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FNSNF

Comparison of lagged partial coherence fields based on high- and low-density EEG

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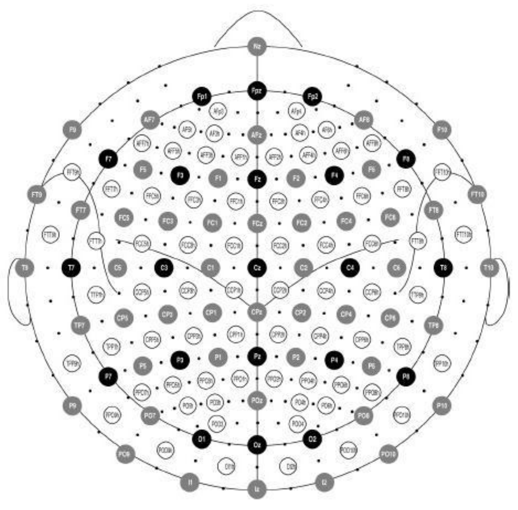
Introduction and Objectives

The wearable ICT for long-term outpatient EEG monitoring will allow low-density EEG (ldEEG, <64 channels). However, the advantage of ldEEG in terms of technical preparations and subject's comfort is balanced by substantial challenges with respect to its quantitative assessments compared to high-density EEG (hdEEG). In particular, the electromagnetic inverse problem suffers from an inadequate surface sampling, making the activity source reconstruction with conventional methods less reliable. **We are seeking a method of analysis, which would minimally suffer from the limitations of ldEEG, making the measurements with wearable ITC scientifically sound and practically useful.** Here we present an approach for quantitative assessment of EEG-based functional connectivity (FC). FC is an appealing feature of the brain electromagnetic activity that has been shown to deteriorate in a number of psychiatric and neurodegenerative diseases including psychogenic nonepileptic seizures (PNES), Alzheimer's disease, etc. (Barzegaran et al. 2012; Knyazeva et al. 2011; 2013).

Research Questions

High Density EEG



Step 1

What is an impact of PNES on FC based on source analysis of hdEEG?

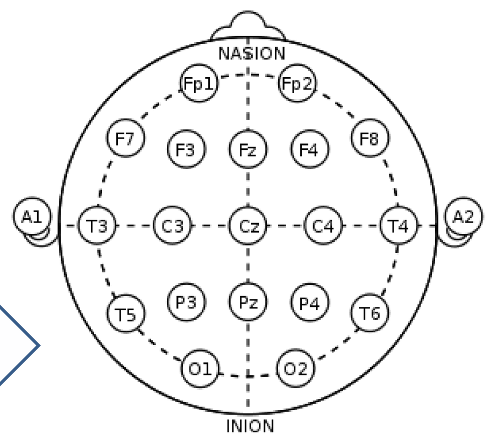
Step 2 & 3

How to analyze ldEEG for obtaining the FC results conceptually similar to *step 1*, considering its limitations (source mixing at sensor level and the impossibility of an accurate transform of ldEEG into the brain space)?

Step 4

To what extent the results obtained with ldEEG are similar to those achieved with hdEEG (for chosen method) ?

Low Density EEG



Step 1. Methods and Results

Objective. To detect PNES-dependent changes in FC using source estimation and synchronization measures based on high-density EEG immune to the volume conductance effects.

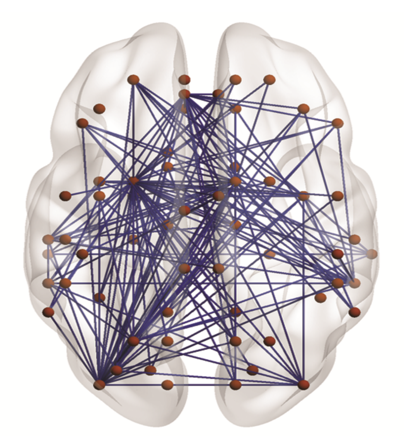
Methods.

- **Dataset**. hdEEGs recording of 18 PNES patients and 18 controls
- **Source estimation.** Local autoregressive model (LAURA) solution
- **Brain regions.** 33 source ROIs in each hemisphere, which formed 9 subnetworks
- **FC estimation.** Classical lagged linear dependency (Pascual-Marqui, 2007)
- **Statistical analysis.** SubNetwork Based Analysis with 9 subnetworks in each hemisphere (Meskaldji, 2011)

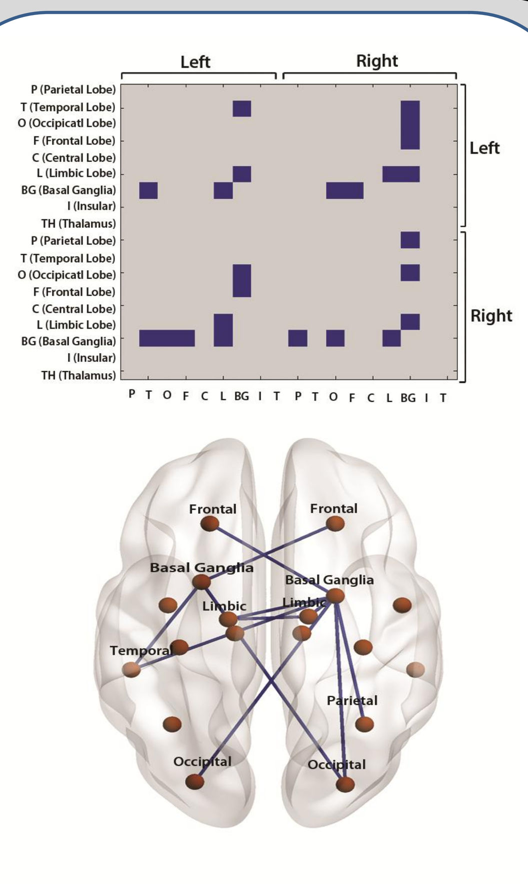
Results.

- **Family-Wise Error (FWER) uncorrected.** Reduced lagged FC for cortico-cortical and cortico-subcortical connections were shown.
- **FWER Corrected.** Decreased lagged FC for cortico-subcortical connections of the basal ganglia with the limbic system, prefrontal, temporal, parietal, and occipital cortices survived in alpha band.

#	Subnetworks
ROI1	Parietal Lobe
ROI2	Temporal Lobe
ROI3	Occipital Lobe
ROI4	Frontal Lobe
ROI5	Central Lobe
ROI6	Limbic Lobe
ROI7	Basal Ganglia
ROI8	Insular
ROI9	Thalamus



Application of Sunetwork Based Analysis



Step 2. Methods and Preliminary Findings

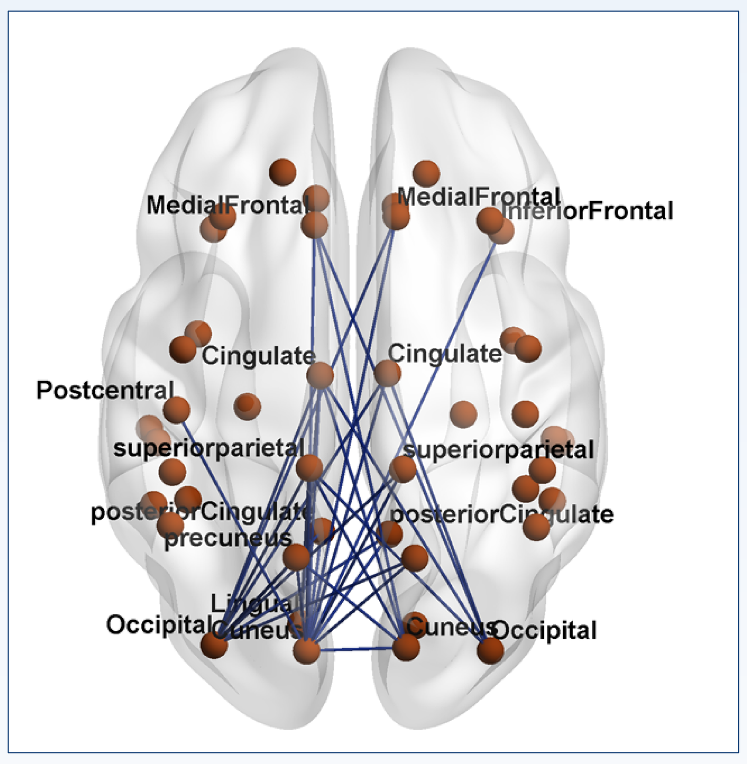
Objective. To test on hdEEG a method of FC estimation that potentially solves the volume conductance and source uncertainty problems in ldEEG (lagged-partial) (Pascual-Marqui, 2011).

Methods.

- **Dataset.** Same hdEEGs as in **Step 1**
- **Sensor partial covariance estimation.** Shrinkage estimator of spectral covariances
- **Lead field matrix estimation.** Forward model based on a boundary element method
- **Brain regions.** 22 ROIs per hemisphere
- **FC estimation.** Lagged interactions between the ROIs
- **statistical analysis.** Permutation-based non-parametric inference within the framework of general linear model, FWER corrected

Results.

- **FWER Corrected.** The pattern of decrease in lagged FC is mainly observed in connections of frontal, occipital, cingulate, cuneus and some parietal areas.



#	Regions
ROI1	Angular Gyrus and Supramarginal Gyrus
ROI2	Anterior Cingulate + Subcallosal gyrus
ROI3	Cingulate Gyrus
ROI4	Cuneus
ROI5	Fusiform Gyrus
ROI6	Inferior Frontal Gyrus + Orbital gyrus + Gyrus rectus
ROI7	Inferior Occipital Gyrus + Middle Occipital Gyrus + Superior Occipital Gyrus
ROI8	Inferior Parietal Lobule
ROI9	Inferior Temporal Gyrus
ROI10	Middle Temporal Gyrus
ROI11	Superior Temporal Gyrus + Transverse Temporal gyrus
ROI12	Insula + Claustrum
ROI13	Lingual Gyrus
ROI14	Medial Frontal Gyrus
ROI15	Middle Frontal Gyrus
ROI16	Parahippocampal Gyrus + Uncus
ROI17	Postcentral Gyrus
ROI18	Posterior Cingulate
ROI19	Precentral Gyrus
ROI20	Precuneus
ROI21	Superior Frontal Gyrus
ROI22	Superior Parietal Lobule

Conclusion

- Conceptually, the results are replicable between the two methods applied to hdEEG. We have found a decrease of distributed FC in PNES patients.
- For cortico-cotrical connectivity, we found stronger effects with lagged-partial than with lagged classical FC.
- Successful application of lagged-partial method to hdEEG allows its further testing on ldEEG.

Further Steps

- **Step 3.** To Apply the same method as in **step 2** to ldEEG from the same patients by means of reducing the original number of sensors (128 to 19).
- **Step 4.** To validate lagged-partial method by comparing the results between **steps 1, 2 and 3**

References:

Barzegaran E et al. 2012 Frontiers in human neuroscience, 6.
Knyazeva, MG et al. 2013 Neurobiology of Aging 34(3): 694-705
Knyazeva, MG et al. 2011 Journal of Neurology, Neurosurgery & Psychiatry, 82(5), 505-511.
Meskaldji, Djalel Eddine, et al. *PloS one* 6.8 (2011): e23009.
Pascual-Marqui, Roberto D., et al. *arXiv preprint arXiv:1108.0251* (2011).
Pascual-Marqui, Roberto D. *arXiv preprint arXiv:0711.1455* (2007).