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Characterization of hemodynamic activity in resting-state networks associated with dementia in Parkinson's disease by fractal analysis

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Introduction: Changes in spontaneous neural activity have been reported in Parkinson's disease (PD) patients with cognitive deficits [1]. However, the frequency dependence of neuronal interaction activities, especially as measured by the fractional amplitude of low-frequency fluctuation (fALFF) and the degree of complexity of these interactions, remains still underinvestigated in PD with cognitive deficits.
Among complexity measures, the Higuchi's fractal dimension (FD) is emerging as being sensitive to capture the complexity of functional connectivity in neurological disorders [2, 3].

Objective: In the present study, we aimed to characterize the frequency dependence and the complexity changes of functional connectivity associated with PD cognitive decline.

Methods: As described in our previous work [4], 118 PD patients were matched for age, sex and education with 35 healthy controls (HC), and classified as 52 PD with normal cognition (PD-NC), 46 with mild cognitive impairment (PD-MCI), and 20 with dementia (PDD) based on an extensive cognitive evaluation. Rs-fMRI data was acquired on 1.5T scanner. Through spatial group ICA, 35 ICs were identified and sorted into 7 functional networks: basal ganglia, auditory (AN), visual, cerebellar, sensorimotor (SMN), cognitive executive (CEN), and default mode network (DMN). Further, a machine learning approach was used to test the best model based on distances between all FDs vs. fALFFs.

Results: The fALFF values in the DMN and CEN were decreased in PD, but increased in the AN, as compared to the HCs. PD-subgroups analyses highlighted that PDD had lower fALFF values than PD-NC/MCI in fronto-parietal internodes located within the CEN.

By contrast, PD patients showed increased complexity than HCs in the SMN, CEN and DMN. Namely, subgroups analyses showed that PDD had increased complexity compared to PD-NC/MCI, in fronto-parieto-occipital internodes located within the CEN and DMN.

Of note, the best model based on distances between all FDs reached the 78% accuracy in differentiating PD-cognitive states as opposed to the 62% accuracy between all fALFFs.

Conclusions: Our study indicates cognitive decline in PD is characterized by an altered spontaneous neuronal activity and an increased temporal complexity, involving namely the CEN and DMN and

reflecting an increased segregation of these networks. Hence, we proposed that FD may serve as a prognostic biomarker of PD-cognitive decline.

References:

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