Exploring EEG Microstates as Biomarkers in Cognitive Impairment and Rehabilitation in Multiple Sclerosis

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INTRODUCTION

Cognitive impairment is a common manifestation of multiple sclerosis (MS), affecting over 40–60%. While various cognitive rehabilitation strategies have been proposed, there is a lack of reliable neurophysiological biomarkers to monitor treatment response or progression. EEG microstate analysis provides a promising, non-invasive tool to explore large-scale neural dynamics.

OBJECTIVE

- To assess whether EEG microstate parameters can identify neurophysiological alterations associated with cognitive impairment in MS.
- To explore microstate after 6 months of home-based cognitive rehabilitation using the MyA Brain Training app.

MATERIALS AND METHODS

Participants:

- 30 MS patients with cognitive impairment (mean age = 49.4 ± 8.9 years; 76.7% female; mean EDSS = 2.4).

Intervention:

- 6-month home-based training (30 min/day, 5 days/week) via MyA Brain Training.

Assessments:

- Neuropsychological battery (BRB) at baseline (T0) and 6 months (T1).
- Resting-state 32-channel EEG analyzed with a 7-microstate model (A–G) according Custo et al. 2017.

RESULTS

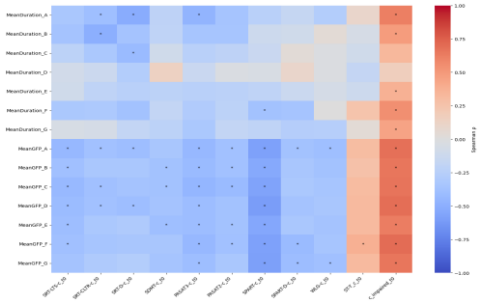

Figure 1. Microstate–clinical correlations matrix
Heatmap showing p value from correlation (Spearman) between EEG microstate temporal parameters: Mean Duration and GlobalFieldPower GFP in MS patients (n = 30). Increased Mean Duration in microstate A and B in cognitively impaired MS patients. Reduced GEV and duration in microstate F (salience network), positively correlated with memory scores (SRT-D).Asterisks indicate uncorrected significance levels: $p < 0.05$

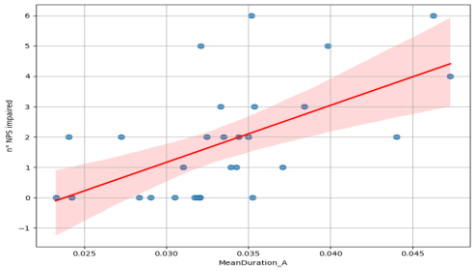

Figure 2. Association between microstate A duration and cognitive impairment
Scatterplot with regression line showing the positive correlation between Mean Duration of microstate A and the number of impaired cognitive domains in MS patients. Longer persistence in microstate A was associated with greater global cognitive impairment.

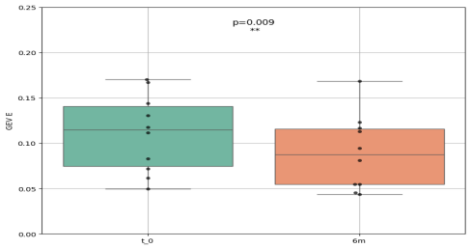

Figure 3. Effect of rehabilitation on microstate E
Boxplot comparing Global Explained Variance (GEV) of microstate E at baseline (T0) and after 6 months (T1). A significant reduction (p = 0.009) was observed post-intervention, suggesting functional reorganization within default mode network dynamics.

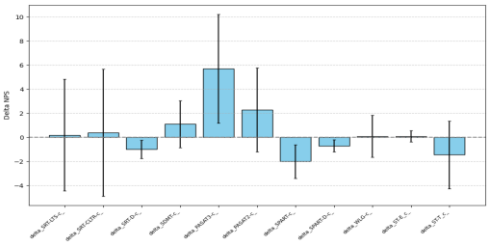

Figure 4. Neuropsychological outcomes after rehabilitation
Bar chart showing mean change (Δ) in cognitive test performance (T1 – T0) across different domains (verbal memory, visuospatial memory, processing speed, attention, executive functions), although no group-level changes reached statistical significance (15 patients have completed 6 month follow up).

DISCUSSION

These preliminary results suggest that EEG microstate analysis can detect neurophysiological alterations associated with cognitive impairment in MS and may capture subtle training-induced changes in network dynamics, particularly in classes A and E, highlighting possible early neuroplastic responses.

CONCLUSIONS

Home-based digital cognitive training using the MyA Brain Training app appears feasible and associated with measurable neurophysiological parameter. EEG microstate analysis may serve as a promising biomarker of cognitive impairment and neuroplasticity in MS.