Alterations of spectral and nonlinear EEG features in resting state and during a memorization task in Mild and Subjective Cognitive Impairment

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Background

Mild (**MCI**) and **Subjective Cognitive Impairment** (**SCI**) are conditions at risk of developing Alzheimer's disease (AD).
Differential between normal aging at early stages can be really challenging; available biomarkers have different sensitivity and specificity, need to be combined, can be quite invasive and expensive, and therefore hardly applicable in routine clinical setting.

Objective

To examine possible **EEG alterations** in MCI and SCI compared to controls,
in particular to check if a **cognitive task** is able to highlight spectral EEG differences,
identifying early EEG features which may predict conversion to AD.

Material & Method

Partecipants:

- **11 MCI patients** [8 F and 3 M; average MMSE score 26,6 (24÷30)],
- **8 SCI patients** [5 F and 3 M; average MMSE score 28,6 (26÷30)],
- **7 healthy controls (C)** [3 F and 4 M; average MMSE score 28,2 (25,4÷30)], all matched for age and education.

They were performed:

- **Neuropsychological assessment**
- **EEG recording at resting state**
- **EEG recording during a mental memory task.**

➡Classical spectral measures and nonlinear parameters were used to characterize EEGs, both for measures at single electrode and on brain regions.

Results

Resting state was found to be a good condition to differentiate between MCI and SCI (mainly by the spectral parameters α2 and IAF peak, both related to the activity in alpha band),
while the **cognitive task** allowed assessing differences between CS and SCI (β2 and γ for the spectral analysis, ZC and FD from nonlinear approach).

A decrease in α1 power for both MCI and SCI compared to CS was also found; even if not statistically relevant in our population, this result is consistent with literature and can be considered a key feature of cognitive impairment

Median values (with 25th and 75th percentiles) of the parameters and channels that showed significant differences among the CS, MCI and SCI groups, calculated grouping channels in scalp regions according to their location, in Resting (R) or Memorization (M) testing condition, and p-values concerning the comparison for each pair of groups.

Scalp region	Parameter	Test	CS	MCI	SCI	CS vs MCI	CS vs SCI	MCI vs SCI
RF	*SD2*	R	11.42 (10.61-12.45)	10.49 (9.17-13.70)	8.99 (8.81-9.81)	n.s.	0.021	n.s.
LF	*β exponent*	R	1.44 (0.88-1.59)	1.02 (0.80-1.25)	1.57 (1.27-1.78)	n.s.	n.s.	0.012
LT	*α2*	R	0.074 (0.071-0.128)	0.068 (0.045-0.098)	0.140 (0.103-0.188)	n.s.	n.s.	0.009
C	*α2*	R	0.068 (0.064-0.102)	0.063 (0.042-0.087)	0.107 (0.087-0.157)	n.s.	n.s.	0.016
C	*β exponent*	R	1.43 (1.06-1.84)	1.33 (1.12-1.43)	1.56 (1.48-1.91)	n.s.	n.s.	0.012
C	*IAF peak*	R	2.6 (1.9-3.1)	2.2 (1.7-2.5)	3.0 (2.6-3.7)	n.s.	n.s.	0.007
P	*α2*	R	0.074 (0.069-0.142)	0.079 (0.064-0.113)	0.184 (0.109-0.242)	n.s.	n.s.	0.009
P	*FD*	M	1.67 (1.65-1.78)	1.62 (1.51-1.73)	1.56 (1.45-1.59)	n.s.	0.006	n.s.
P	*ZC*	M	403 (316-429)	313 (269-418)	301 (236-310)	n.s.	0.021	n.s.
P	*β2*	M	0.114 (0.097-0.155)	0.077 (0.062-0.100)	0.080 (0.037-0.085)	n.s.	0.021	n.s.
P	*γ*	M	0.166 (0.082-0.215)	0.096 (0.053-0.177)	0.072 (0.023-0.079)	n.s.	0.021	n.s.

Comparing EEG features between resting state and cognitive task performance, decreased α1 and α2 power was found predominantly in frontal regions in SCI, spread out in all regions in MCI.
Frontal areas are known to be involved in free recall task; this could explain our findings for SCI and CS, while we hypothesize that in MCI patients different brain networks need to be activated to perform the same recall task, and compensate for encoding deficit.

P-values of the Wilcoxon signed rank test performed to compare, for each group of subjects (CS, MCI and SCI), parameters (spectral analysis) calculated for the memorization task and resting state, according to the scalp region.

Parameter	Group	Scalp region RF	LF	RT	LT	C	P	O
δ	CS	n.s.	0.047	n.s.	n.s.	n.s.	0.016	0.047
	MCI	0.014	n.s	n.s.	0.049	0.027	n.s.	n.s.
	SCI	0.047	0.047	n.s.	n.s.	n.s.	n.s.	n.s.
α1	CS	0.031	0.047	0.047	0.016	0.031	0.031	0.031
	MCI	0.002	0.002	0.006	0.010	0.002	0.002	0.002
	SCI	0.031	0.016	n.s.	n.s.	n.s.	n.s.	n.s.
α2	CS	0.047	0.016	n.s.	n.s.	n.s.	n.s.	n.s.
	MCI	0.006	0.004	n.s.	n.s.	n.s.	n.s.	n.s.
	SCI	0.016	0.031	0.016	n.s.	0.016	n.s.	0.016

Moreover, during cognitive task, decreased EEG complexity was found in SCI compared to controls, therefore EEG complexity reduction could be a possible early hallmark of the disease.

P-values of the Wilcoxon signed rank test performed to compare, for each group of subjects (CS, MCI and SCI), parameters (Poincarè plot) calculated for the memorization task and resting state, according to the scalp region.

Parameter	Group	Scalp region RF	LF	RT	LT	C	P	O
SD1	CS	0.047	0.031	n.s.	n.s.	n.s.	n.s.	n.s.
	MCI	0.004	0.020	0.010	0.037	0.014	0.010	0.004
	SCI	n.s.	n.s.	n.s.	n.s.	n.s.	0.031	0.031
SD2	CS	0.047	0.031	n.s.	n.s.	n.s.	n.s.	n.s.
	MCI	0.002	0.006	n.s.	0.020	0.010	0.037	0.006
	SCI	0.047	n.s.	n.s.	0.047	0.047	n.s.	n.s.

Discussion

This study draws attention on the importance of nonlinear approach in EEG analysis and the potential role of cognitive task in highlighting EEG alterations at very early stages of cognitive impairment. Larger study population need to be recruited to obtain more statistically significant results, but the protocol simplicity and the short EEG epochs needed for analysis, make him suitable for use in a clinical context.
EEG could therefore have a practical impact in clinical dementia diagnosis.

References

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