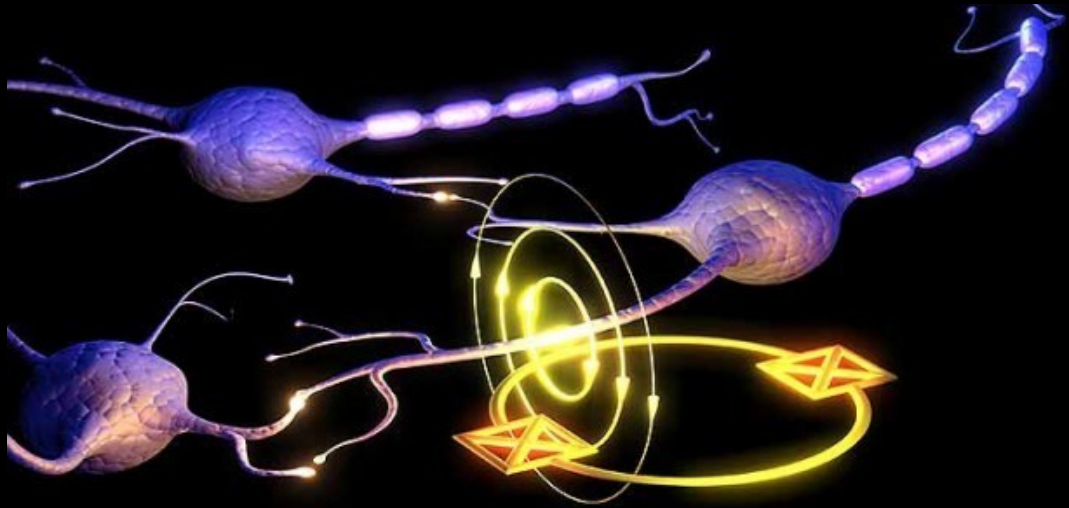


Multifrequency analysis of brain connectivity using MEG

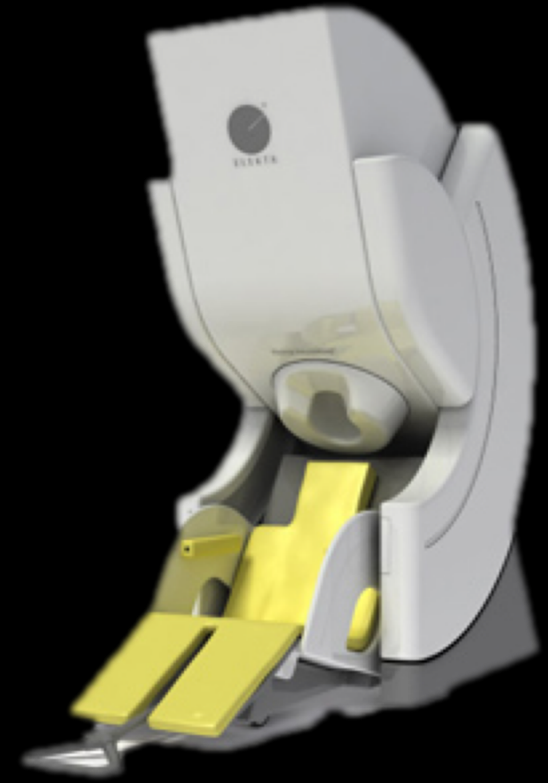
Jeremy GUILLON, PhD student



Magnetoencephalography?



« Electromagnetic waves are produced whenever charged particles are accelerated »

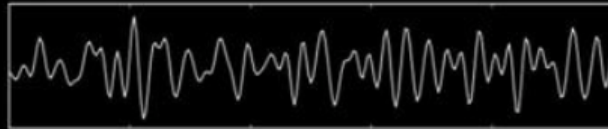


Multifrequency analysis?



Gamma: 30-100+ Hz

Binding senses, cognition, information processing, learning, perception, REM sleep



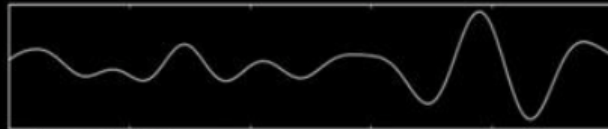
Beta: 12-30 Hz

Conscious focus, memory, problem solving



Alpha: 8-12 Hz

Relaxation



Theta: 4-7 Hz

Creativity, emotional connection, intuition, relaxation



Delta: 0-4 Hz

Immune system, natural healing, restorative / deep sleep

...and in Alzheimer disease?

MEG Signals Power Spectra

What does the literature say?

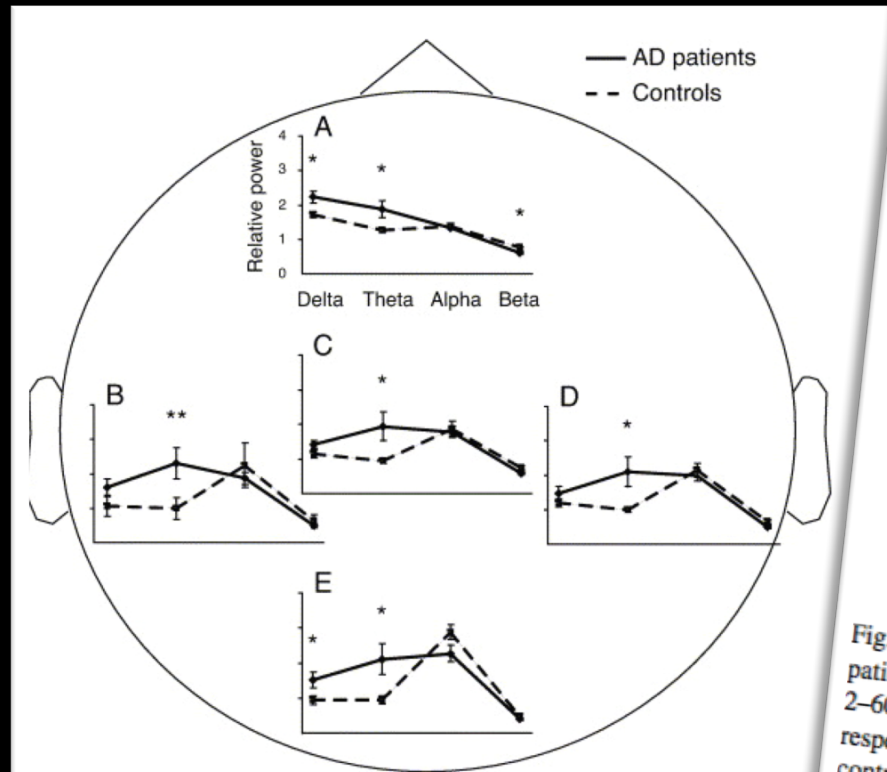


Fig. 3. Mean relative power and standard errors in delta, theta, alpha, and beta bands in both groups (A), left temporal (B), central (C), right temporal (D), and occipital (E) regions. *P < 0.05; **P < 0.01.

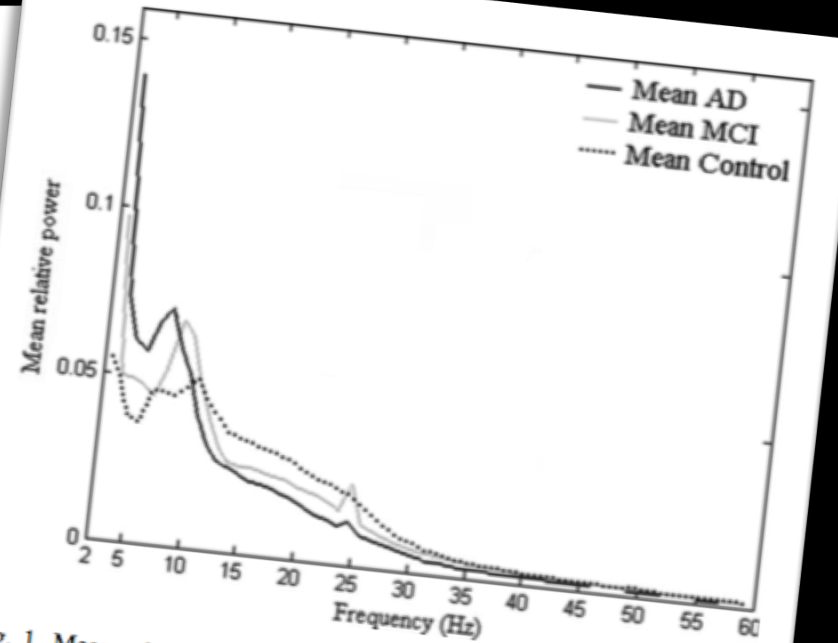
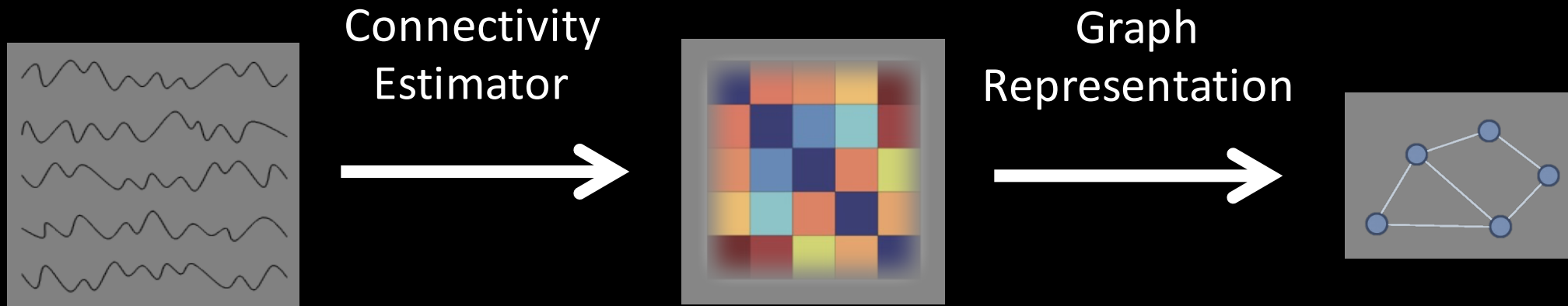


Fig. 1. Mean relative power spectra for all channels in each group: AD patients, MCI subjects and healthy controls. Spectra are represented in the 2–60 Hz frequency band. Spectrum of AD patients is shifted to the left with respect to MCI and healthy subjects. When comparing MCI individuals and controls, a slightly shift to the left of spectrum and an increase in magnitude of alpha peak are observed.

Values are means (SE).
 *P < 0.05; **P < 0.01 (Mann-Whitney U test for two independent samples).

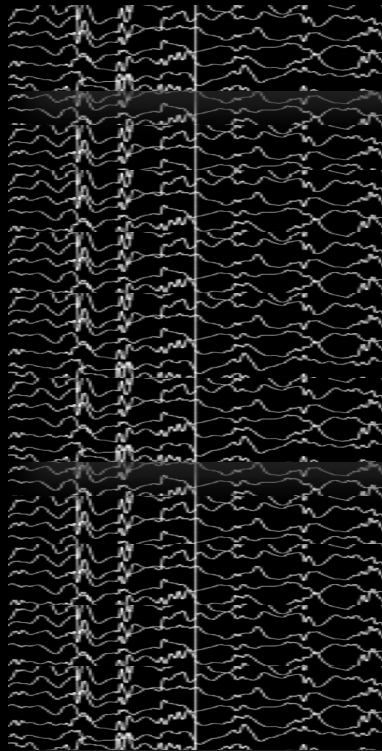
Fernández et al., 2006
 Berendse et al., 2000
 Osipova et al., 2005

Brain connectivity networks construction

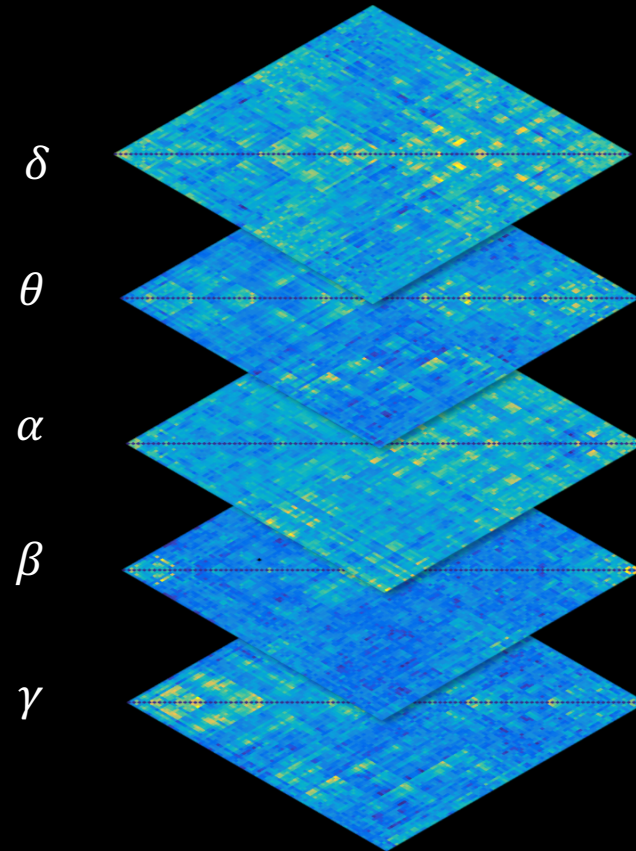


Ex.: Cross-Correlation $(f \star g)[n] = \sum_{m=-\infty}^{\infty} f^*[m]g[m+n]$

Brain networks in Alzheimer patients

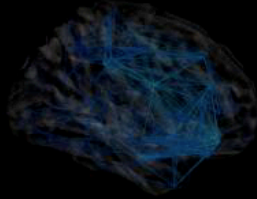


Spectral
Coherence

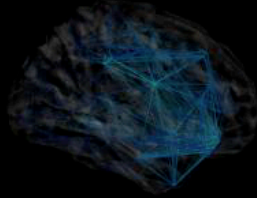


Topological network characterization

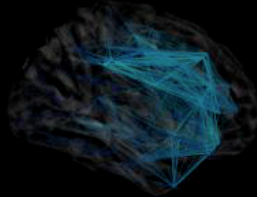
δ



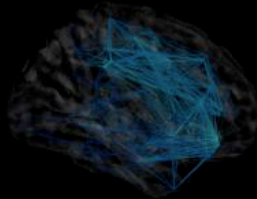
θ



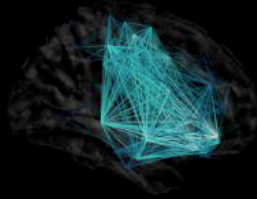
α



β



γ




Index
Extraction

- Clustering coefficient
- Average shortest path length
- Participation coefficient

Topological analysis?

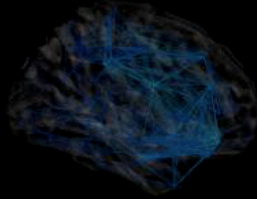
Results

- 
- Clustering coefficient in AD > HC in δ -band
 - Clustering coefficient in AD < HC in α -band
 - Path length in AD < HC in δ -band
 - Path length in AD > HC in α -band
 - Nothing for the Participation Coefficient

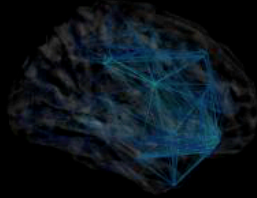
Stam et al. 2007 and 2009
de Haan et al. 2009

Topological network characterization

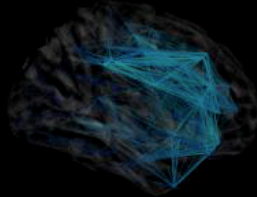
δ



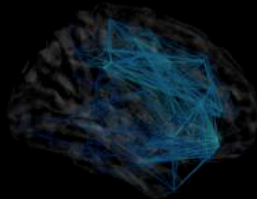
θ



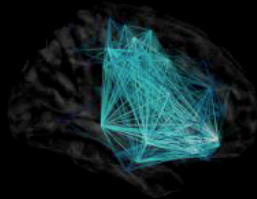
α



β



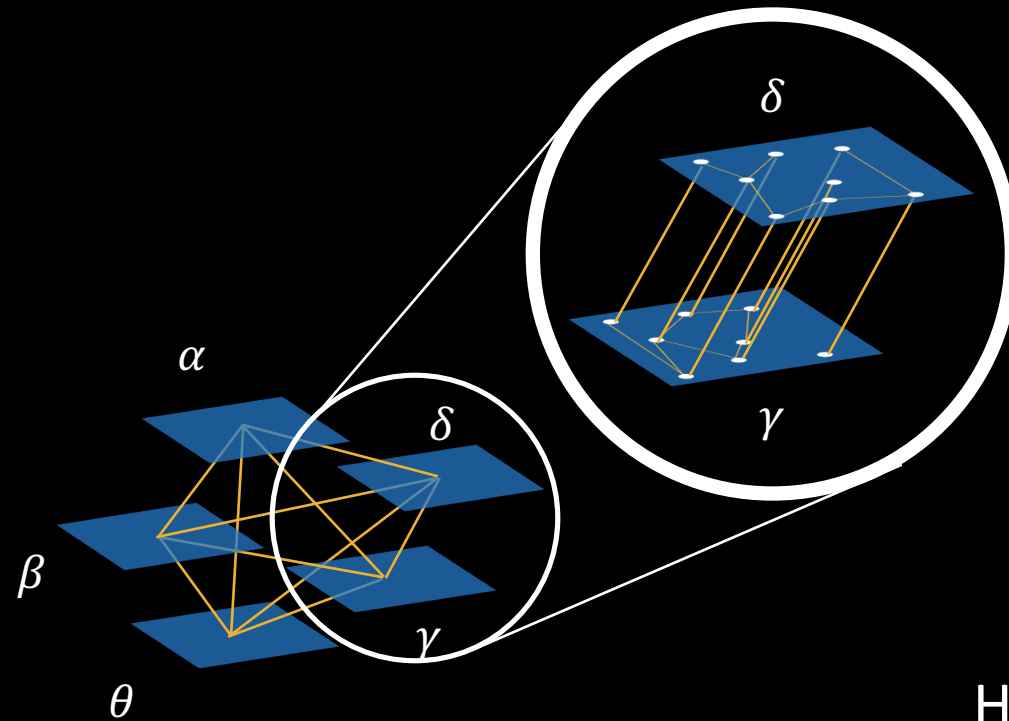
γ



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Extraction

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Multiplex Construction



How to characterize such
networks?

Multilayer Networks



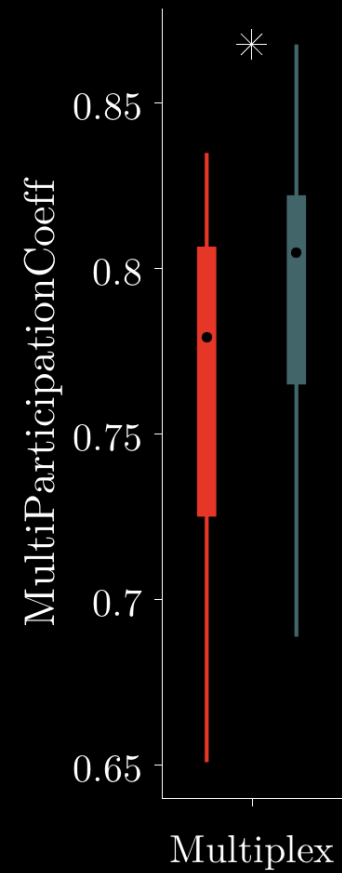
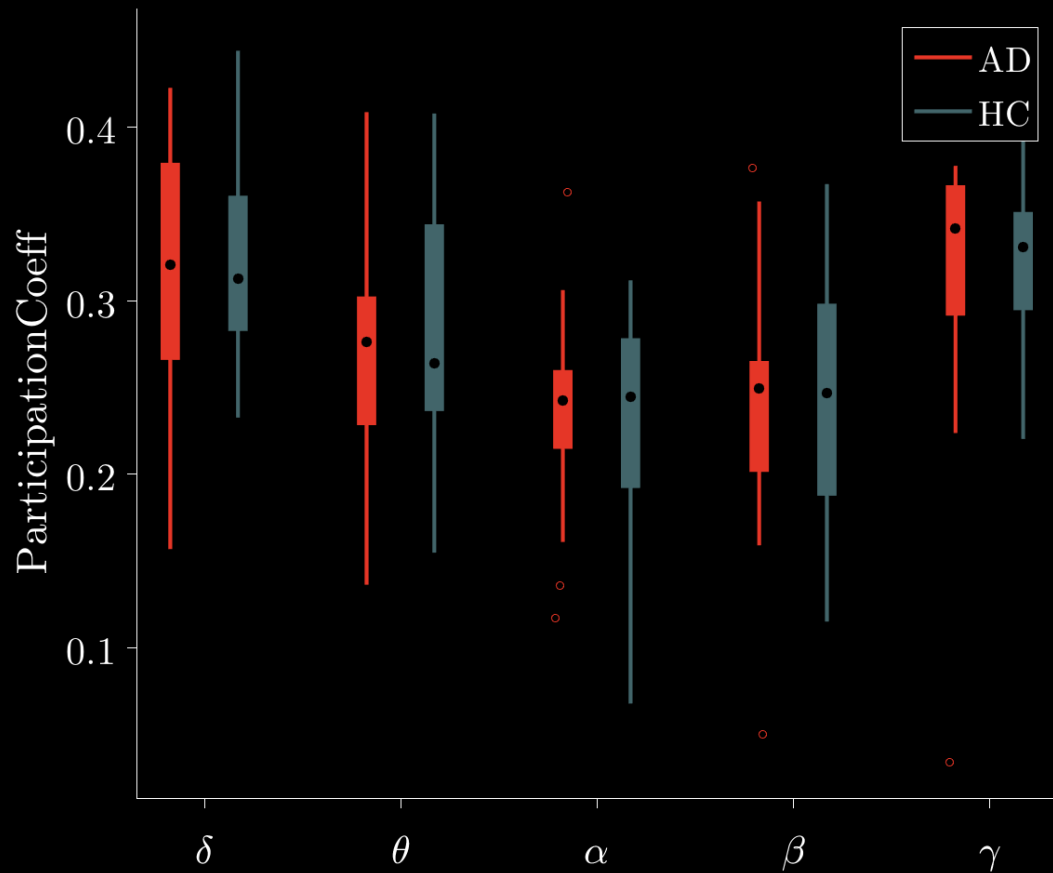
Topological Characterization

Index
Extraction

- Clustering coefficient
- Average shortest path length
- Participation coefficient
- Multi-1/2-Clustering coefficient
- Interdependence
- Multi-Participation coefficient

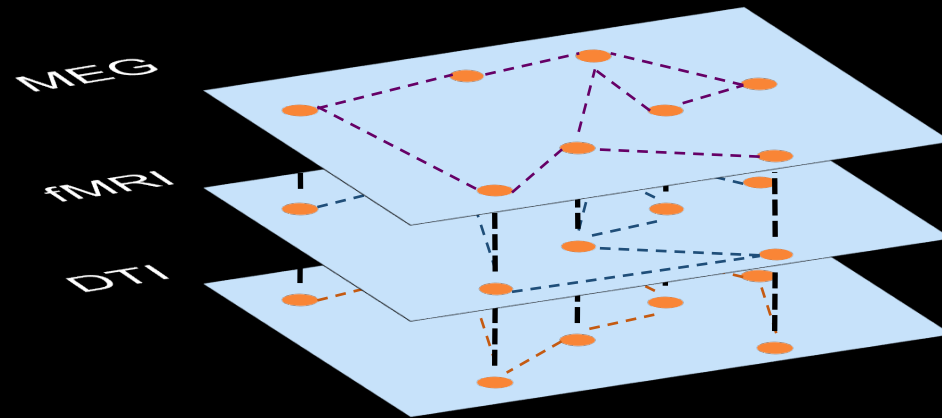
$$P_i = \frac{M}{M-1} \left[1 - \sum_{\alpha=1}^M \left(\frac{k_i^{[\alpha]}}{o_i} \right)^2 \right]$$

Preliminary Results



What about the future?

Apply this methodology to multimodal networks



Thank you for your attention



Mario
Chavez
[Co-Supervisor]



Jeremy
Guillon



Fabrizio
De Vico Fallani
[Supervisor]



Power spectrum density

