number of classes, we additionally conducted sensitivity analyses across alternative clustering solutions (number of classes K = 4–7) (Wei et al., 2018), repeating the microstates temporal-parameter comparisons for each configuration. These analyses are reported in the **Supplementary Materials** and support the theory-informed rationale for retaining the seven-class solution as a compromise between model parsimony and representational specificity.

Concerning potential group differences in the temporal “syntax”, reflecting the propensity to enter or exit specific microstate classes (Lehmann et al., 2005), we also examined whether pairwise transition probabilities to and from each microstate class significantly differed between groups by means of a series of fourteen repeated measures ANOVAs (rmANOVA). Specifically, for each microstate class, we performed one set of 7 “FROM” ANOVAs - analyzing transitions from each class to all other classes - and another set of 7 “TO” ANOVAs - analyzing transitions to each class from all other classes (Antonova et al., 2022). In each analysis, the within-subjects factor was the transition direction (“FROM” or “TO”), and GROUP (FND, HC) was included as a between-subjects factor. Greenhouse-Geisser correction was applied to account for violations of sphericity in rmANOVAs. Where significant interactions were observed, post-hoc comparisons were Bonferroni-corrected for the six pairwise transitions within each ANOVA. No additional correction was applied across the set of repeated-measures ANOVAs. All analyses were performed using JASP (version 19.3).

3. Results

3.1. *Microstates temporal parameters*

One participant in the FND group was excluded as an outlier based on an extreme value in microstate G duration (>3 standard deviations from the FND group mean) identified during quality control procedures. Among the microstate parameters, only the mean duration of microstate class G differed significantly between groups: FND patients exhibited a shorter mean duration compared to HC ($t = 2.90, p = 0.005$, Cohen’s $d =$ -0.619, see Fig. 1 and Table 2). No other class showed significant group differences in duration, occurrence rate, coverage, mean GFP, or explained variance after correction (all $p > 0.007$). Analyses of microstates duration across alternative configurations with different number of classes (K = 4–7) yielded a consistent directional pattern, with effect sizes of comparable range observed when the somatosensory-related state was resolved as a distinct class (see **Supplementary Materials**).

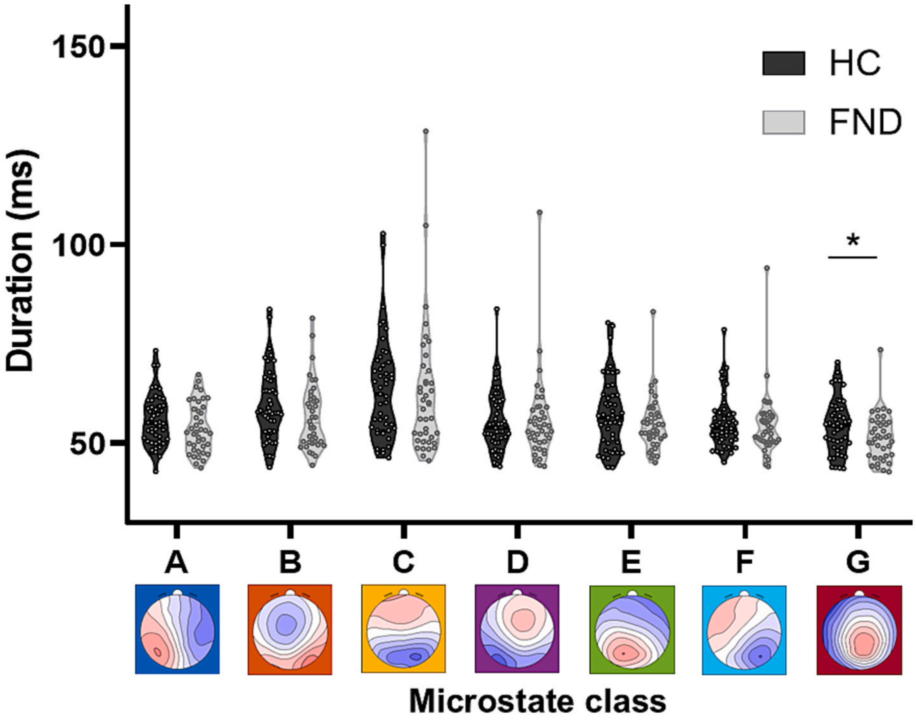

Fig. 1. Mean microstate duration. Mean duration of the seven EEG microstate classes derived using a seven-class microstate decomposition applied to resting-state EEG recordings in patients with Functional Neurological Disorder (FND) and healthy controls (HC). Group differences were assessed using independent-samples t-tests with Bonferroni correction across microstate classes. Microstate G showed a significantly shorter mean duration in FND patients compared to HC, whereas no other microstate class differed between groups.

Table 2

Duration of the different microstate classes. Mean duration (in seconds) of each EEG microstate class obtained from a seven-class microstate analysis of resting-state EEG in patients with Functional Neurological Disorder (FND) and healthy controls (HC). Group differences were assessed using Welch's independent-samples t-tests. Family-wise error was controlled across the seven classes using a Bonferroni-adjusted significance threshold ($\alpha = 0.05/7 \approx 0.007$). Only microstate G showed a significant reduction in duration in FND patients.

Microstate class		Mean	SD	t (Welch)	df	p (uncorrected)	Cohen's d
A	FND	0.054	0.006	−1.630	82.31	0.107	−0.352
	HC	0.056	0.006				
B	FND	0.057	0.008	−1.461	82.48	0.148	−0.316
	HC	0.059	0.009				
C	FND	0.062	0.016	−0.385	70.84	0.701	−0.084
	HC	0.064	0.013				
D	FND	0.055	0.011	−0.199	68.20	0.843	−0.044
	HC	0.056	0.008				
E	FND	0.054	0.005	−2.066	74.69	0.042	−0.437
	HC	0.057	0.009				
F	FND	0.054	0.008	−0.572	73.61	0.569	−0.125
	HC	0.055	0.007				
G	FND	0.054	0.005	−2.900	82.15	0.005	−0.619
	HC	0.056	0.007				

A trend-level negative correlation was observed between microstate G duration and F-MDRS scores across all patients (Pearson's $r = -0.337$, $p = 0.052$). Although this trend did not reach conventional significance, it suggests a possible inverse relationship between microstate G temporal stability and functional motor symptom severity.

To assess the potential predictive value of microstate G duration, we conducted a logistic regression with group membership (FND vs. HC) as dependent variable. Microstate G duration emerged as a significant predictor (model $\chi^2 = 7.1, p = 0.009$), explaining 11.6% of variance (Nagelkerke $R^2 = 0.116$). The analysis revealed moderate discriminative capacity (AUC = 0.65 [95% CI: 0.54–0.76]), with optimal cutoff yielding 48.7% sensitivity and 70.2% specificity.

3.2. Transition probabilities

The rmANOVA on the adjusted transition probabilities "FROM class A" revealed a significant main effect of transition direction, $F_{5,\,420} = 29.35$, $p < .001$, $\eta_p^2 = .259$, and a significant interaction between transition direction and group, $F_{5,\,420} = 2.83$, $p = 0.029$, $\eta_p^2 = 0.033$. To further explore the interaction, post-hoc comparisons were conducted for each transition (see Fig. 2). The A→B adjusted transition probability was significantly lower in FND compared to HC ($p = 0.007$). Similarly, the A→C transition was also significantly different between groups ($p = 0.030$). No significant differences were found between groups for the remaining raw and adjusted transition probabilities (A→D, A→E, A→F, A→G), all $p > 0.19$, nor for the other microstate-based transition series rmANOVAs (i.e., FROM classes B, C, D, E, F or G).

Concerning transitions towards each microstate class, the rmANOVA on the adjusted transition probabilities "TO class A" revealed a significant main effect of transition direction, $F_{5,\,400} = 23.21$, $p < 0.001$, $\eta_p^2 = 0.225$, and a significant interaction between transition direction and group, $F_{5,\,400} = 2.46$, $p = 0.032$, $\eta_p^2 = 0.030$. post-hoc comparisons were then conducted. A significant group difference emerged for the B→A microstate transition, with FND patients exhibiting lower adjusted transition probabilities compared to HC ($p = 0.006$, see Fig. 2). No other transitions to class A (i.e., from C, D, E, F, or G) showed significant group differences. Furthermore, none of the rmANOVAs conducted for transitions towards the remaining microstate classes revealed significant group interactions.

4. Discussion

This study constitutes the first systematic investigation of resting-state EEG microstate dynamics across a mixed FND cohort, i.e. including different subtypes, providing novel insights into both the temporal stability of discrete brain states and the probabilistic patterns by which they transit from one to another. Beyond the diminished duration of microstate G, implicated in somatosensory integration (Tarailis et al., 2024), here we demonstrated a distinctive pattern of transitions among microstates A, B, and C in FND, which may provide a potential framework for future investigations into their relationship with core symptomatology.

Before discussing the present findings, it is important to emphasize that functional interpretations of EEG microstates are inherently probabilistic. Associations between specific microstate classes and large-scale brain networks or psychological processes are primarily derived

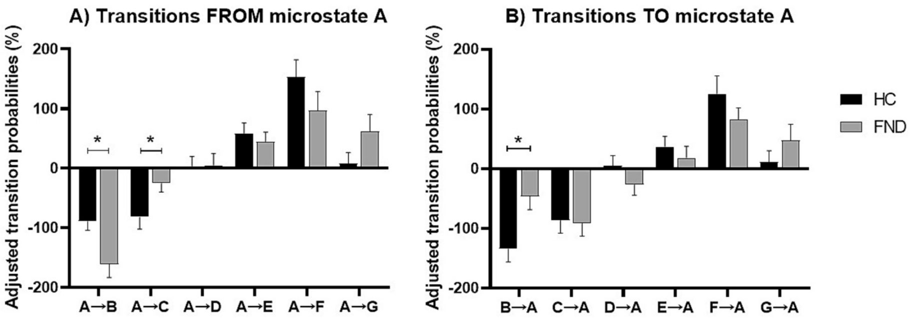

Fig. 2. Altered adjusted transition probabilities involving microstate A. Group differences in adjusted microstate transition probabilities derived from resting-state EEG using a seven-class microstate approach. Panel (**A**) illustrates adjusted transition probabilities *from* microstate A to all other classes, and panel (**B**) illustrates transitions *to* microstate A from all other classes. Adjusted transition probabilities reflect deviations from chance-level transitions. Group effects were tested using repeated-measures ANOVAs with transition direction as within-subject factor and group as between-subject factor, followed by Bonferroni-corrected post-hoc comparisons. Patients with FND showed significantly reduced A → B and A → C transitions, as well as reduced B → A transitions, compared to healthy controls.

from EEG–fMRI coupling and source localization studies, often with modest effect sizes, and may vary across analytical pipelines, samples, and experimental contexts. Accordingly, the interpretations offered below should be regarded as heuristic and hypothesis-generating rather than definitive mappings between microstates and specific cognitive or affective functions. Using the approach with seven microstates, our observation of a reduced duration of microstate G in FND patients, in the absence of coverage differences, indicates that FND patients transiently engage this configuration but fail to sustain it, reflecting possible temporal instability (Al Zoubi et al., 2019). Importantly, microstate G is a relatively recently and limitedly described microstate, whose sources have been localized in the right inferior parietal lobule, superior temporal gyrus, and cerebellum in EEG-fMRI studies; owing to the strong cerebellar activity observed, it has been speculated to relate to the sensorimotor network (Custo et al., 2017); also, its duration has been linked to cerebello-parietal connectivity (Stoffers et al., 2015), supporting the idea that, in healthy individuals, microstate G facilitates the contextualization of bodily signals and the integration of sensory input into motor plans (Tarailis et al., 2024; Custo et al., 2017; Zanesco et al., 2021). The temporal instability of microstate G in FND may reflect disruptions in the neural maintenance of sensorimotor states, suggesting that patients are less able to sustain coherent representations of bodily input (Tarailis et al., 2024; Britz et al., 2010). Importantly, the specificity of the effect to microstate G - and not to other microstate classes – points to a targeted alteration rather than a generalized abnormality. While the effect size was moderate, the putative link between microstate G and somatosensory processes offers a plausible basis for considering its relevance in the context of FND. Indeed, the trend-level association with motor symptom severity, as measured by S-FMDRS, supports the clinical relevance of this finding, though it must be interpreted with caution and replicated in larger samples before being considered a prognostic biomarker of somatosensory network dysfunction in FND. While insufficient for a standalone diagnosis, this parameter could enrich existing clinical assessments. Notably, the observed specificity of 70.2% indicates that, while a substantial proportion of healthy controls can be correctly identified, a non-negligible number of false positives remains, suggesting that microstate G alterations are neither wholly unique to FND nor exclusively reflective of pathological processes. Rather, these dynamics likely intersect with broader mechanisms of somatosensory processing that may also be perturbed in related neuropsychiatric conditions.

Interpretations of altered transition probabilities should be considered in light of the probabilistic nature of microstate labeling. Although microstate classes were quantitatively matched to established templates, functional associations remain indirect and context-dependent. Nonetheless, our analysis of transition probabilities adds a complementary dimension to the results, revealing that even at rest patients with mixed subtypes of FND exhibit an endogenous bias in their patterns of state-to-state transitions. Notably, alterations in transition patterns among microstates A, B, and C occurred in the absence of group differences in occurrence, coverage, or duration, suggesting that the fundamental properties of these individual states remain intact. Rather than reflecting a global change in the stability or prevalence of specific brain states, the observed differences point to a selective disruption in the temporal coordination and sequencing of these states – a dysfunction not in the states themselves, but in the dynamic pattern by which the brain moves between them. First, the greater resistance for transitions from microstate A→B suggests that individuals with FND, despite minimal external stimulation (as in the resting condition), are less prone than HC to shift from an arousal-related network (microstate A) toward circuits supporting both visual perception and the conscious visualization of autobiographical scenes (microstate B) (Tarailis et al., 2024). Microstate A's association with both auditory processing and heightened arousability implies a baseline of sensory vigilance (Tarailis et al., 2024; Britz et al., 2010; Bréchet et al., 2019); the preferential recruitment of occipital-parietal regions (microstate B) may reflect an internally driven hypervigilance, that limits access to imagery-based and integrative processes (Chivu et al., 2024; Bréchet et al., 2019; Damborská et al., 2019).

Second, the patients' reduced resistance to transition from microstate A→C suggest a facilitated drift toward self-referential and introspective processes. In healthy resting-state dynamics, spontaneous drifts into microstate C are thought to support mind-wandering and the integration of bodily and autobiographical information, with neural activations partially overlapping the default-mode network (DMN) (Custo et al., 2017; Bréchet et al., 2019); however, in FND this smoother access to microstate C may reflect an unbalanced interplay between arousal-laden states and DMN-mediated regulatory functions that ordinarily facilitate coherent self-narrative construction (Britz et al., 2010; Milz et al., 2016). Rather than supporting flexible disengagement, such a bias toward microstate C could contribute to less coherent integration of self-referential information.

Finally, the reduced resistance to transition from microstate B→A in FND highlights an altered oscillatory balance between sensory imagery and arousal systems. In controls, the relative difficulty of this shift may serve to stabilize visual or imagery-based processing before returning to a baseline of vigilance. By contrast, the facilitated B→A transitions observed in FND suggest that once visual or imagery-related states are engaged, they are more readily reset toward arousal-dominated dynamics. Collectively, the pattern of results supports convergent abnormalities in both the temporal persistence of a sensorimotor state, as reflected by microstate G instability (within-state), and in the dysregulation of the probabilistic grammar of network transitions (between-state) between microstates A (linked to arousability), B (self-visualization) and C (integration of autobiographical memories) in FND patients.

Several limitations should be acknowledged when interpreting the present findings. First, the FND sample was clinically heterogeneous, encompassing motor, cognitive, and mixed symptom presentations. While this heterogeneity reflects the real-world clinical spectrum of FND and a strength of the study, it also warrants caution when interpreting the results in terms of subtype-specific neurophysiological mechanisms, as the results are driven by an average of mixed subtypes. Second, potential confounding factors related to arousal, vigilance, and medication effects cannot be fully excluded. Many patients with FND present with comorbid psychiatric symptoms such as depression, anxiety, post-traumatic stress, or fatigue, and are commonly treated with psychoactive medications including antidepressants, benzodiazepines, antipsychotics, or antiseizure medications. These factors may have influenced resting-state EEG dynamics, including microstate parameters and have not been accounted for in this study.

In addition to that, although the alternating eyes-open/eyes-closed design was implemented to reduce prolonged drowsiness, indices of vigilance or sleepiness such as subjective drowsiness ratings were not quantified. Ultimately, the choice of a seven-class microstate configuration represents an important methodological consideration. Although this solution was selected to capture a broader range of functionally distinct brain states described in recent literature and showed high topographic stability, the optimal number of microstates remains an open question and may vary across datasets and analytical pipelines. In the present study, robustness across alternative microstate configurations (number of classes K = 4–7) was explicitly assessed through sensitivity analyses, which indicated consistent patterns across solutions (see **Supplementary Materials**). Future studies should extend this approach by incorporating formal model selection criteria and independent replications.

5. Conclusions

This investigation provides the first direct demonstration that FND is associated with a targeted impairment in the temporal stability of a sensorimotor-related brain microstate alongside a reshaping of the brain's intrinsic transition between brain states. The shortened duration of microstate G suggests compromised maintenance of coherent somatosensory representations, whereas the altered propensity to oscillate between arousal, self-visualization and information integration microstates suggests dysregulated dynamics that may affect self-related processing. Future studies should confirm these findings in larger, independent samples and include appropriate psychiatric and neurological control groups. It will also be important to determine whether the microstate alterations found here are specific to FND or reflect a shared mechanism across neuropsychiatric disorders.

6. Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the authors used Grammarly and ChatGPT in order to improve the clarity, readability, and linguistic quality of the manuscript. After using this tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

CRediT authorship contribution statement

Irene Lozzi: Writing – original draft, Formal analysis. **Cristina Concetti:** Writing – review & editing, Data curation. **Natascha Stoffel:** Investigation. **Michael Mouthon:** Methodology, Data curation. **Miriam Braga:** Methodology. **Michele Tinazzi:** Validation. **Mirta Fiorio:** Supervision. **Selma Aybek:** Supervision, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.nicl.2026.103969.

Data availability

The full dataset used for the current study cannot be shared due to ethical and privacy restrictions. Anonymized derived data and analysis pipelines will be made openly available on the Open Science Framework (OSF) upon publication of this manuscript.

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