EVALUATION OF FUNCTIONAL CONNECTIVITY IN MEG SIGNALS OF AD AND MCI SUBJECTS WITH MST

Dragos Stanciu[1],
Alberto Fernández[2],
Javier Escudero[3]

THE UNIVERSITY of EDINBURGH
informatics

INTRODUCTION

Studying mild cognitive impairment (MCI) may help to understand early Alzheimer's disease (AD). Biomarkers can offer information about AD pathology but currently considered ones provide limited temporal information about brain activity [1]. The magnetoencephalogram (MEG) is a noninvasive recording of brain activity with high temporal resolution [2]. AD is hypothesised to be a disconnection syndrome. Estimating functional connectivity between MEG signals provides an excellent opportunity to analyze whole brain activity in this disease. Graph theory is a framework that only recently has been applied to the study of connectivity in the human brain [3].

GOAL

What are the differences in brain connectivity between AD, MCI and control (CON) subjects?

METHODOLOGY

- **MEG dataset**: Resting-state MEGs recorded from 26 CON, 18 MCI subjects and 36 patients with AD at 169.54 Hz. Artefact-free MEG epochs of 10 seconds were selected for analysis and inspected in blocks of 2s with 50% overlap.
- **Signal Processing**: We computed the imaginary part of coherence (ImCOH) and the debiased Weighted Phase Lag Index (dWPLI) between pairs of MEG channels with FieldTrip [4] because of their robustness to common sources. The adjacency matrices for the classical spectral bands (δ, θ, α, β and γ) were computed.
- **Graph Analysis**: The adjacency matrices were transformed into binary graphs by computing their minimum spanning tree (MST) [5].
  The MSTs were characterised with their diameter, leaf number, and characteristic path length (L).

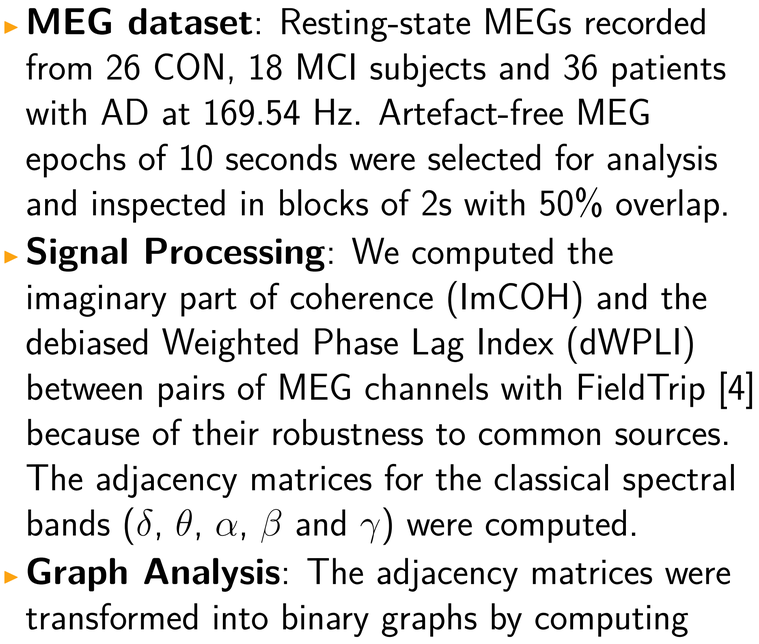

Figure 1 : Minimum Spanning Tree. Each edge is weighted with a number roughly equal to its length. Dark, thick edges are in the minimum spanning tree.

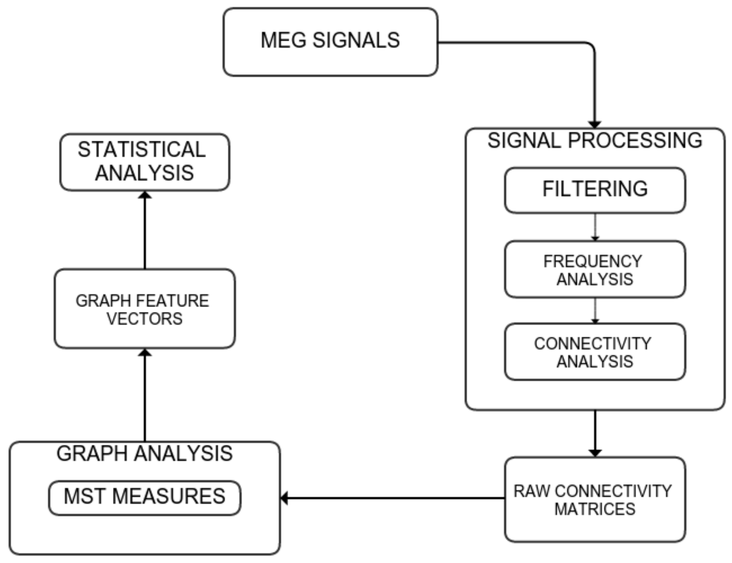

Figure 2 : Data Processing Pipeline

RESULTS AND CONCLUSIONS

- Significant differences between the CON and MCI groups for L in the δ and θ bands, diameter in the θ band and for number of leaves in the δ and θ bands. Between CON and AD subjects, differences in L and diameter were identified in the β band. Dissimilarities were also seen between MCI and AD groups for MST diameter in β, leaf number in δ and θ, and L in α and β.
- The values of the graph metrics for MCI subjects tended to fall outside the range of CON-AD for L in δ, θ, α and β, for diameter in θ and for leaf number in δ and θ.
- These results relate to computational studies that have found that transient increases in activity and connectivity of brain activity in MCI may not be compensatory but pathological [6].

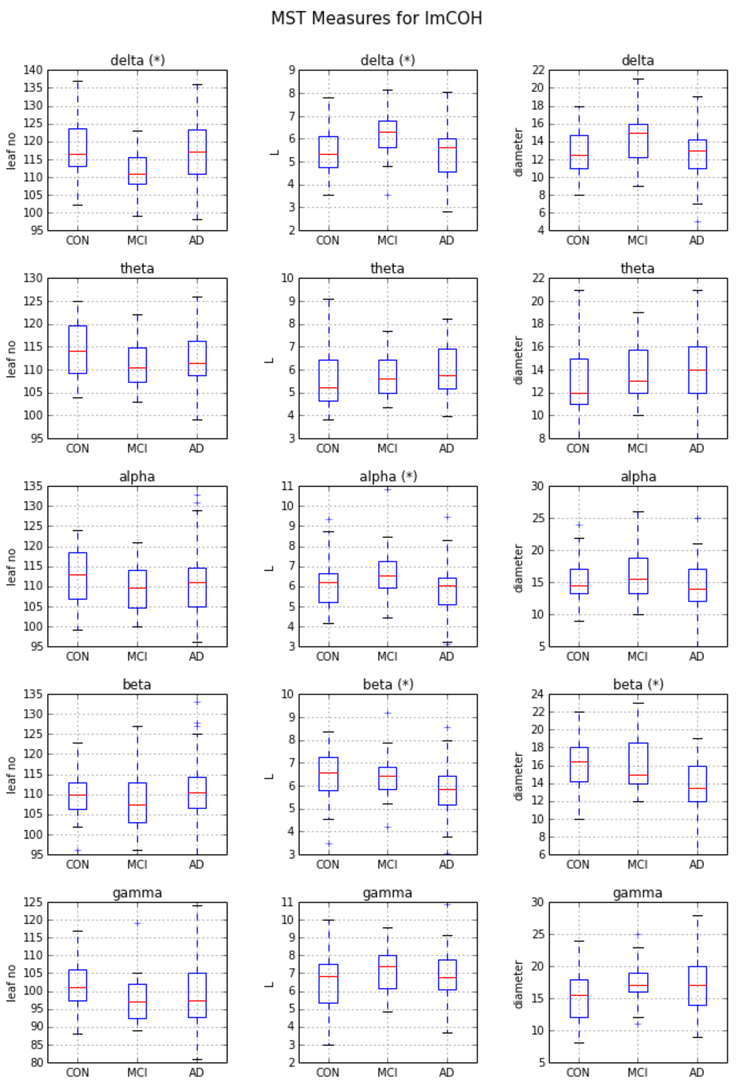

Figure 3 : MST Measures for ImCOH

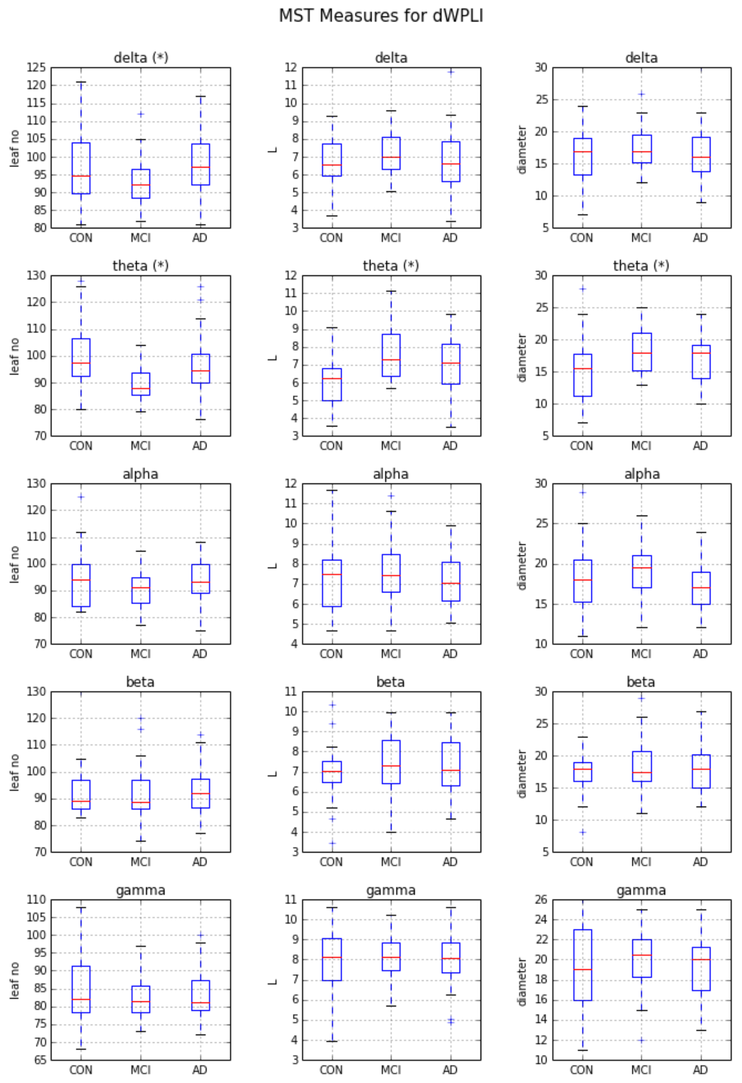

Figure 4 : MST Measures for dWPLI

(*) - significant results ($p<0.05$)

FURTHER IMPROVEMENTS

- Explore other connectivity measures
- Source reconstruction – estimate time-series for specific sources in the brain

REFERENCES

[1] C. R. Jack, et al., 'Introduction to the recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease', Alzheimers. Dement., vol. 7, no. 3, pp. 257–262, May 2011.

[2] F. Lopes da Silva, "EEG and MEG: Relevance to Neuroscience," Neuron, vol. 80, no. 5, pp. 1112-1128, Dec. 2013.

[3] F. D. V. Fallani, J. Richiardi, M. Chavez, and S. Achard, 'Graph analysis of functional brain networks: practical issues in translational neuroscience', Phil. Trans. R. Soc. B, vol. 369, no. 1653, p. 20130521, May 2014.

[4] R. Oostenveld, P. Fries, E. Maris, and J.-M. Schoffelen, 'FieldTrip: Open Source Software for Advanced Analysis of MEG, EEG, and Invasive Electrophysiological Data', Computational Intelligence and Neuroscience, vol. 2011, Dec. 2010.

[5] C. J. Stam, et al., 'The trees and the forest: Characterization of complex brain networks with minimum spanning trees', International Journal of Psychophysiology, vol. 92, no. 3, pp. 129–138, Jun. 2014.

[6] W. de Haan, K. Mott, E. C. W. van Straaten, P. Scheltens, and C. J. Stam, 'Activity Dependent Degeneration Explains Hub Vulnerability in Alzheimer's Disease', PLoS Comput Biol, vol. 8, no. 8, p. e1002582, Aug. 2012.

CONTACT

[1]Doctoral Training Centre in Neuroinformatics and Computational Neuroscience, School of Informatics, University of Edinburgh, dragos.stanciu@ed.ac.uk,
[2]Departamento de Psiquiatría y Psicología Médica, Universidad Complutense de Madrid, Madrid, Spain,
[3]Institute for Digital Communications, School of Engineering, University of Edinburgh, javier.escudero@ed.ac.uk