Cognitive impairment and brain network organisation in MS patients

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Introduction

Multiple sclerosis (MS) affects people in the prime of their lives and 50% experience cognitive impairment (CI). Our central question is: **Can we use EEG to predict CI in MS**? Specifically we:

- Used EEG to estimate functional connectivity
- Related network measures to CI using:
- 1) Classical statistics (linear relation)
- 2) Machine learning (non-linear relation)

Methods

Eyes-closed EEG resting-state data for 114 intact and 113 impaired MS patients were used for analysis:

- Source reconstruction using scalar beamforing of cleaned EEG
- A 38 parcellation was used for summary time-series contruction
- Functional connectivity analysis using iCOH and PLV in 4 frequency bands: delta (1-4Hz), theta (4-8Hz), alpha (8-12Hz) and beta (13-30Hz).
- Classical T-test between groups of the mean ratio of intra-hemispheric and inter-hemispheric connections
- Random forest classifier for cognitive status prediction

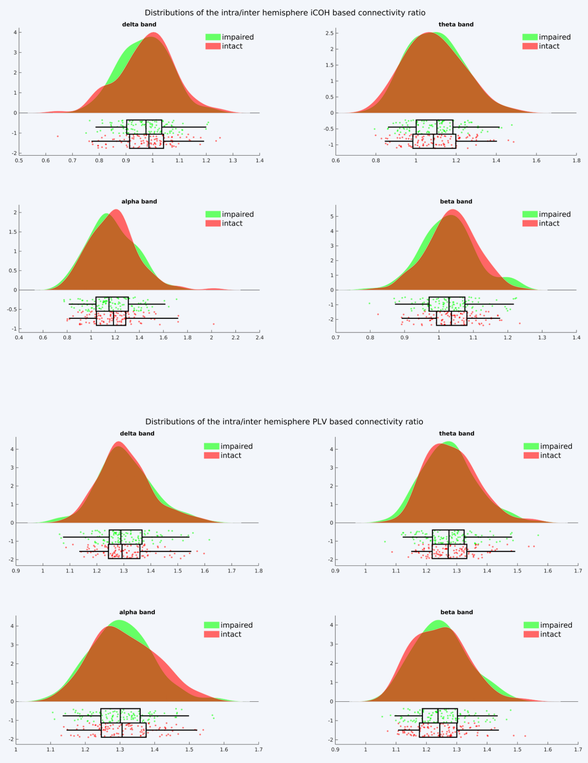
We found no clear link between EEG-based connectivity and cognitive status in MS.

Results

Intra/inter hemispheric ratio

Table 1: Results for the intra/inter hemispheric ratio obtained using iCOH and PLV and averaged per frequency band. Mean and standard deviation per group (impaired and intact group) or shown and the statistical test (impaired vs. intact group; uncorrected P-values and the t-values are shown in the last column).

CONNECTIVITY	FREQUENCY BAND	IMPAIRED MEAN (SD)	INTACT MEAN(SD)	P-VALUE (T-VALUE)
ICOH	Delta (1-4Hz)	0.97 (0.09)	0.98 (0.11)	.60 (-0.52)
	Theta (4-8Hz)	1.10 (0.13)	1.09 (0.14)	.76 (0.31)
	Alpha (8-12Hz)	1.17 (0.19)	1.19 (0.20)	.56 (-0.59)
	Beta (13-30HZ)	1.03 (0.08)	1.04 (0.07)	.39 (-0.87)
PLV	Delta (1-4Hz)	1.31 (0.10)	1.30 (0.10)	0.84 (0.20)
	Theta (4-8Hz)	1.28 (0.09)	1.28 (0.08)	0.57 (-0.56)
	Alpha (8-12Hz)	1.30 (0.09)	1.31 (0.09)	0.35 (-0.94)
	Beta (13-30HZ)	1.25 (0.09)	1.24 (0.090.3)	0.68 (0.42)



Random forest classifier

Table 2. The results for each feature set (edge detection x frequency band) are given in terms of the averaged accuracy (ACC), sensitivity (Sens) and specificity (Spec) obtained using repeated 10-fold CV with a random forest classifier. Standard deviation of the scoring metrics is provided in brackets.

Feature set		Scoring metric		
Connectivity	Frequency	Mean ACC (SD)	Mean Sens (SD)	Mean Spec (SD)
ICOH	Delta	0.43 (0.06)	0.45 (0.13)	0.43(0.12)
	Theta	0.36 (0.08)	0.37 (0.17)	0.40 (0.15)
	Alpha	0.36 (0.10)	0.32 (0.17)	0.45 (0.22)
	Beta	0,28 (0.09)	0.25 (0.14)	0.34 (0.17)
PLV	Delta	0.30 (0.10)	0.29 (0.15)	0.34 (0.25)
	Theta	0.28 (0.05)	0.25 (0.10)	0.34 (0.16)
	Alpha	0.28 (0.11)	0.31 (0.16)	0.30 (0.16)
	Beta	0.23 (0.07)	0.17 (0.14)	0.32 (0.16)

Discussion

Neither the classical statistical analysis nor the predictive analysis using machine learning showed a relationship between EEG-based source space connectivity and cognitive status. Given the large sample size, this suggests that while in rest with eyes closed, (non-linear) effects of connectivity on cognition are either very small or non-existing.

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