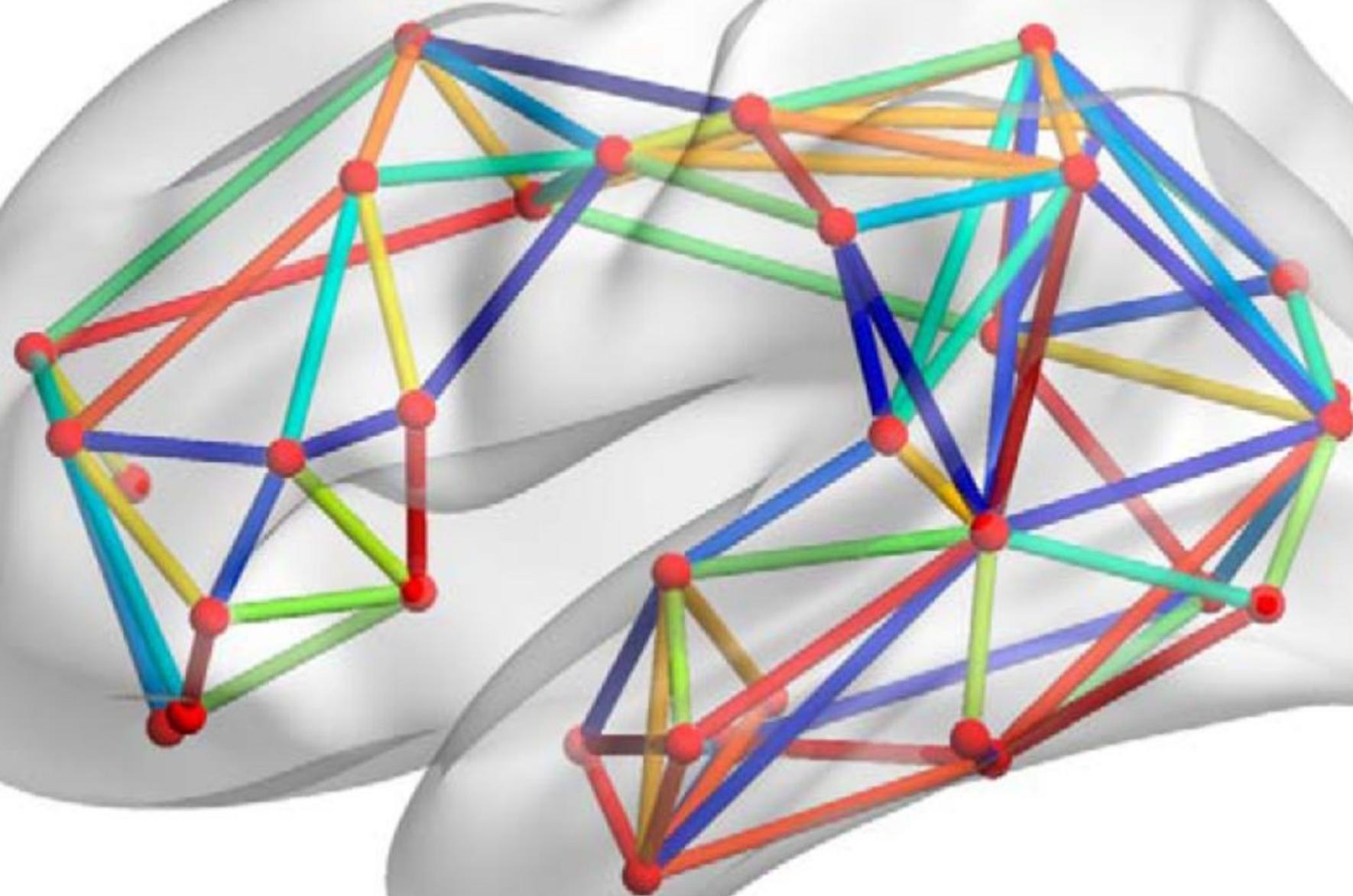


Dynamical Functional Connectivity

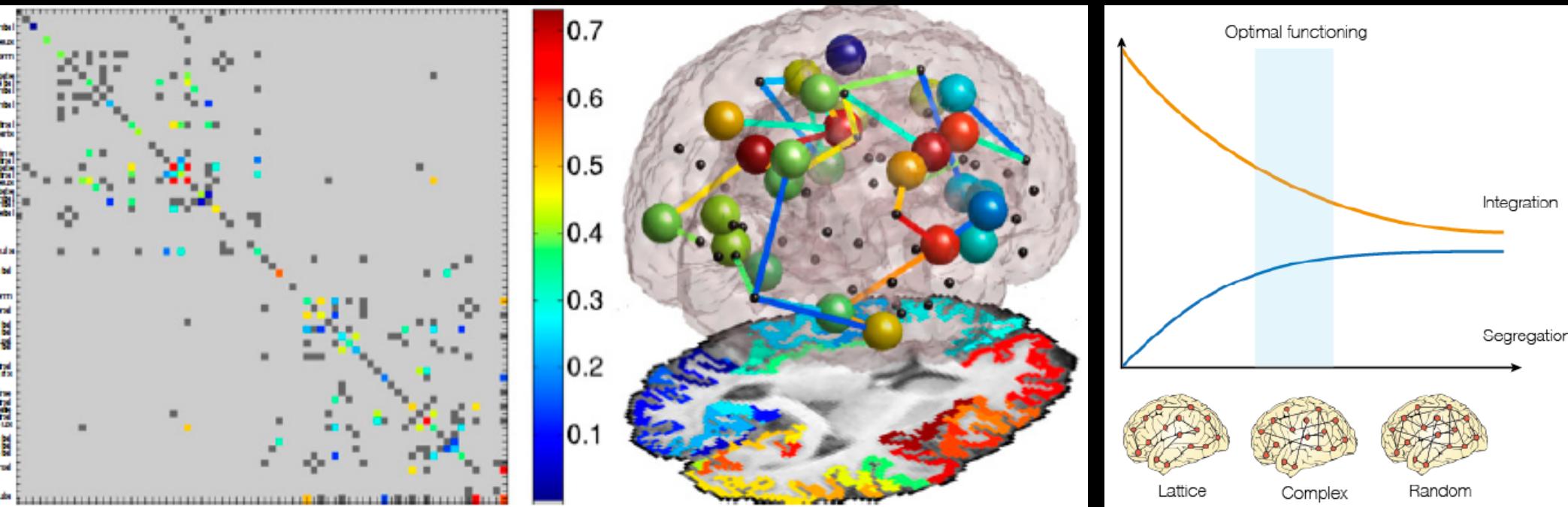
Dr. Alessandro Crimi

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

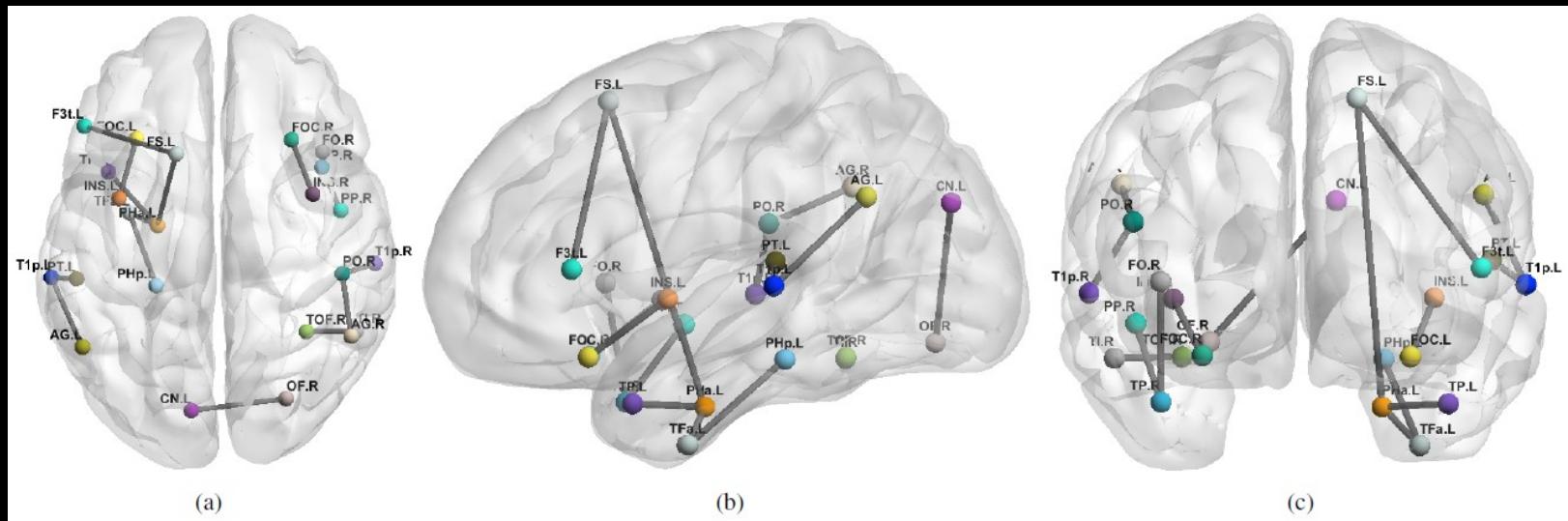
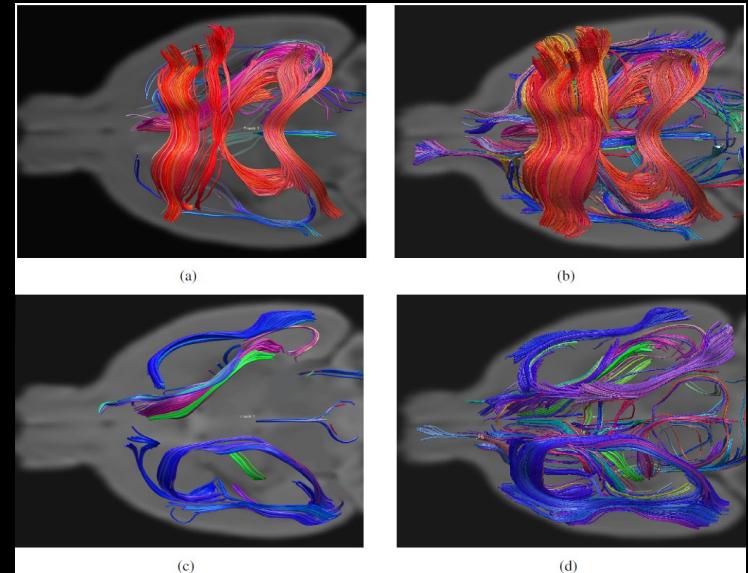


(Jahanshad et al. PNAS 2013)

(Deco et al. Nature Review 2016)

Healthy subjects vs Patients differences

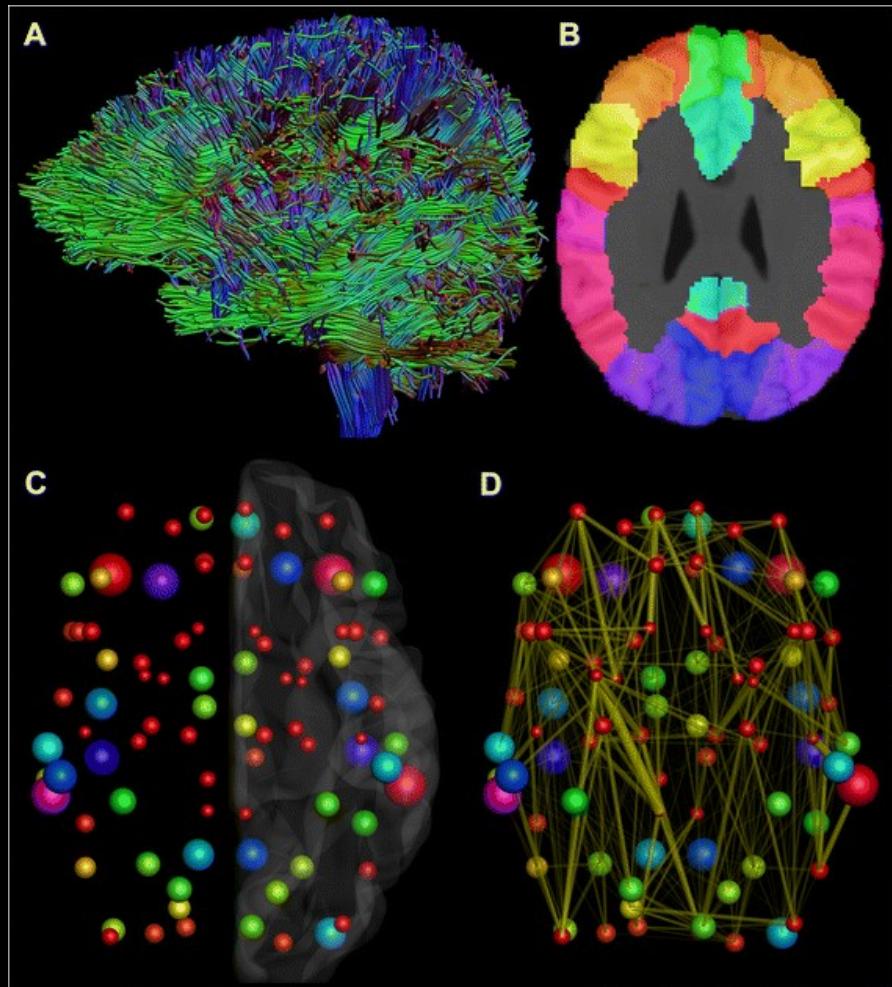
- Statistical tests can find local difference across populations.
- We can go back to see the original neuronal fibers



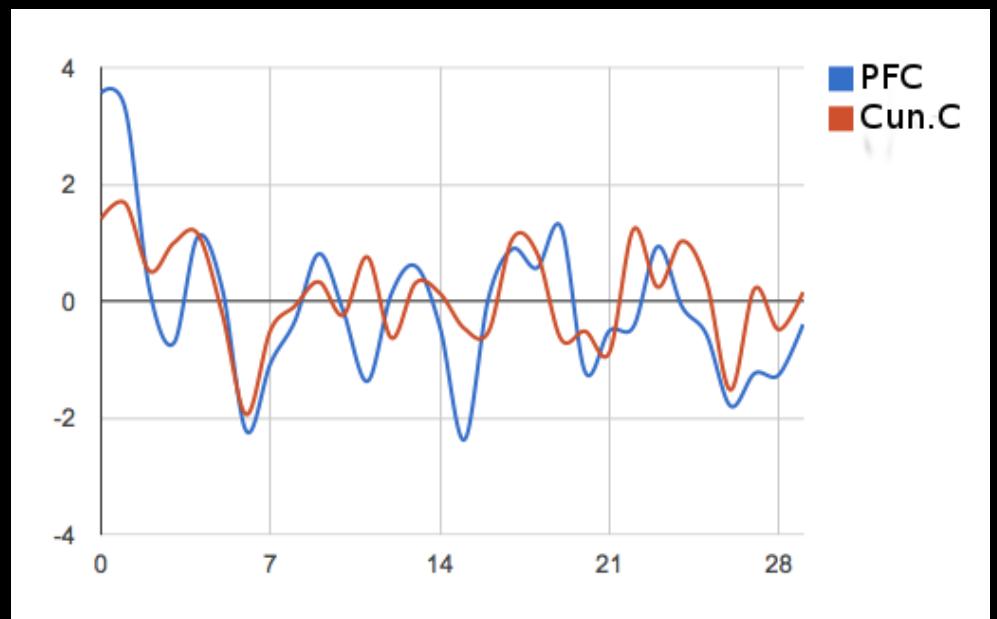
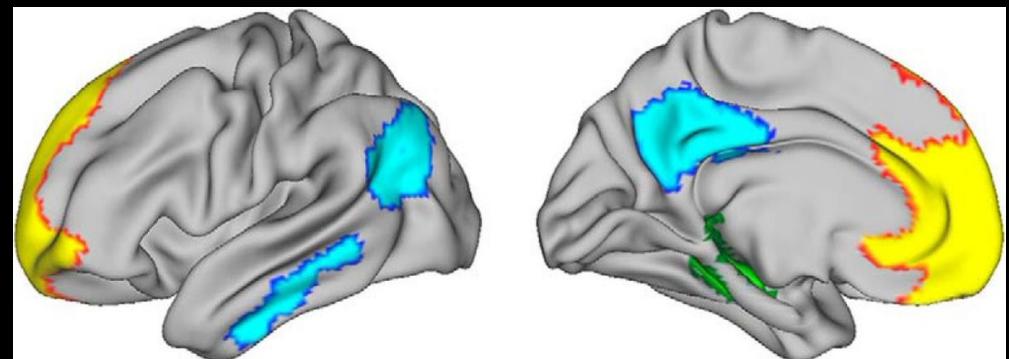
Structural vs Functional

Friday tutorial

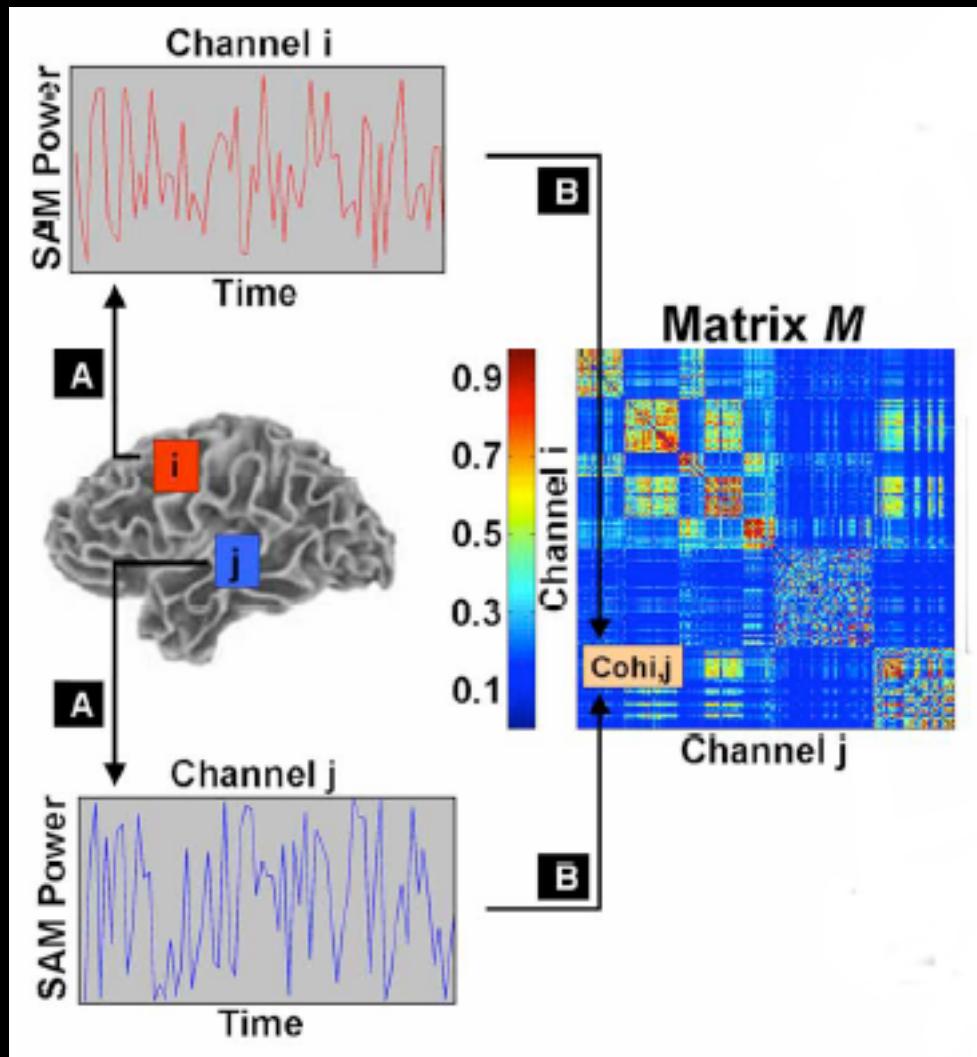
Hackathon Project
(and online poll)



(Roine et al. Molecular Autism 2015)



Functional Connectivity



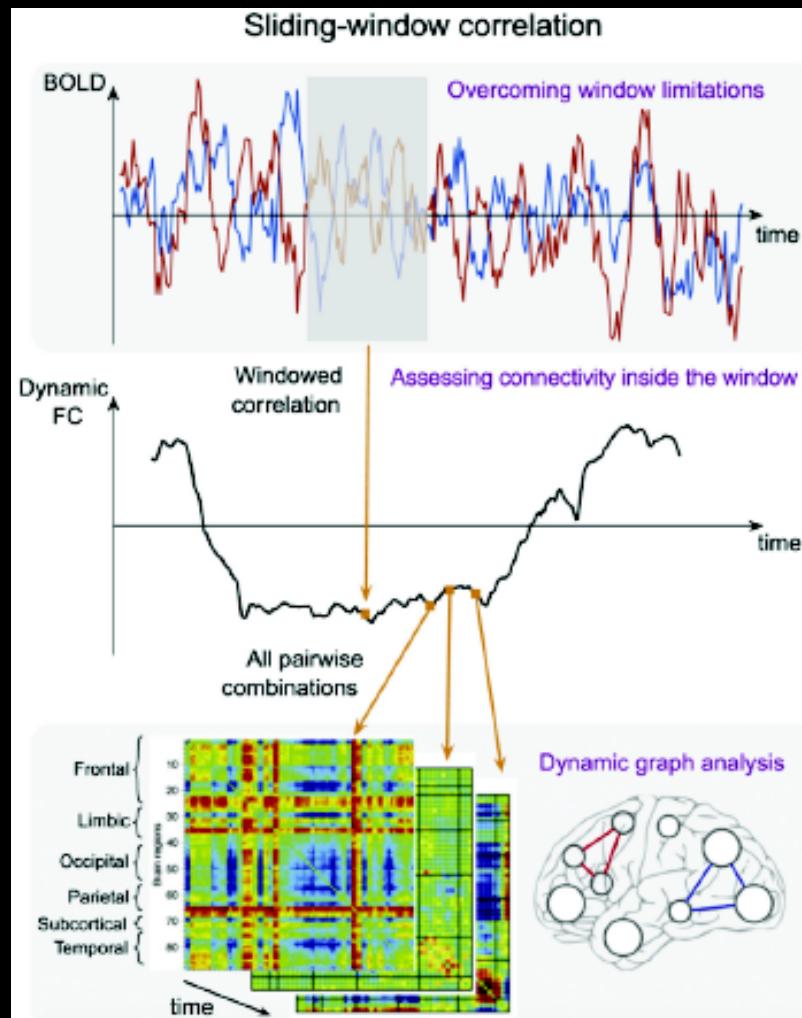
The easiest way is with Pearson correlation (a pairwise measure of association):

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

This is just the iceberg tip:

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

Dynamical Functional Connectivity

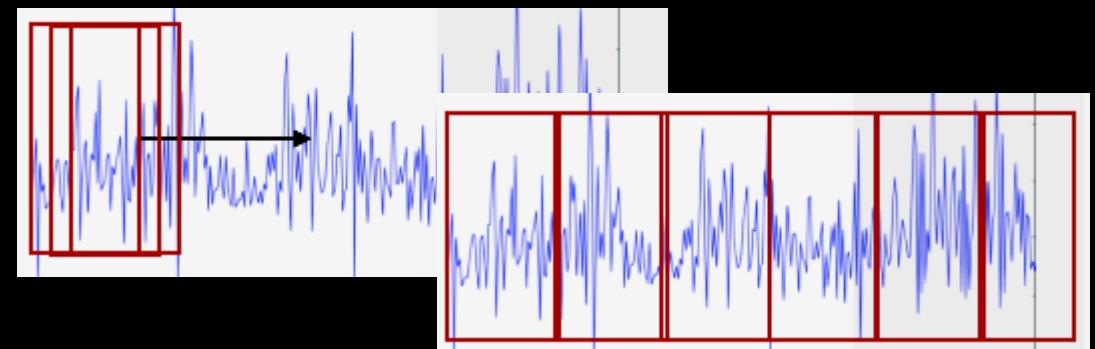


(Sakoğlu et al. MR Materials 2010)

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

Widnowing choices matters:

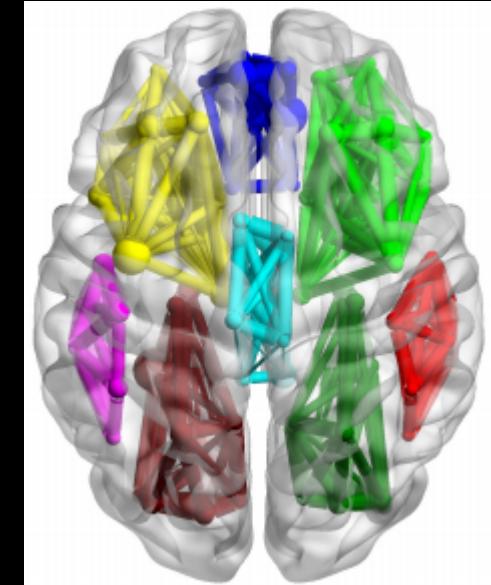
(Hindriks et al. NeuroImage 2016).



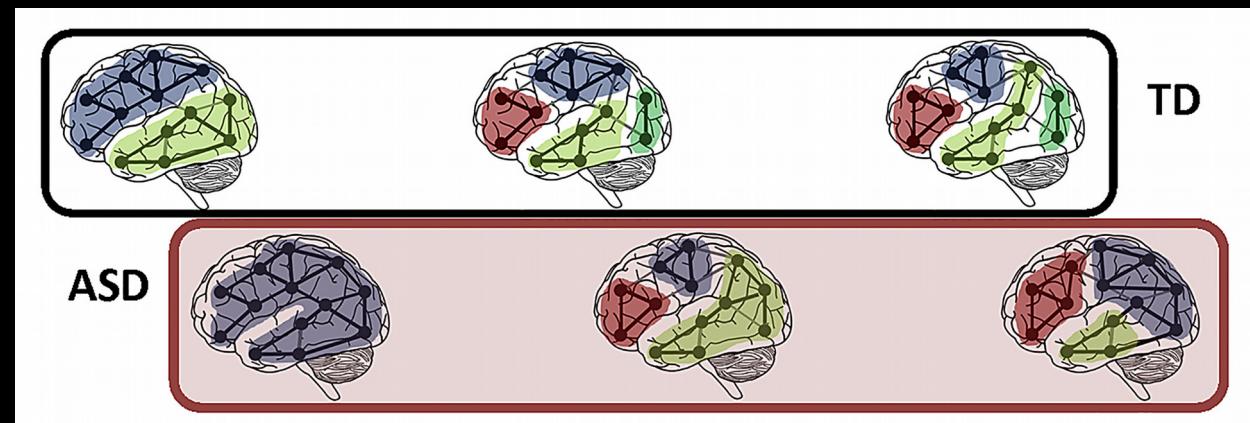
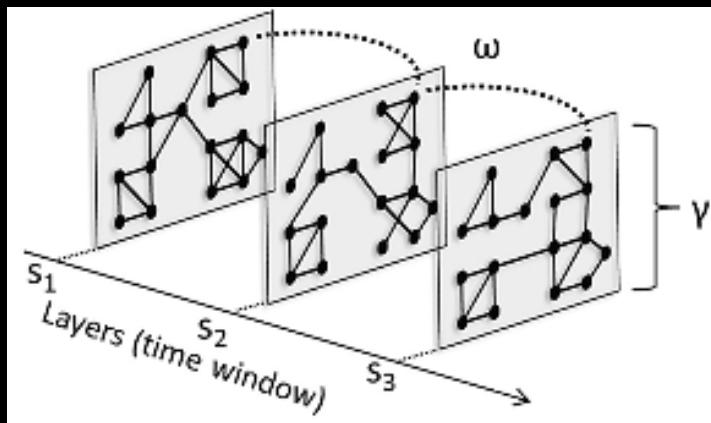
Information is only in few windows (Vergara et al. Neuroimage 2018)

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):

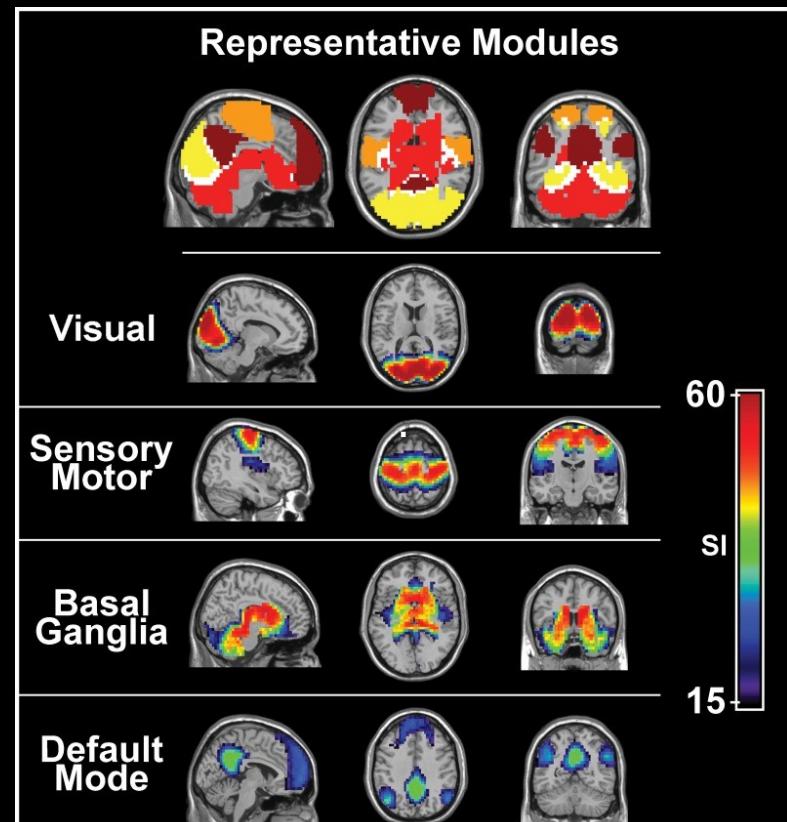


(Crimi et al. MICCAI 2016)



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 (γ -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).

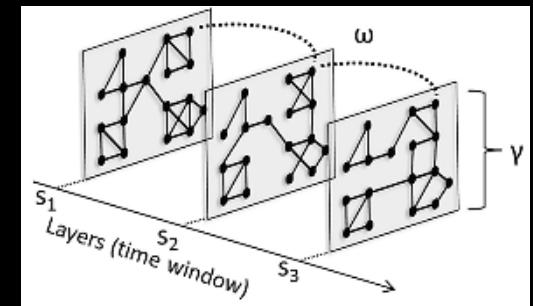
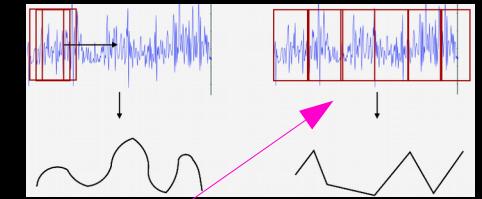
3) Compare (t-test, SVM, other machine learning...)

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
- @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

