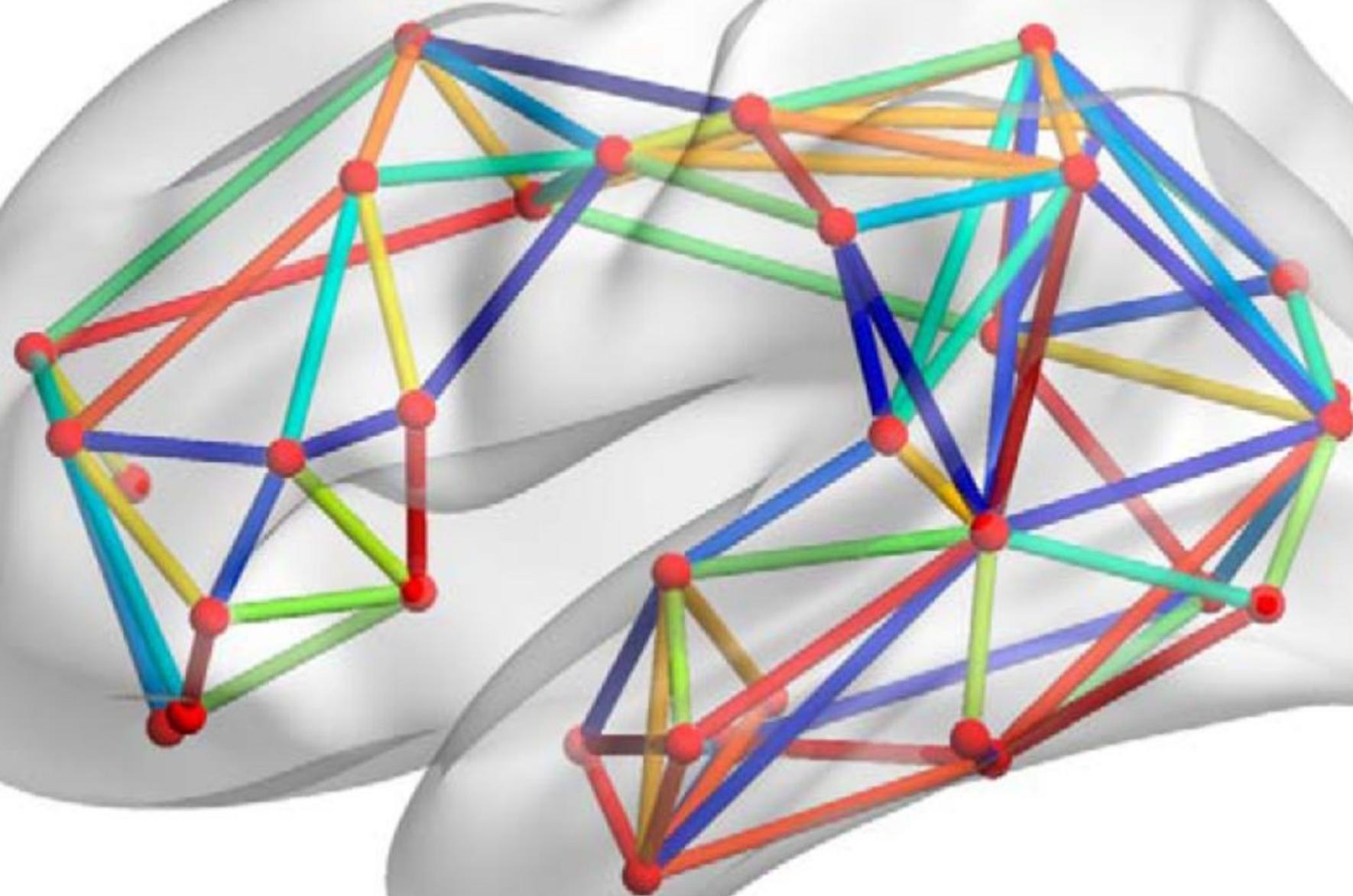


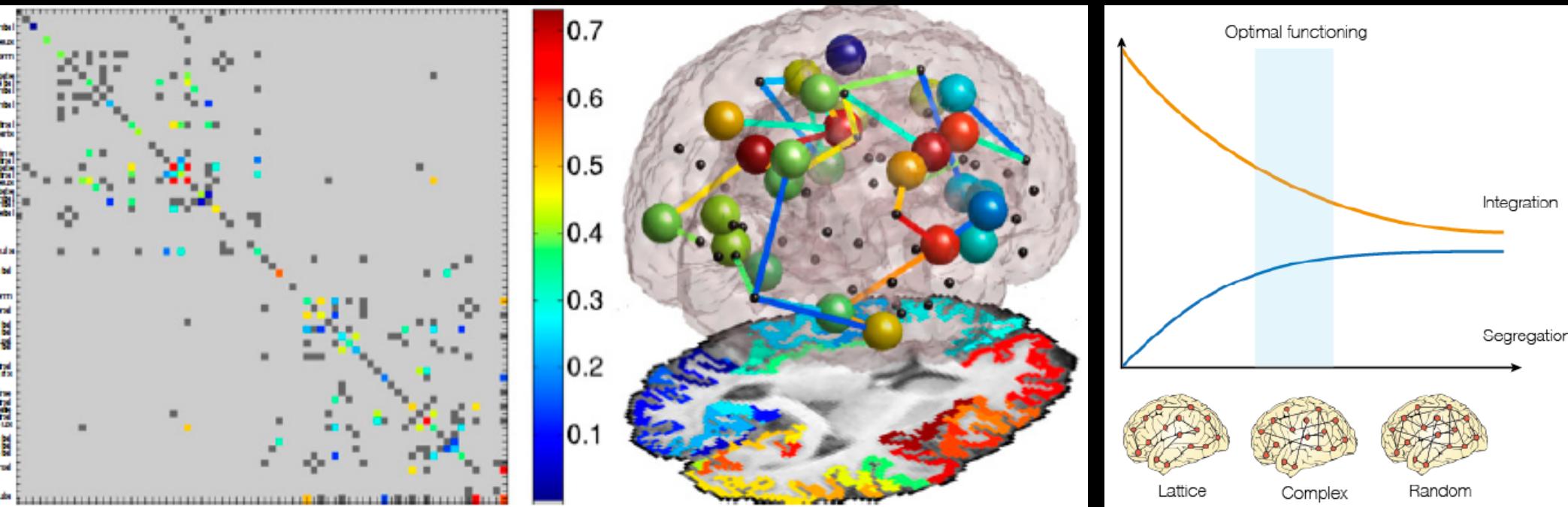
Dynamical Functional Connectivity  
Dr. Alessandro Crimi

# Brainhack Project Overview

- Focus on Dynamical Connectivity
- Communities/Clusters detection
- Compare 2 groups of subjects.
- Available data (Brain tumor, Alzheimer's, schizophrenia, autism...)
- Put everything on Github.



# Visualization & Diagnosis

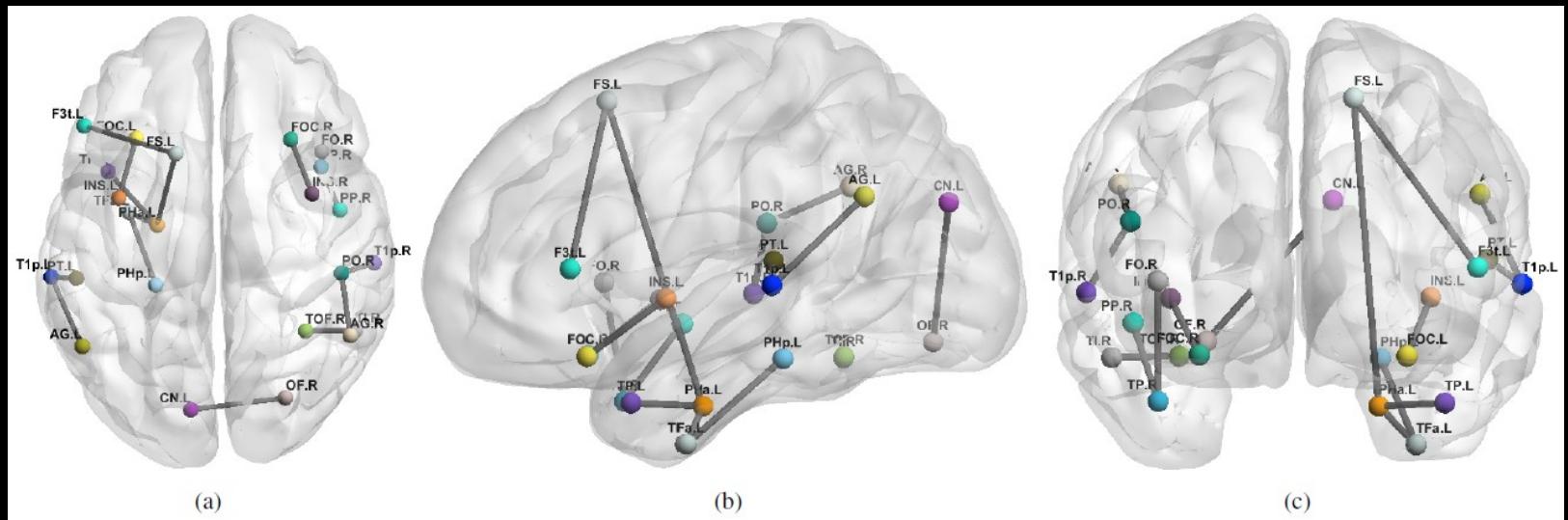
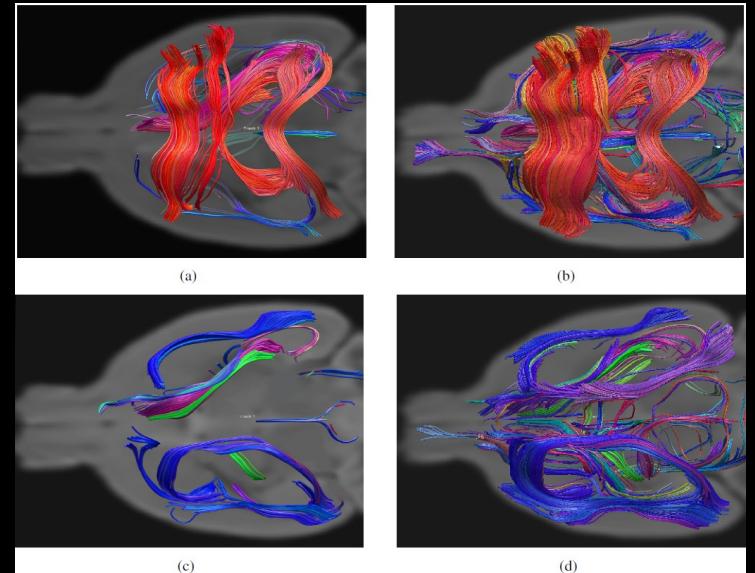


(Jahanshad et al. PNAS 2013)

(Deco et al. Nature Review 2016)

# Healthy subjects vs Patients differences

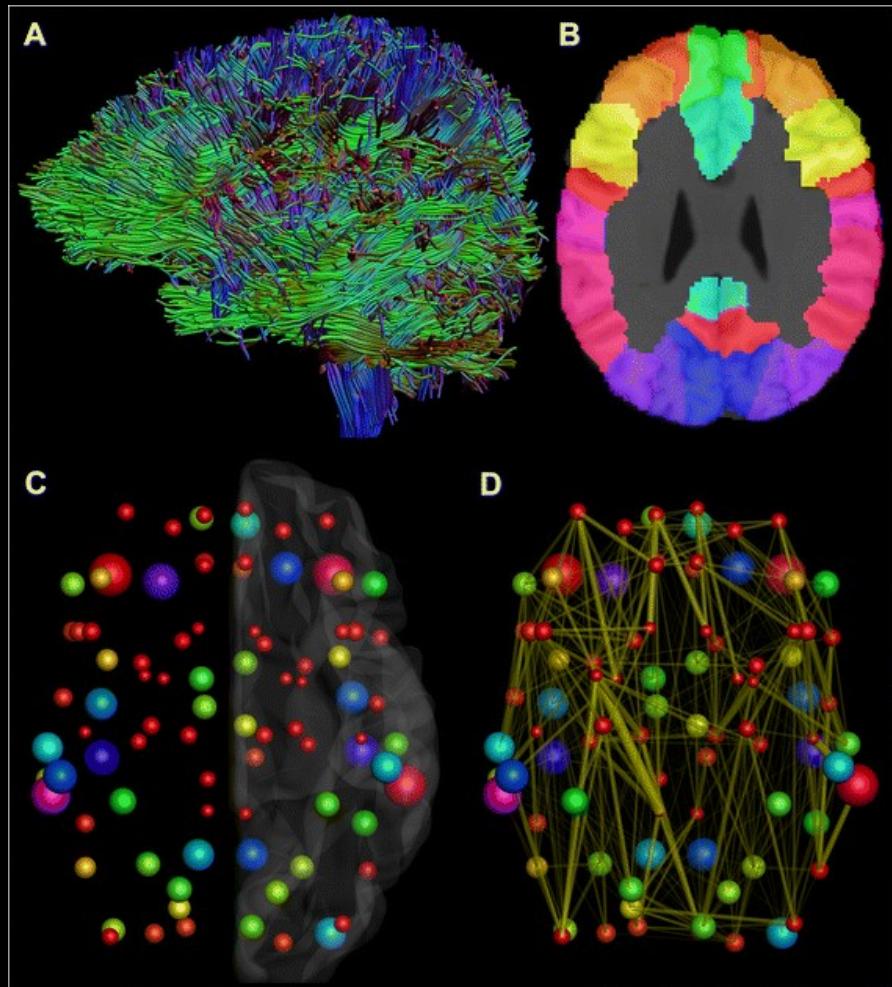
- Statistical tests can find local difference across populations.
- We can go back to see the original neuronal fibers



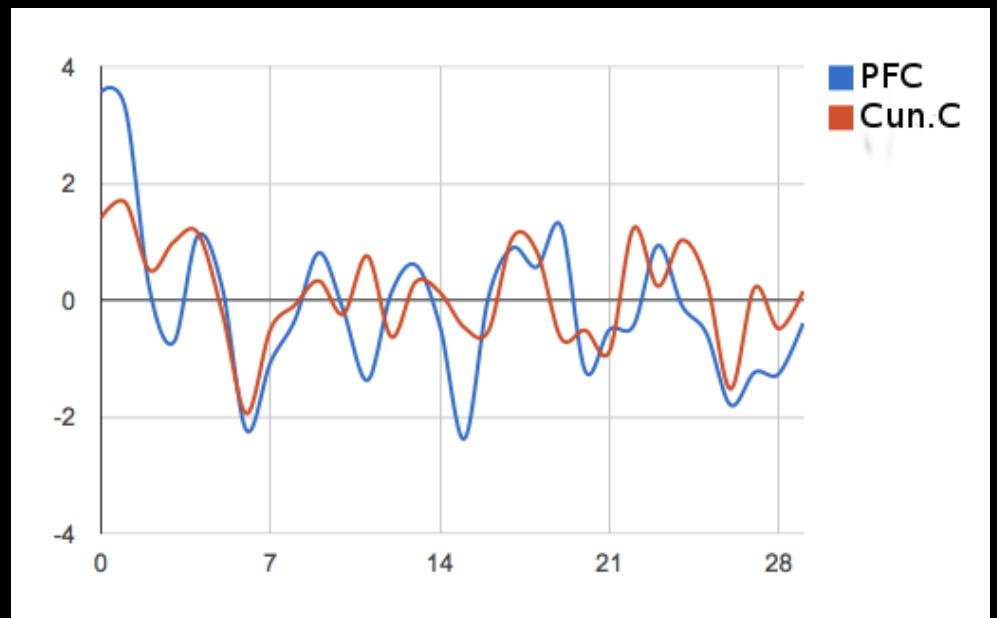
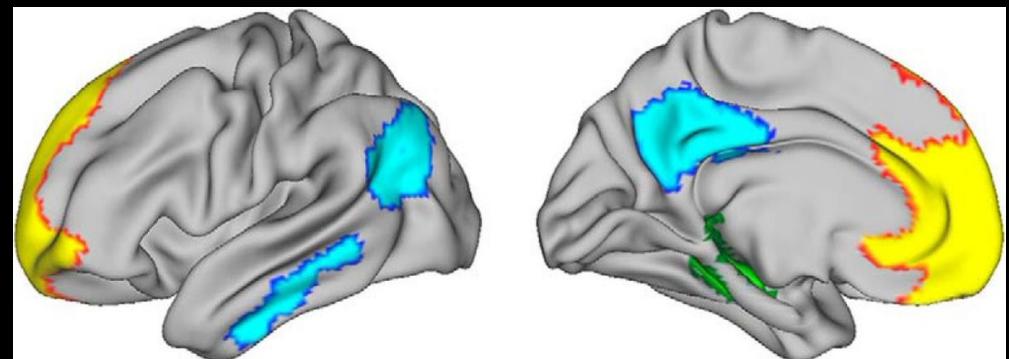
# Structural vs Functional

Friday tutorial

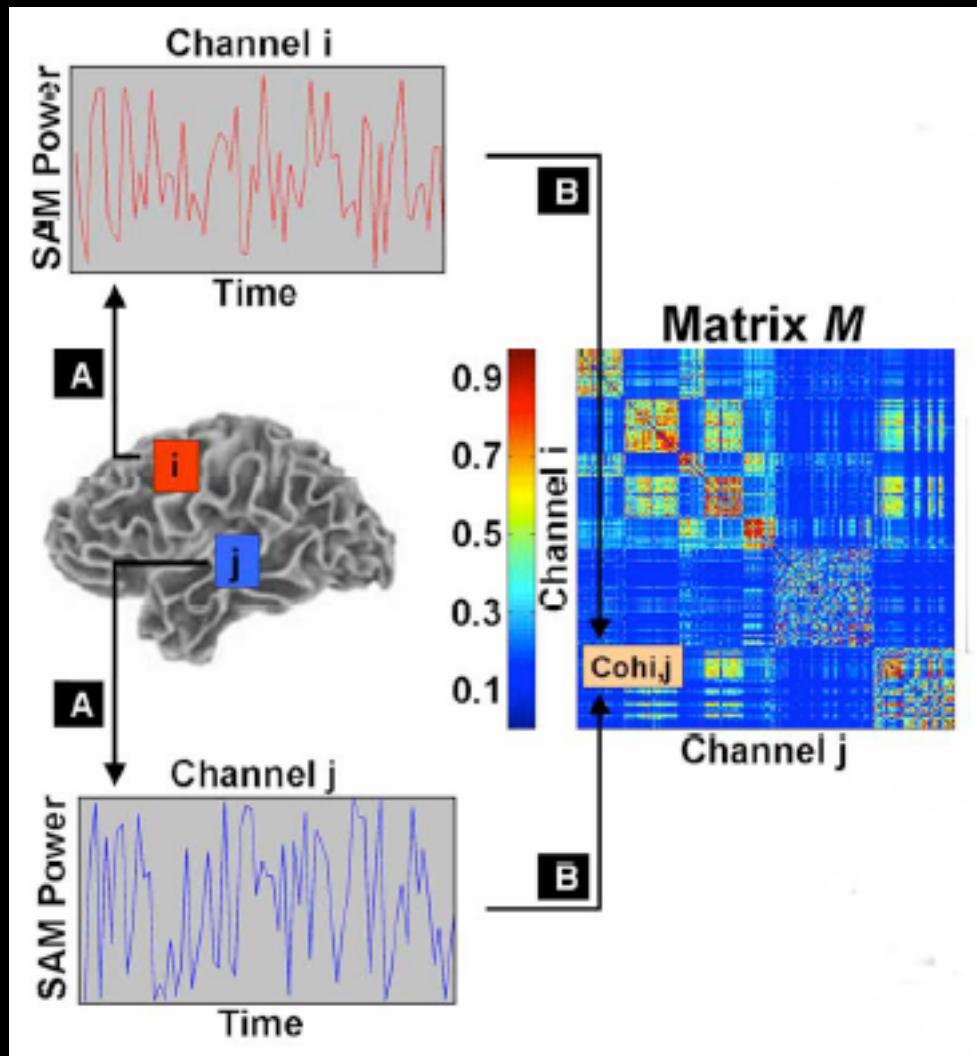
Hackathon Project  
(and online poll)



(Roine et al. Molecular Autism 2015)



# Functional Connectivity



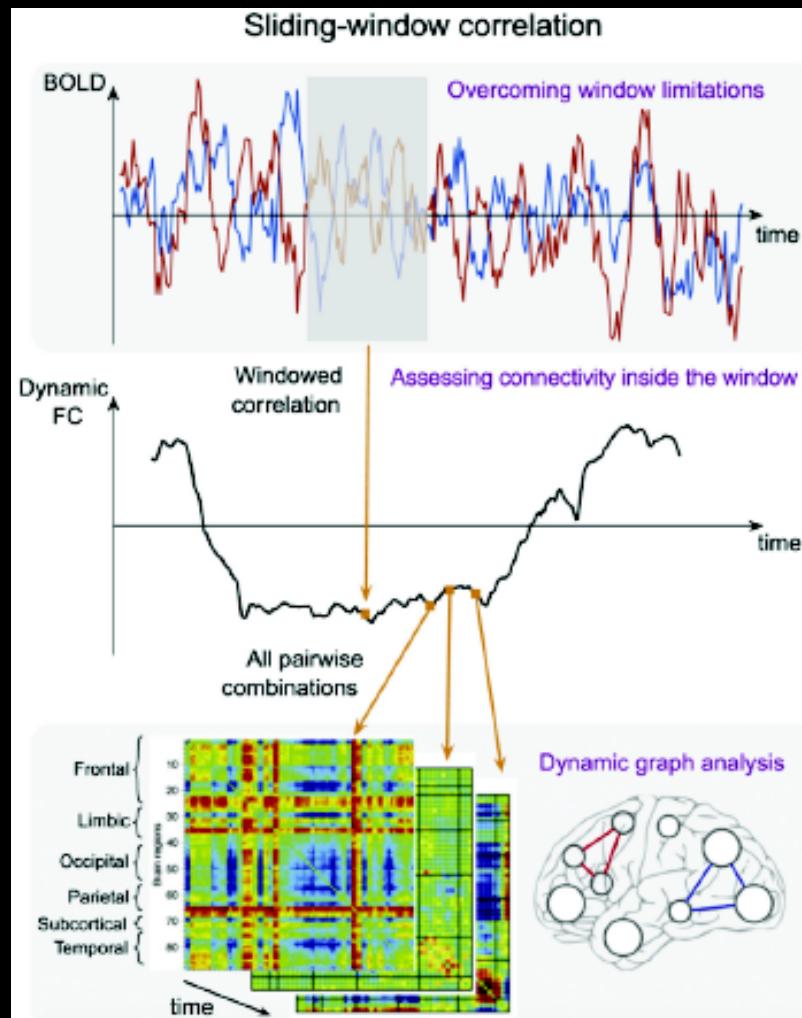
The easiest way is with Pearson correlation (a pairwise measure of association):

$$\rho_{X,Y} = \frac{\text{cov}(X, Y)}{\sigma_X \sigma_Y}$$

This is just the iceberg tip:

- Envelope Frequency response corr.
- Wavelet
- Corr. post-ICA
- Etc...

# Dynamical Functional Connectivity

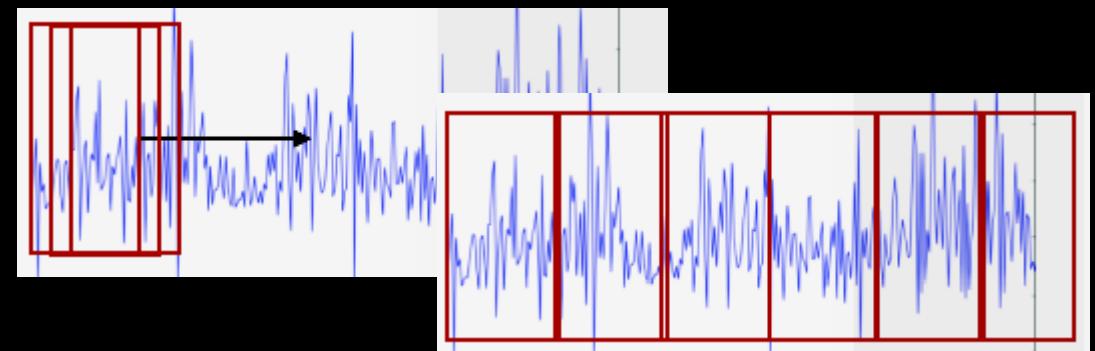


(Sakoğlu et al. MR Materials 2010)

Analysis of the temporal patterns in functional connectivity with use of a sliding window.

Widnowing choices matters:

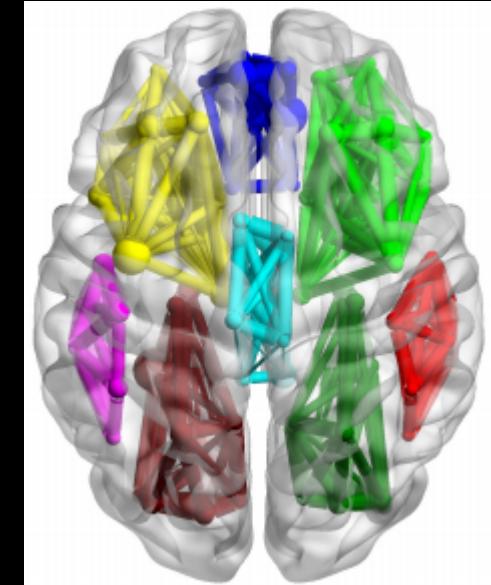
(Hindriks et al. NeuroImage 2016).



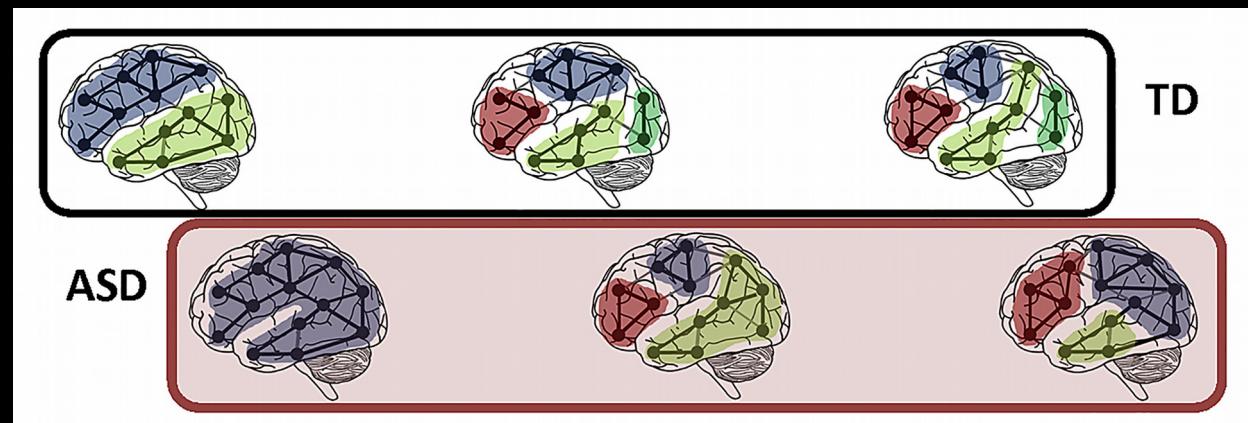
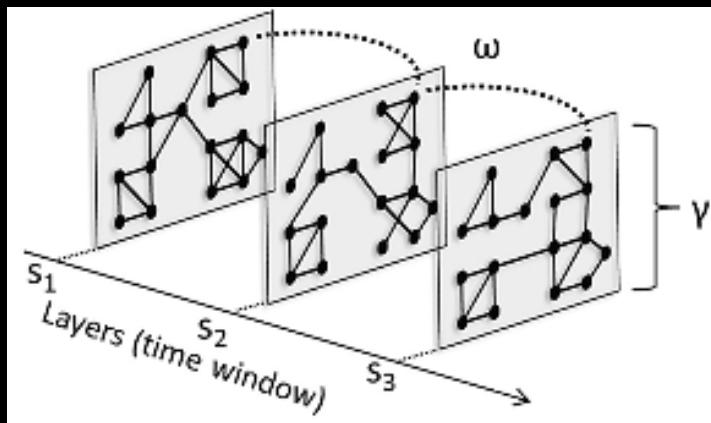
Information is only in few windows (Vergara et al. Neuroimage 2018)

# Functional Communities/Clusters

- Community modularity characterize the fundamental organization of human brain functional connectivity during learning (Bassett et al. PNAS 2011).
- How neural units cluster into densely interconnected groups can provide coordinated activities such as perception, action, and adaptive behaviors (Meunier et al. Frontiers 2010).
- This can also be studied from dynamical functional connectivity (Braun et al. Neuron 2018):

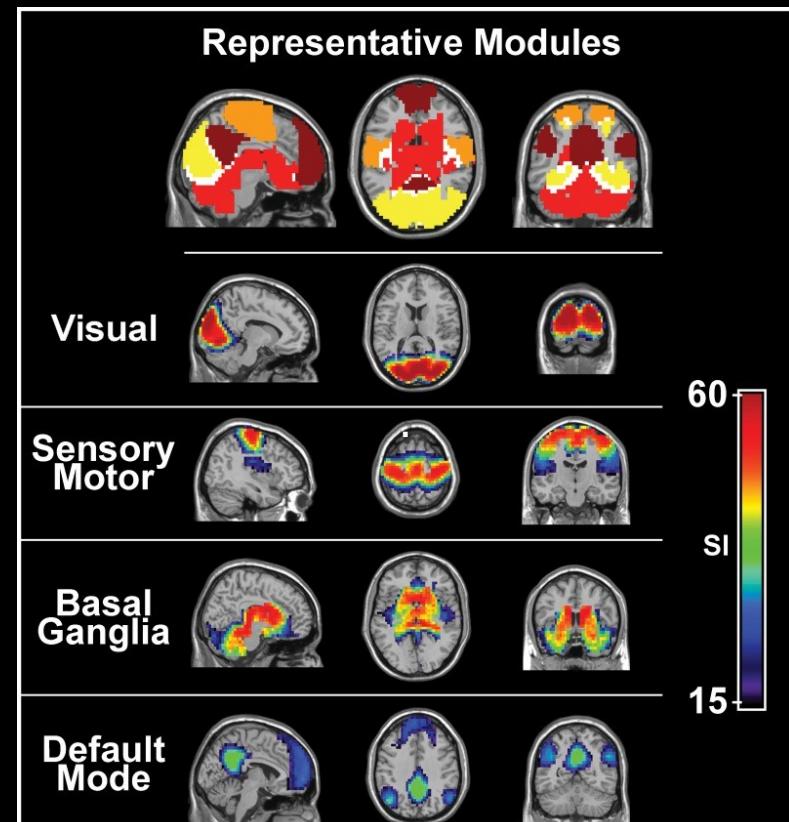


(Crimi et al. MICCAI 2016)



# Resting-State FMRI

- “Spontaneous fluctuations at rest” (Biswal et al. MR Med.1995)
- Physiology: **Fundamental activities of the conscience, attention...** (infinite literature), e.g. DMN activates when individuals focus on internal tasks such as daydreaming.
- Physics point of view: The effect of oscillations on the cortex given by **spatial** harmonics (generalization of FFT) (Atasoy et al. Nature comm.2016).
- Mixed point of view: RS oscillatory cortical networks emerge from interplay of excitation (glutamatergic principal cells) and inhibition ( $\gamma$ -aminobutyric acid GABAergic interneurons) (Isaacson et al. Neuron 2011).



(Moussa et al. PlosOne 2012)

# Brainhack Project

Given Resting State fMRI

1) Impact of windowing (nice to have, let's start with non-overlapping)

2) Community detection in  
Dyn.Func. Connectome  
(some code exist in Matlab but not Python).

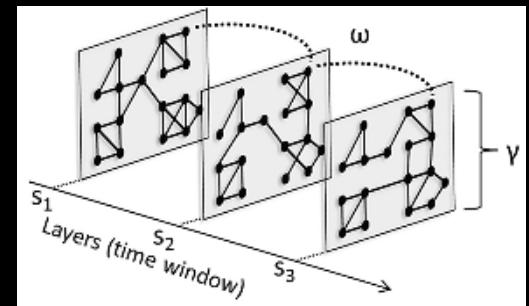
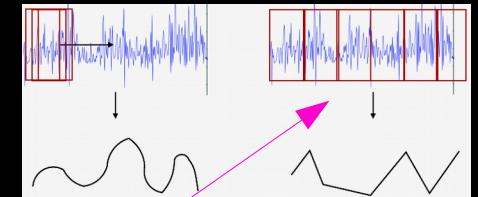
3) Compare (t-test, SVM, other machine learning...)

1 disease against healthy people  
(or 1 disease against another as Autism vs Schizophrenia)

4) Put everything on Github

Available data:

- Brain tumor patients with and without aphasia (non-distributable).
- Alzheimer patients vs Healthy Elderly or vs MCI (to be preprocessed).
- Schizophrenia patients vs Healthy Control subjects.
- Autism Spectrum Disorder vs typically developing subjects.



# Catch me up

- [alessandro.crimi@usz.ch](mailto:alessandro.crimi@usz.ch)
- @Dr\_alex\_crimi
- <https://github.com/alecrimi/dyfunconnclustering.git>

See you on Friday for the tutorial !

Answer the poll about fMRI pre-processing!

Have installed:

Python, Numpy/Scipy, Nibabel, SkLearn

