



**IMT Atlantique**

Bretagne-Pays de la Loire  
École Mines-Télécom

# WASAA – Practical machine learning on brain signals 1

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January 2023

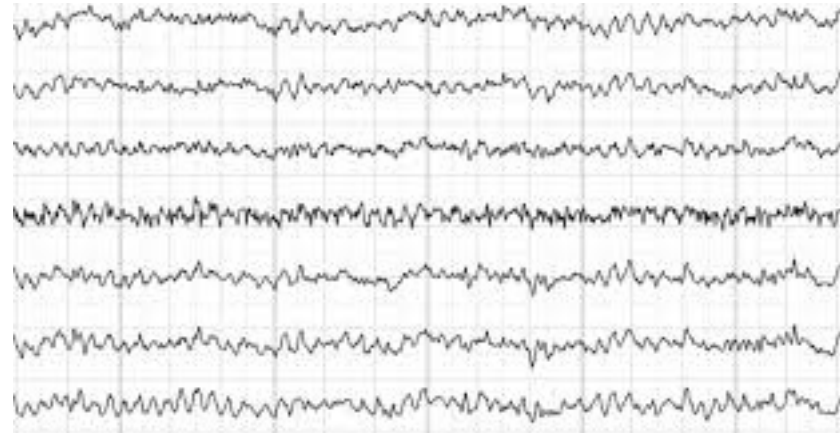
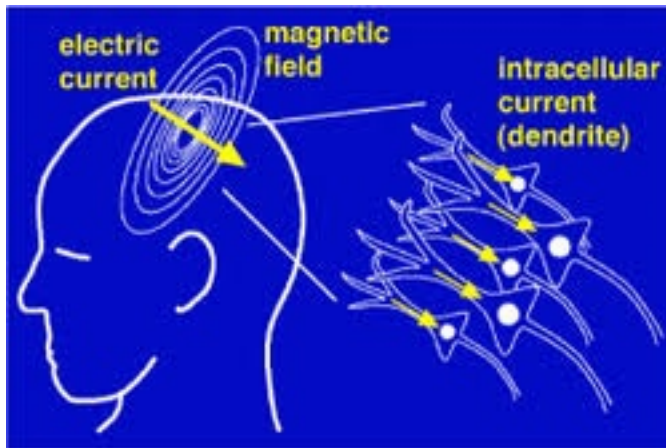
# Agenda

1. Neuroimaging techniques
2. Brain Connectivity using MRI
3. Lab session

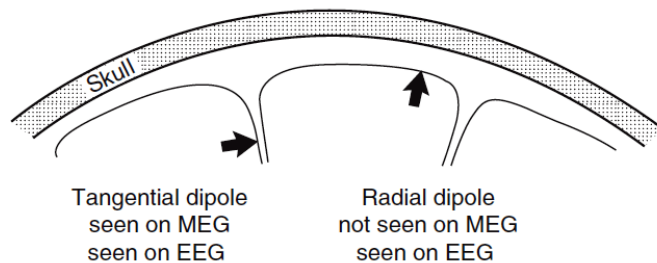


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- ▶ Electroencephalography (EEG)
- ▶ Electrical current measured at the scalp level
- ▶ Up to 256 electrodes at 1000 Hz
- ▶ Many sources of artifacts

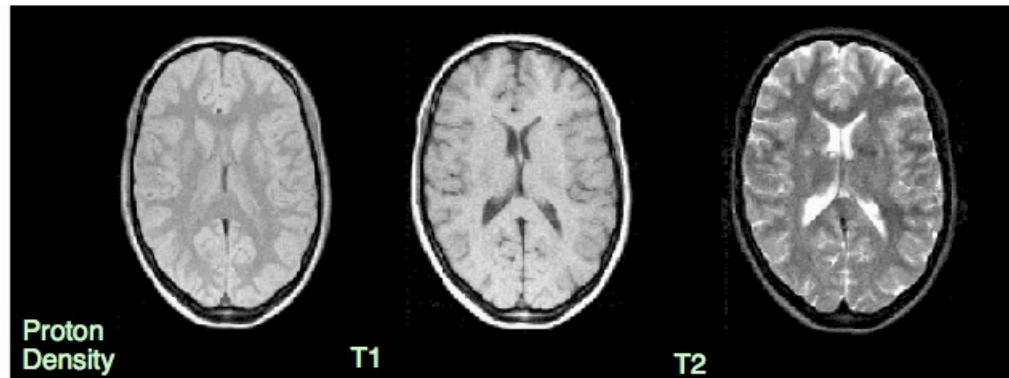


- ▶ Magnetoencephalography (MEG)
- ▶ Magnetic field resulting from neuronal activity
- ▶ Enables better source localization
- ▶ Extremely costly

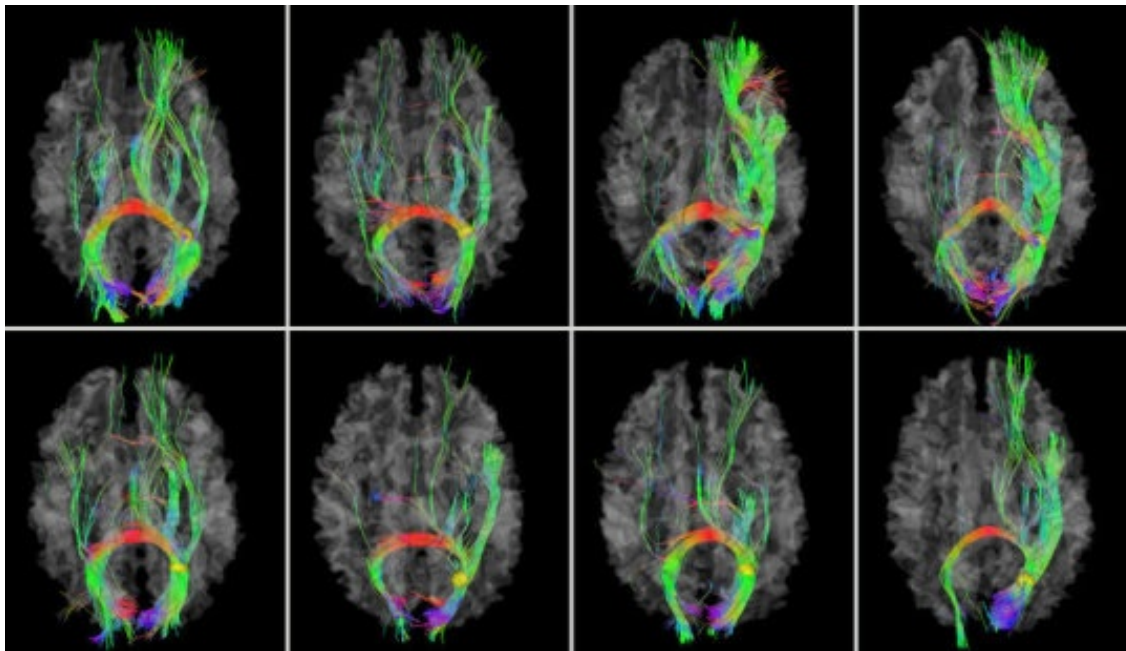


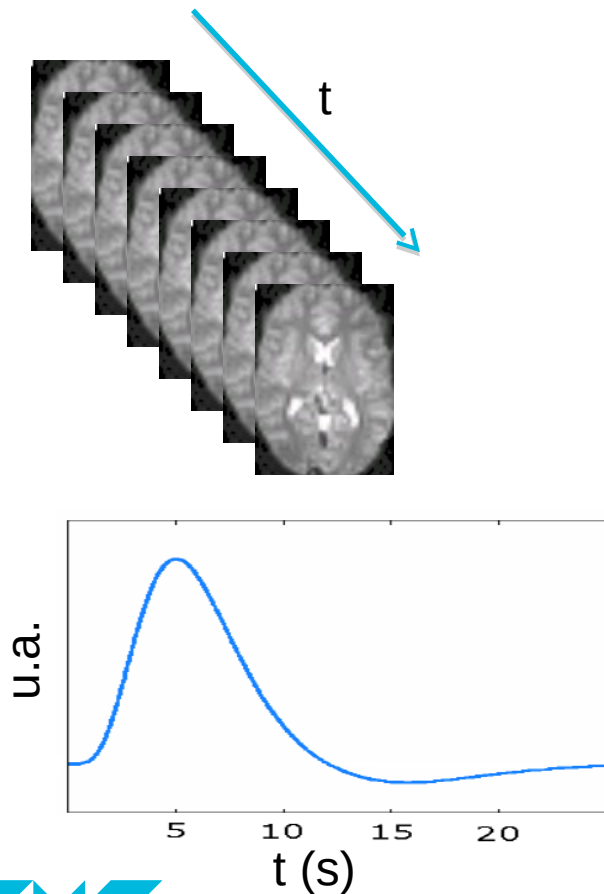


- ▶ 3D brain images -> volumes
- ▶ Different contrast types are generated w.r.t. local tissue properties
- ▶ Structural MRI, Diffusion MRI,
- ▶ Functional MRI.



- ▶ Diffusion MRI
- ▶ Contrast sensitive to the direction of water molecules present around white matter
- ▶ Can be used to estimate brain structural connectivity (fibers of white matter)

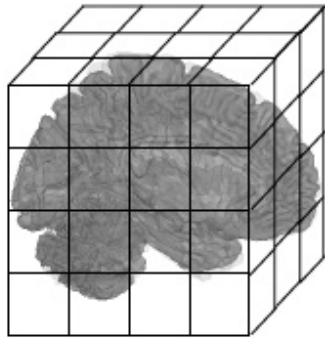




fMRI enables the study of cognitive and affective functions in the brain by an indirect estimation of brain activity

Echo Planar Imaging sequences generate a contrast sensitive to the so-called « Blood-Oxygen Level Dependent » (BOLD) signal

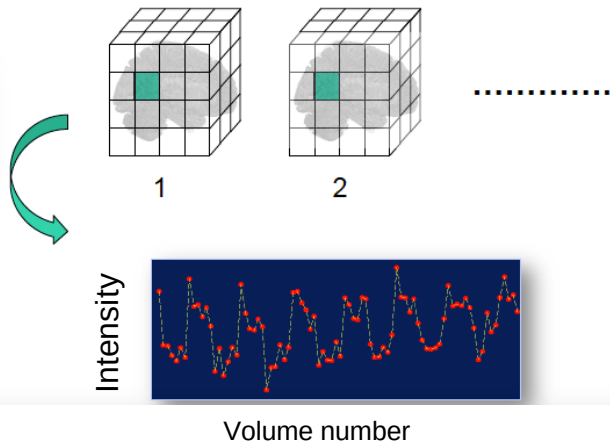
- ▶ Local loss of oxygen in hemoglobin as a result of neuronal activity – Hemodynamic response
- ▶ Subtle variations in the BOLD signal indirectly reflect brain activity (+ several seconds lag)



An acquired volume is composed of several thousand volume elements = voxels

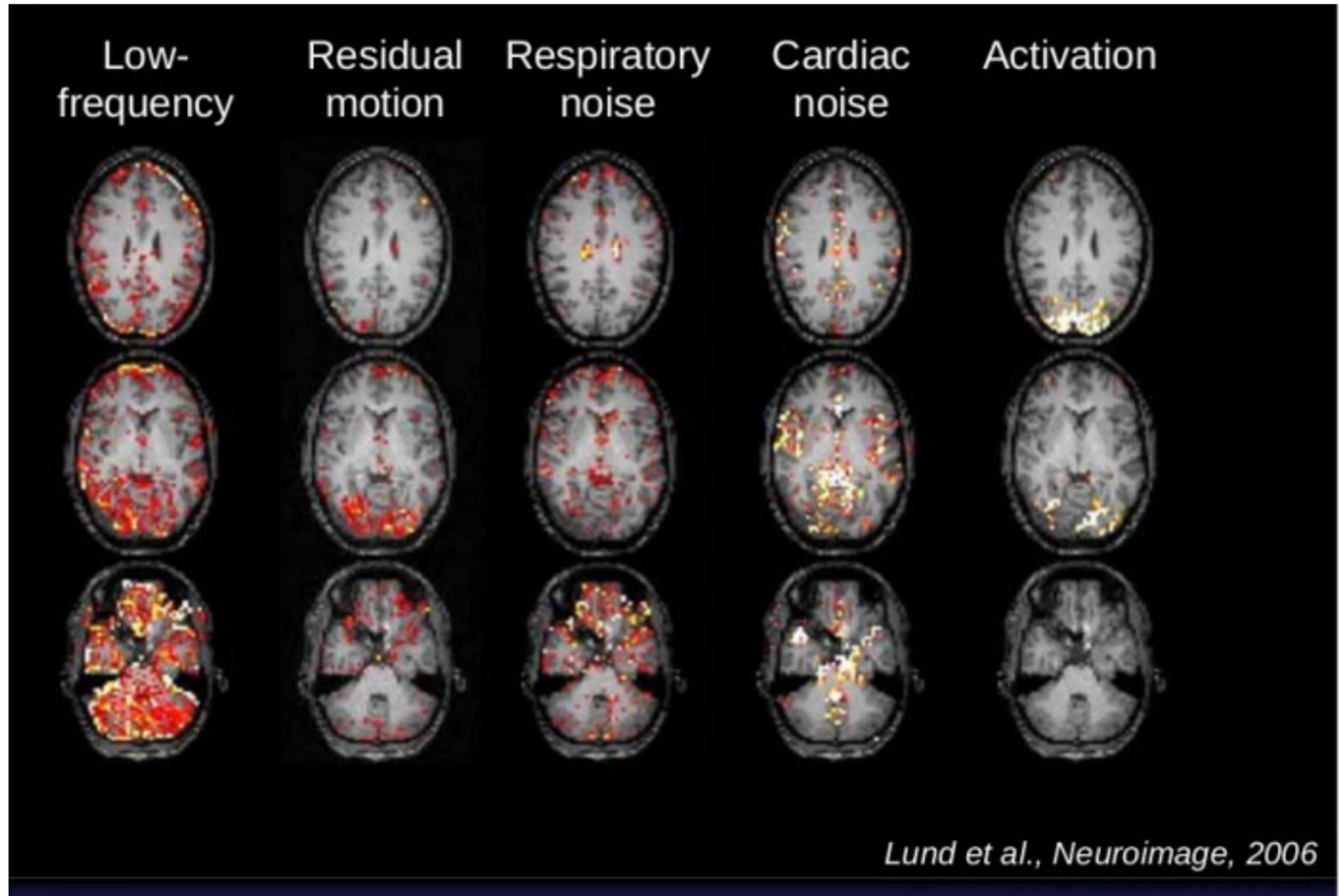
## Main features

- ▶ Voxels = 1.5 to 3 mm<sup>3</sup> cubes -> high spatial resolution
- ▶ A full volume acquired every 1 to 2 seconds -> Low temporal resolution





# Functional MRI – Artifacts (aka confounds or nuisance)



# Functional MRI - Example

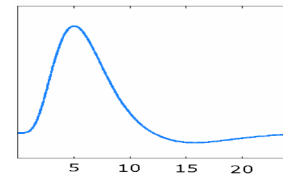
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Contrast based analysis

## Event-related design

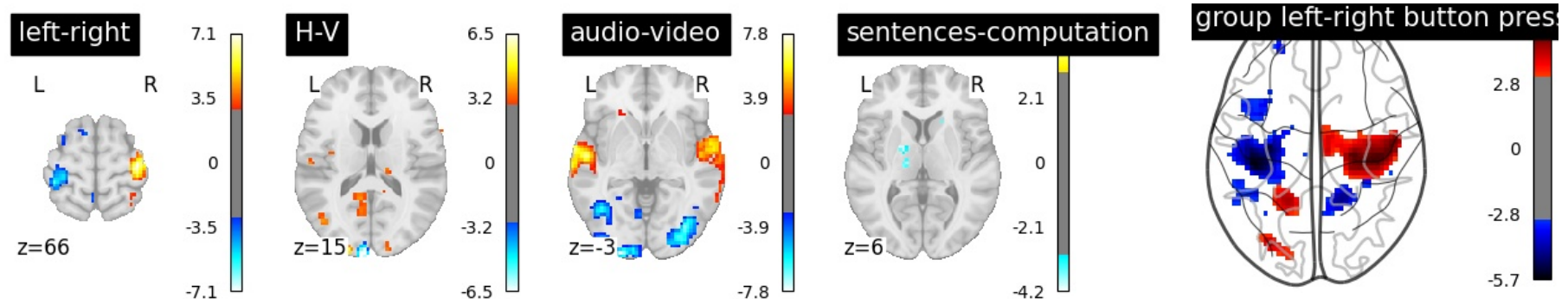
### ► 5 minutes of stimulation with 80 events of different types

- 'audio\_computation',
- 'audio\_left\_hand\_button\_press',
- 'audio\_right\_hand\_button\_press',
- 'horizontal\_checkerboard',
- 'sentence\_listening',
- 'sentence\_reading',
- 'vertical\_checkerboard',
- 'visual\_computation',
- 'visual\_left\_hand\_button\_press',
- 'visual\_right\_hand\_button\_press'

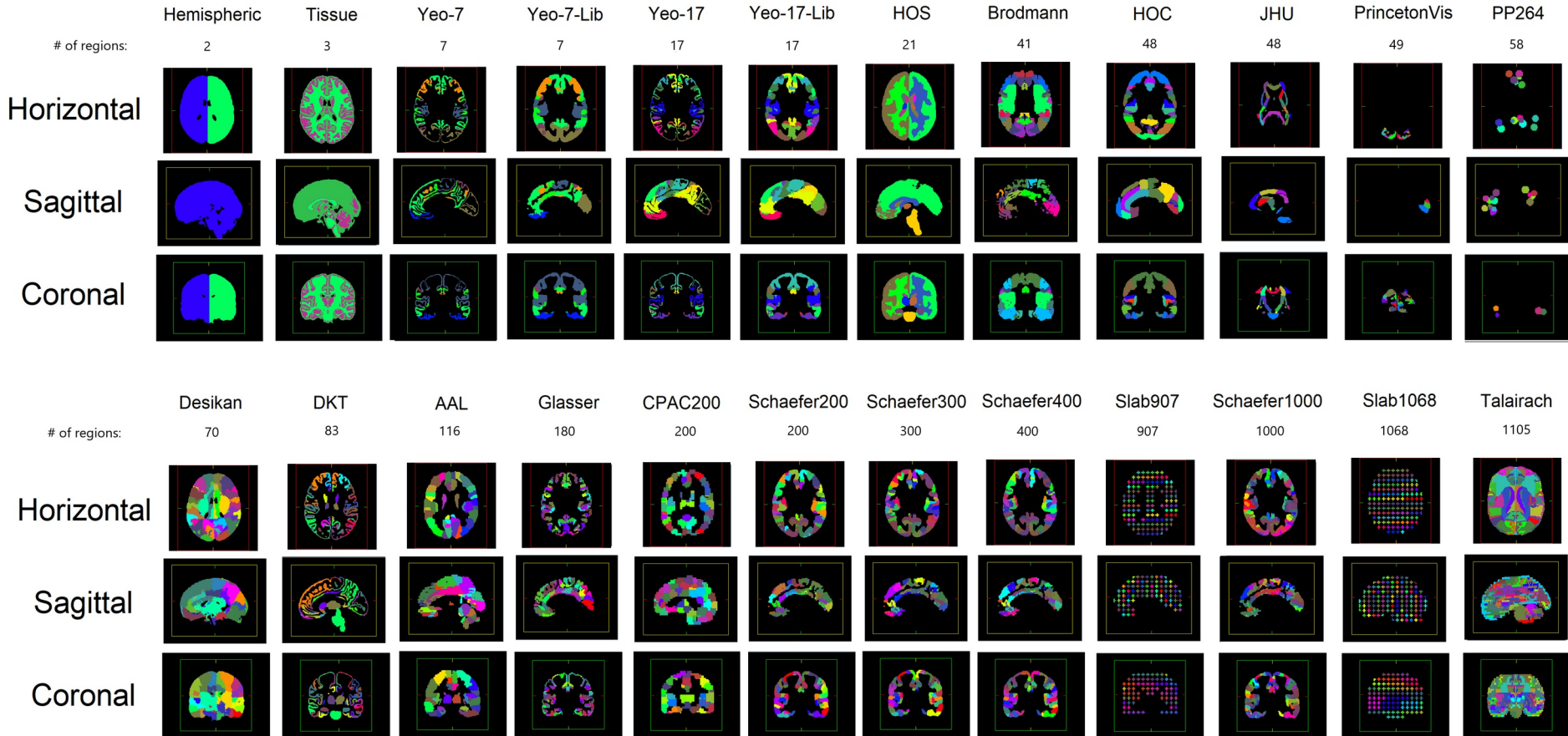


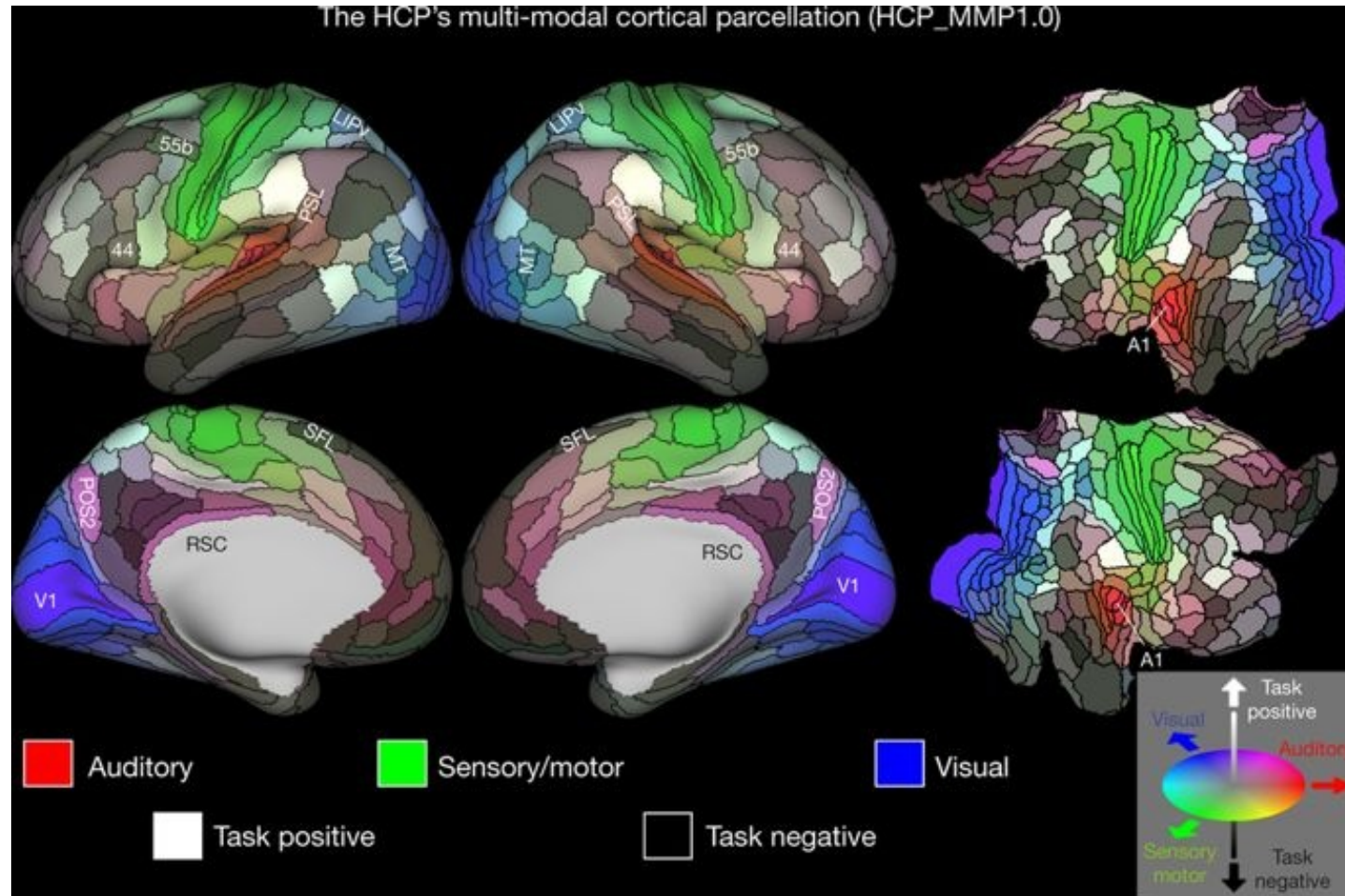
### ► Linear model of the response to each event

### ► Contrasts between model fits



Source: nilearn examples



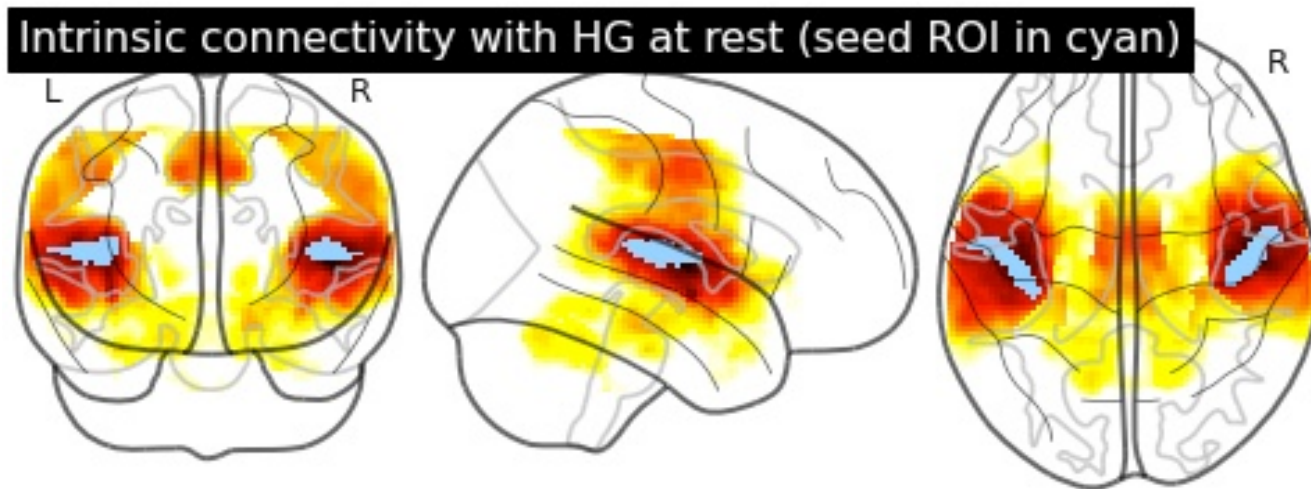


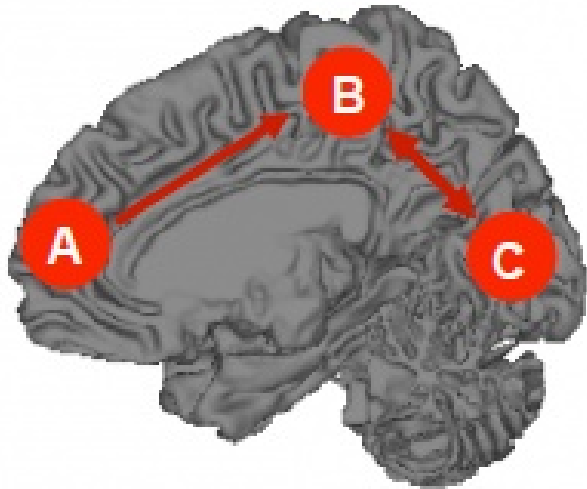
Glasser et al., 2016, Nature



“Seed-based functional connectivity”

“seed” = reference point. How similar is the rest of the brain’s activity compared to this seed ?





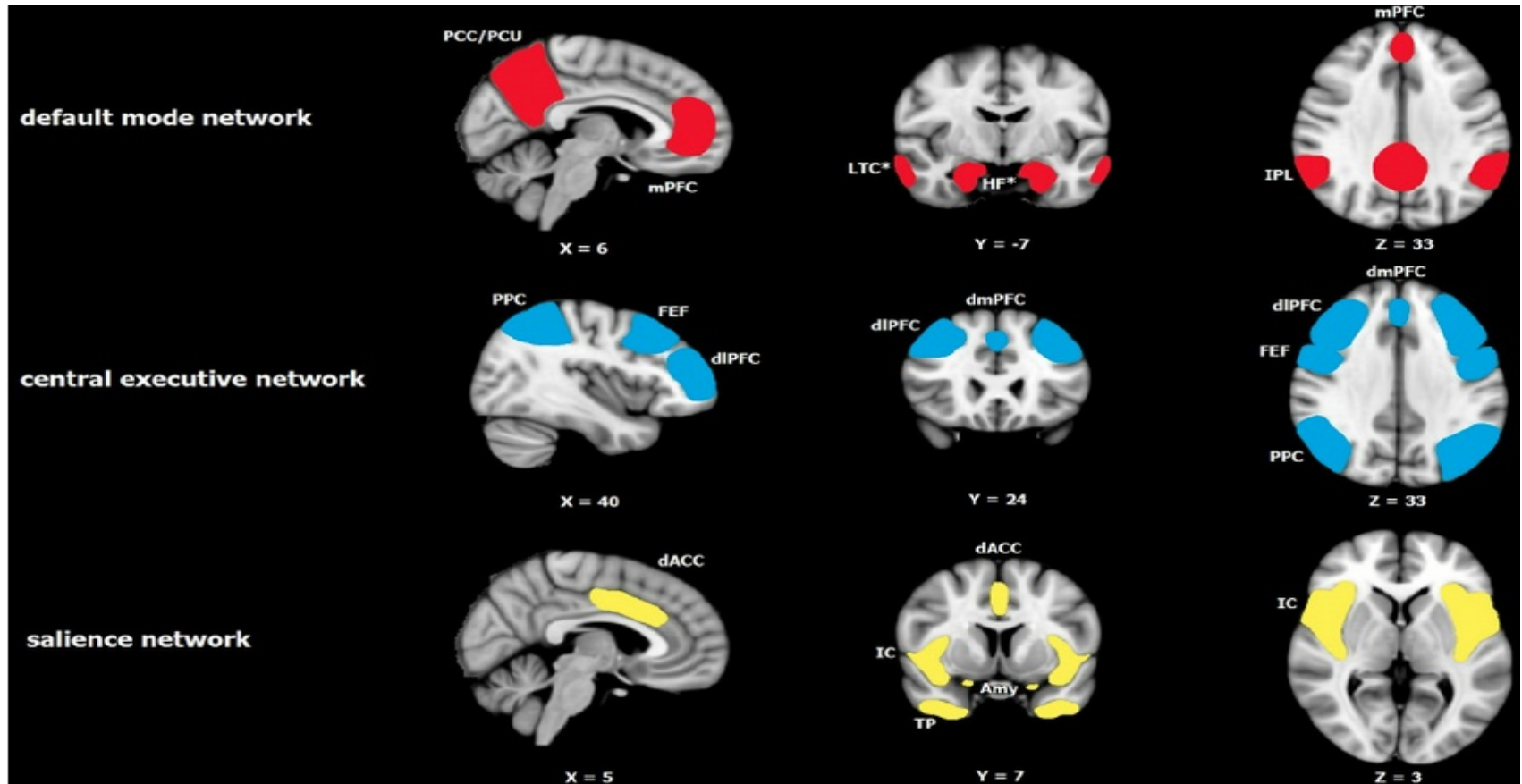
## Brain Connectivity

### A paradigm shift

Connectivity studies consider the brain as a network of regions interacting with each other, as a function of experimental parameters or subjects.

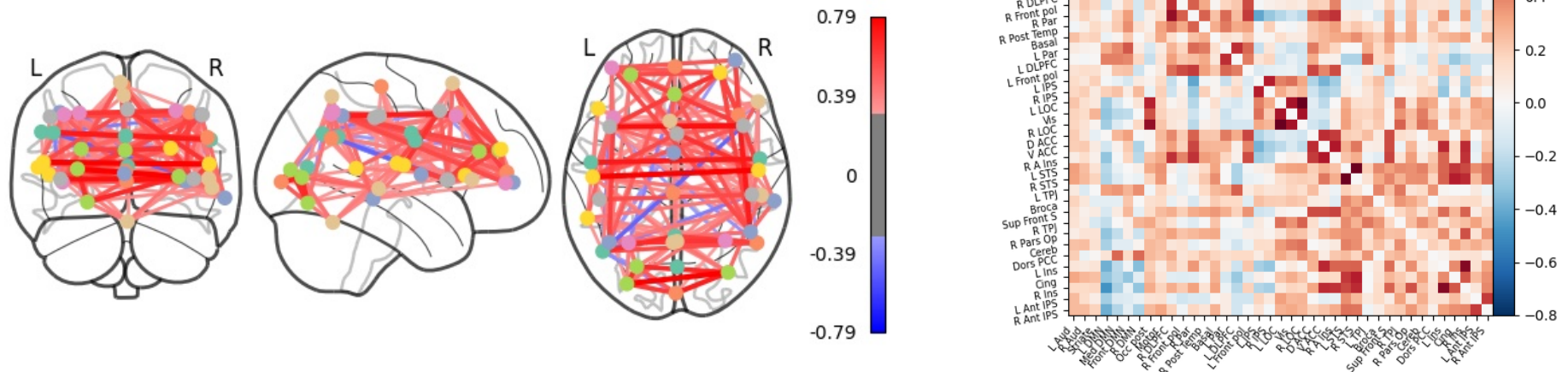
-> Graph theory for topological analysis of networks

Spontaneous networks = « resting-state functional connectivity »

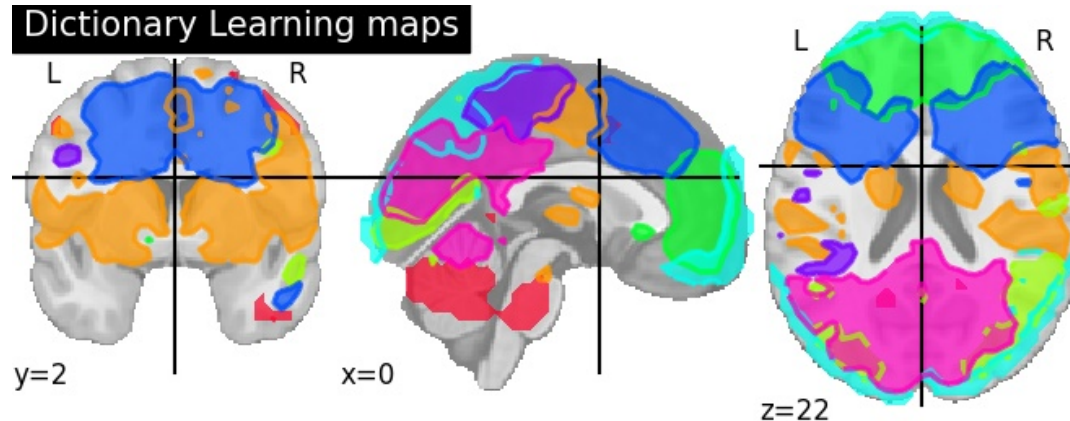


# Resting-state functional connectivity

Examples from nilearn



Dictionary Learning maps

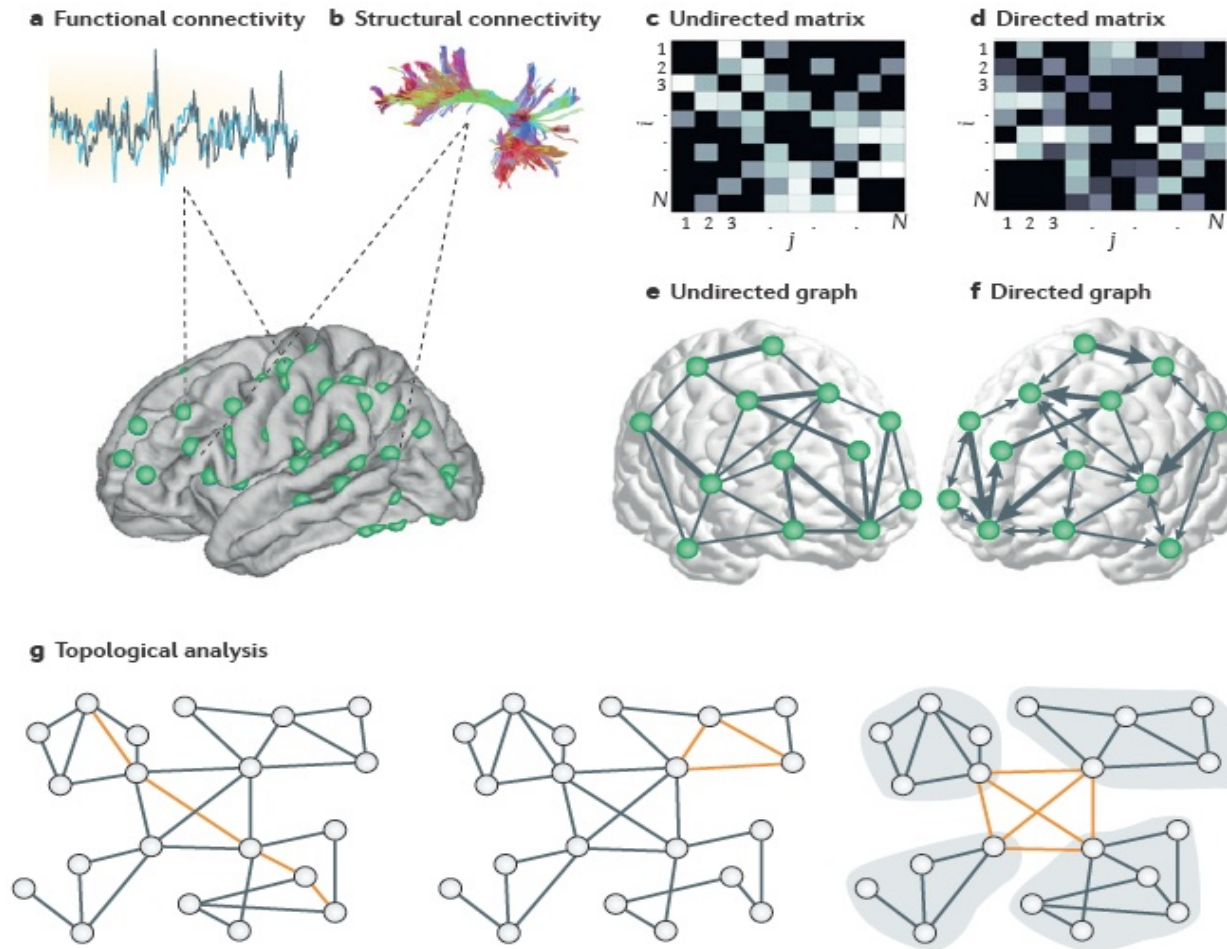




# Connectivity Graphs

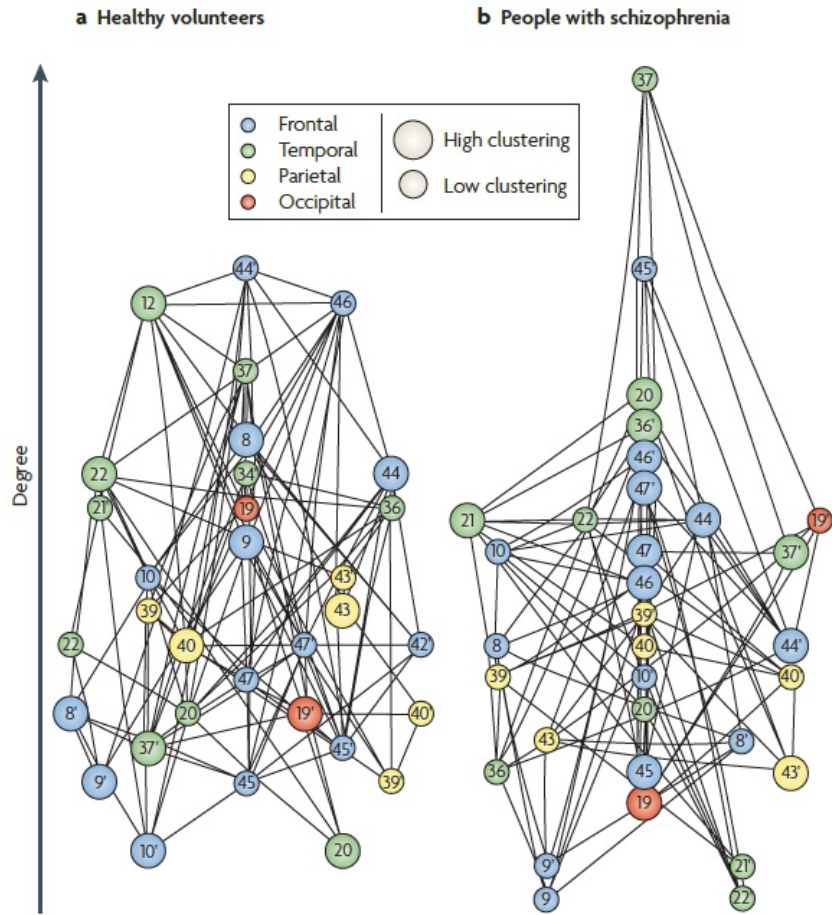
## Functional and structural connectivity

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Fornito et al. 2015  
Nature Neuro

## Example



Two examples of graph-based measures :

1 – Clustering coefficient

For each vertex, how much are neighbors connected with each other

2- Characteristic path length

The brain as a small world network ?

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# Questions?

Merci de votre attention!  
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