Electrocortical Connectivity and Non-linear Quantitative Analysis of EEG Signal in PD-MCI

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BACKGROUND

Parkinson's Disease (PD) is frequently associated with a reduction in cognitive performances ranging from Mild Cognitive Impairment (PD-MCI) to dementia. Electrophysiological studies show an association between cognitive decline, decreased alpha rhythm and increased slow-frequency electrocortical activity. Moreover, variations in the connections between specific cortical regions appear to be related to neuropsychological performances in PD.

AIMS

The main objective of the present study was to analyze, by means of *low resolution electromagnetic tomography (LORETA)* and *non-linear quantitative EEG analysis*, electrocortical networks possibly related with cognitive decline in a group of patients with PD-MCI compared to patients with normal cognition (PD-NC).

MATERIALS & METHODS

Study Population

From the *PaCoS (Parkinson's disease Cognitive Study)* cohort of 659 PD patients, a representative sample of 102 subjects was selected based on the presence of a comprehensive neuropsychological assessment and at least one artifact-free EEG recording. Diagnosis of PD-MCI was made according to *Litvan et al, 2012.*

EEG Analysis

EEG signal epochs were analyzed using the *Independent Component Analysis (ICA) LORETA*. The Power Spectral Density (PSD) of site-specific signal epochs was also obtained together with the *power law exponent* β, computed as minus the slope of the power spectrum versus frequency in a Log-Log scale to estimate self-similarity and then fractal-like behavior of site-specific electrocortical signal.

RESULTS

Study Population. A total number of 102 patients [54 men (52.9%); mean age 65.7 ± 8.4 years; HY stage 2.1 ± 0.6] were enrolled, including 46 PD-MCI patients and 56 PD-NC group-matched by age, sex, age at onset, HY stage, UPDRS-ME score and cumulative daily L-dopa equivalent dosage.

LORETA Analysis. LORETA analysis revealed significant differences in the group of PD-MCI patients as compared to PD-NC, with a reduced network involving alpha activity over the occipital lobe (lingual gyrus, Brodmann area 17; **Fig.1**), an increased network involving beta activity over the frontal lobe associated with a reduction over the parietal lobe (precuneus, Brodmann area 7; **Fig.2**), an increased network involving theta and delta activity over the frontal lobe (superior and middle frontal gyrus respectively, Brodmann area 11; **Fig.3,5**) and a reduction of networks involving theta and delta activity in the parietal lobe (postcentral gyrus, Brodmann area 7; **Fig. 4,6**).

Quantitative EEG Analysis. Quantitative EEG analysis showed a significant decrease of alpha PSD over the occipital regions (O1: p = 0.02; O2: p = 0.01) and an increase of delta PSD over the left temporal region (T3: p = 0.05), with a significant β increase over the frontal regions in PD-MCI as compared to PD-NC (**Tab.1**).

Table 1. Scaling Index β values per Electrode Coordinates in PD-NC and PD-MCI.

	PD - NC			PD - MCI			
Coordinates	**Mean**	**S.D.**	**S.E.**	**Mean**	**S.D.**	**S.E.**	**p values†**
F3	2.51	0.44	0.06	2.76	0.54	0.08	**0.009***
F4	2.51	0.45	0.60	2.75	0.07	0.52	**0.02***
F7	2.48	0.45	0.06	2.71	0.55	0.08	**0.02***
F8	2.52	0.43	0.06	2.70	0.52	0.08	0.06
T3	2.59	0.47	0.06	2.73	0.55	0.08	0.16
T4	2.62	0.41	0.05	2.74	0.50	0. 07	0.18
P3	3.12	0.30	0.04	3.17	0.42	0.06	0.46
P4	3.11	0.33	0.04	3.20	0.38	0.06	0.20
O1	3.03	0.34	0.04	3.05	0.42	0.06	0.76
O2	3.01	0.35	0.05	3.06	0.39	0.06	0.51

Legend: S.D., Standard Deviation; S.E., Standard Error. † independent samples t-test. * p < 0.05.

CONCLUSIONS

Study findings suggest reduced occipital resting-state alpha rhythms and enhanced frontal low-frequency electrocortical networks associated with non-stationary EEG signals in PD-MCI as compared to PD-NC.

Alpha

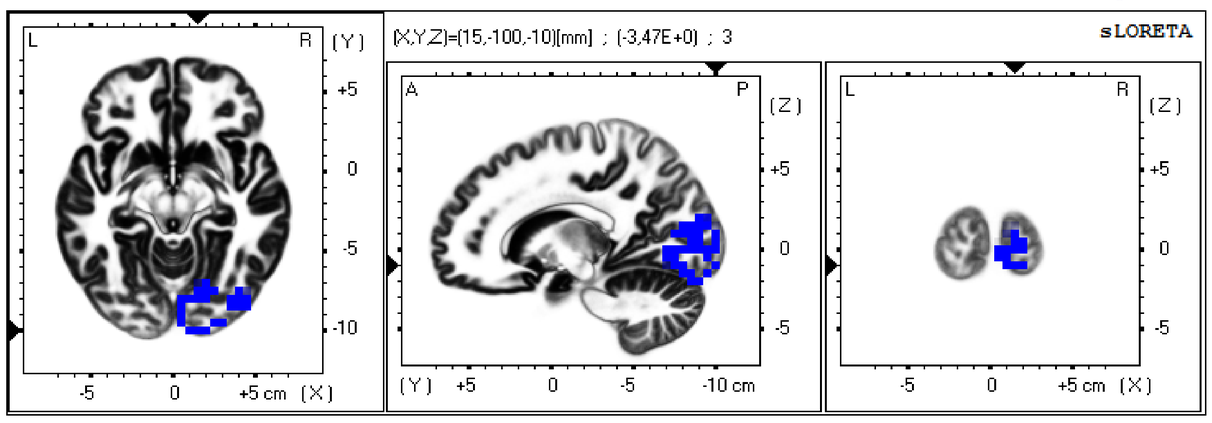

Figure 1. LORETA ICA showing a **reduction (blue) of alpha activity** in a network involving the **lingual gyrus** in PD-MCI.

Beta

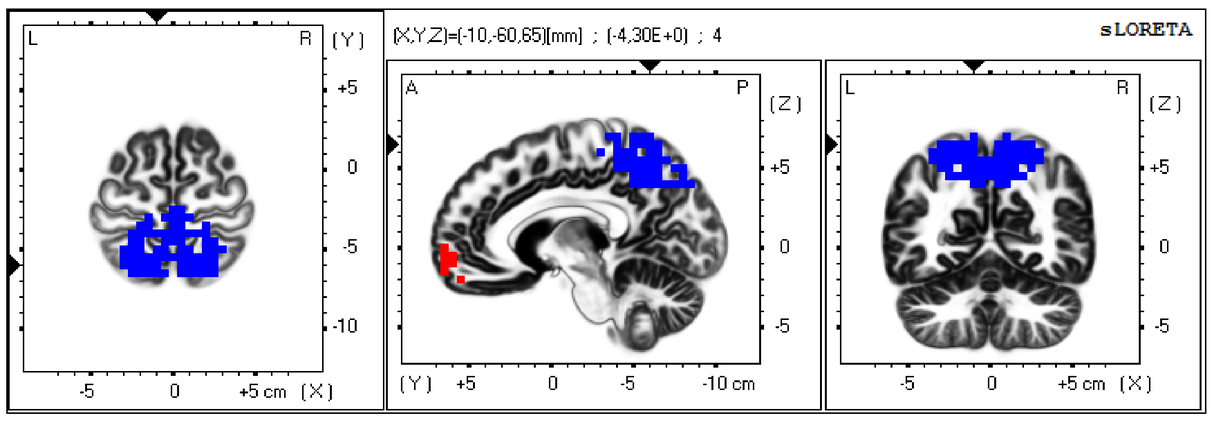

Figure 2. LORETA ICA showing an **increase (red) of beta activity** in a network involving the **frontal lobe** and **reduction (blue)** in the **precuneus** in PD-MCI.

Theta

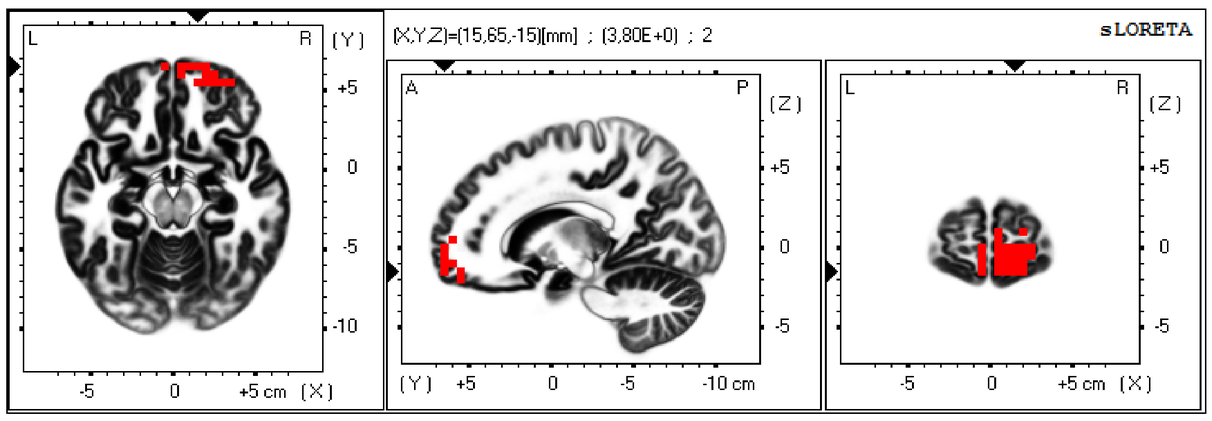

Figure 3. LORETA ICA showing an **increase (red) of theta acitivity** in a network involving the **superior frontal gyrus** in PD-MCI.

Theta

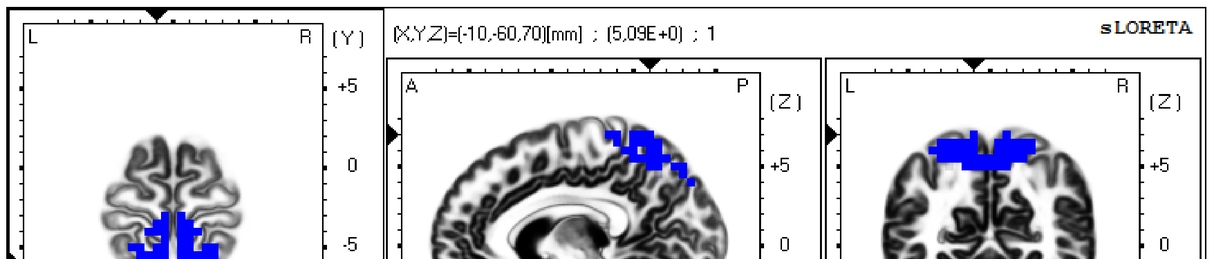

Figure 4. LORETA ICA showing a **reduction (blue) of theta activity** in a network involving the **postcentral gyrus** in PD-MCI.

Delta

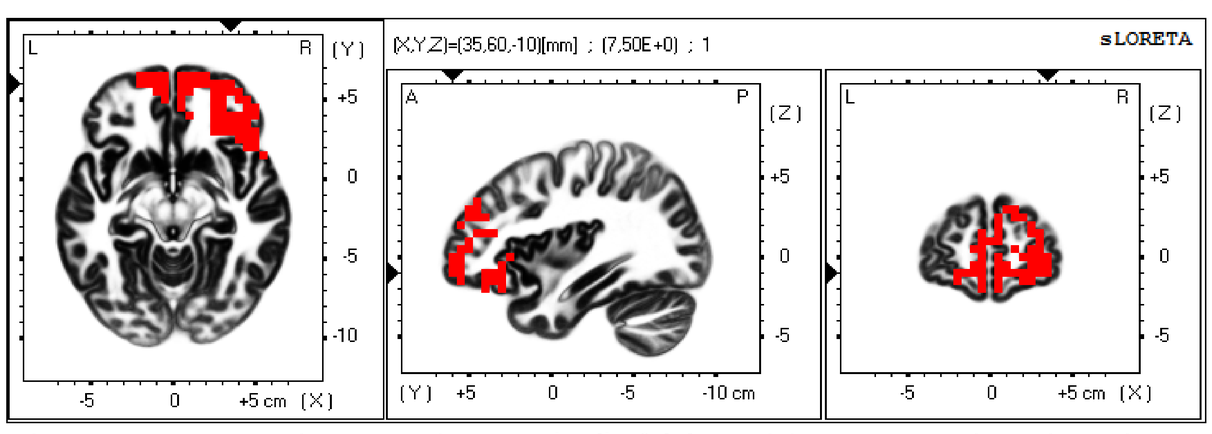

Figure 5. LORETA ICA showing an **increase (red) of delta activity** in a network involving the **middle frontal gyrus** in PD -MCI.

Delta

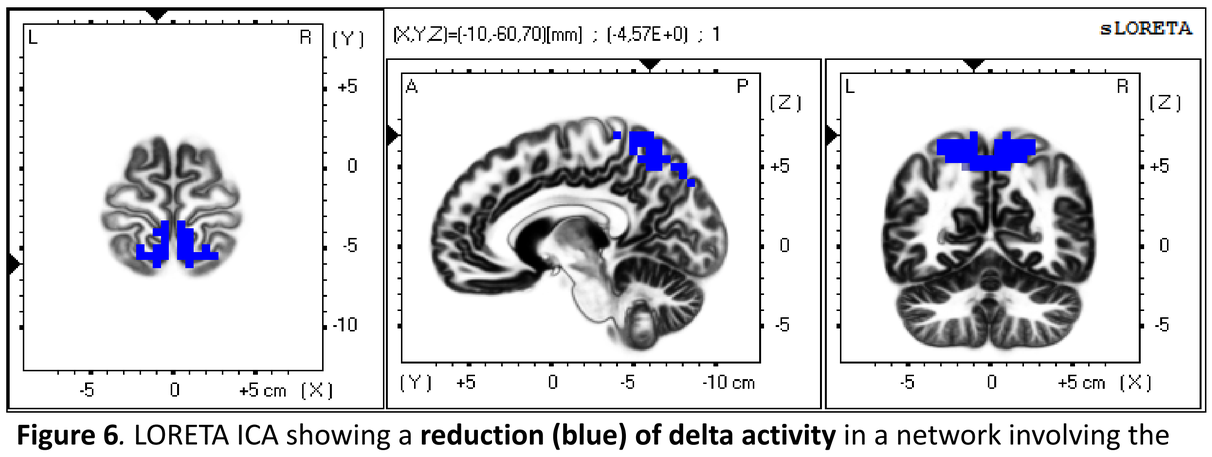

Figure 6. LORETA ICA showing a **reduction (blue) of delta activity** in a network involving the **postcentral gyrus** in PD-MCI.