Whole brain effective connectivity from fMRI data

Some subtitle

Andrea Insabato

November 27th, 2017

COLUMBIA UNIVERSITY
THE ITALIAN ACADEMY
FOR ADVANCED STUDIES IN AMERICA

Whole brain connectivity

Whole brain connectivity

- Whole brain is divided in ROIs (parcellation)

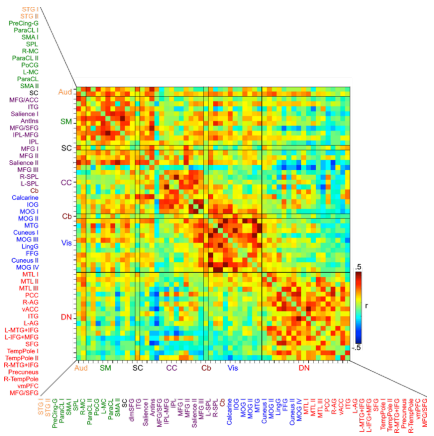
Whole brain connectivity

- Whole brain is divided in ROIs (parcellation)
- Average activity in each ROI

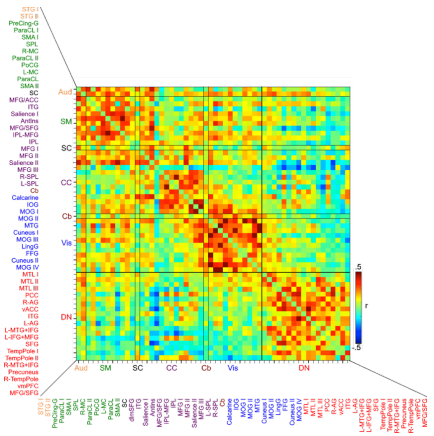
Whole brain connectivity

- Whole brain is divided in ROIs (parcellation)
- Average activity in each ROI
- Connectivity between ROIs

Functional Connectivity (FC)

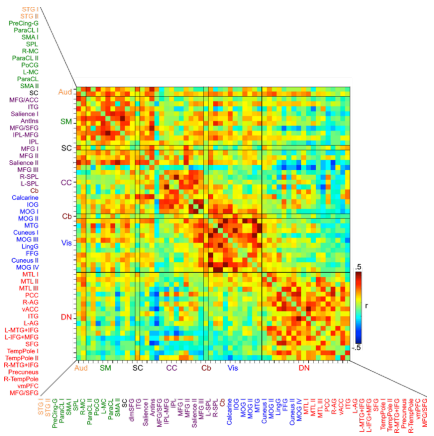


Functional Connectivity (FC)



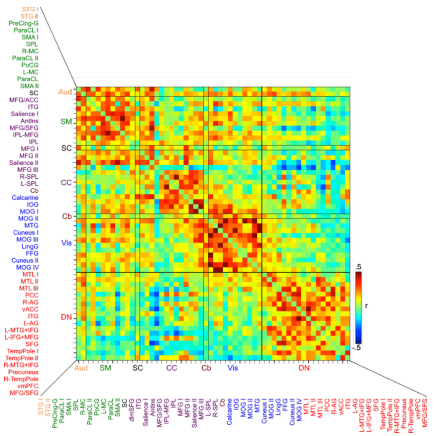
- Pearson correlation between ROIs

Functional Connectivity (FC)



- Pearson correlation between ROIs
- Dense

Functional Connectivity (FC)



- Pearson correlation between ROIs
- Dense
- Symmetric: no directionality of interactions

Effective Connectivity (EC)

Effective Connectivity (EC)

- Network model

Effective Connectivity (EC)

- Network model
- Sparse

Effective Connectivity (EC)

- Network model
- Sparse
- Asymmetric: no directionality of interactions

Outline

Outline

- Network model

Outline

- Network model
- EC based subject and condition identification

Outline

- Network model
- EC based subject and condition identification
- Estimation of model parameters

Network model

Network model

- Each node is an Ornstein-Uhlenbeck process

Network model

- Each node is an Ornstein-Uhlenbeck process
- $dx_i(t) = [-\frac{x_i(t)}{\tau_i} + \sum_{j \neq i} C_{ij} x_j + \eta_i]dt + dB_i; \qquad dB_i \sim \mathcal{N}(0, \sigma_i^2)$

Network model

- Each node is an Ornstein-Uhlenbeck process
- $dx_i(t) = [-\frac{x_i(t)}{\tau_i} + \sum_{j \neq i} C_{ij} x_j + \eta_i]dt + dB_i; \qquad dB_i \sim \mathcal{N}(0, \sigma_i^2)$

Characterization of whole brain networks underlying “mental” states

Characterization of whole brain networks underlying watching a movie

Characterization of whole brain networks underlying remembering

Characterization of whole brain networks underlying calculating

Characterization of whole brain networks underlying pathological states (dementia, autism, depression, etc.)

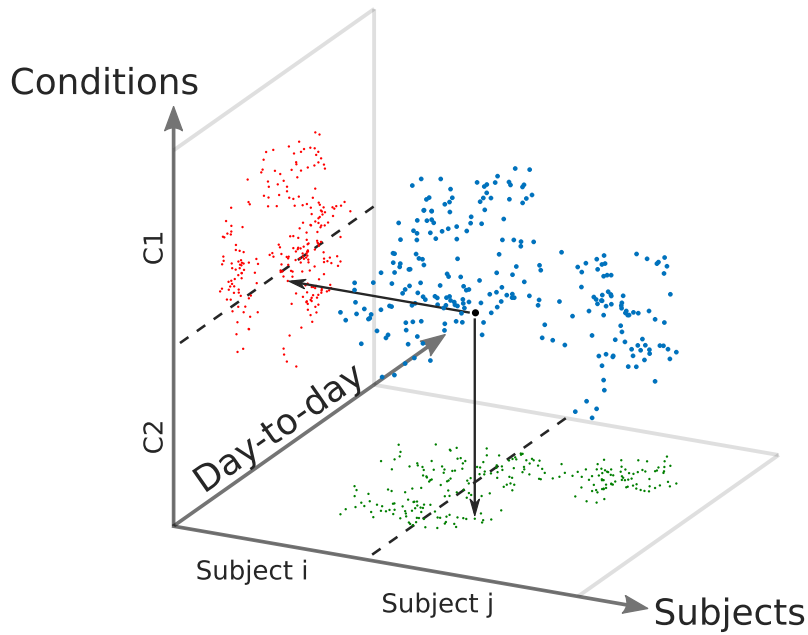
Characterization of whole brain networks underlying “mental” states

Characterization of whole brain networks underlying "mental" states

- Separate different sources of varibility

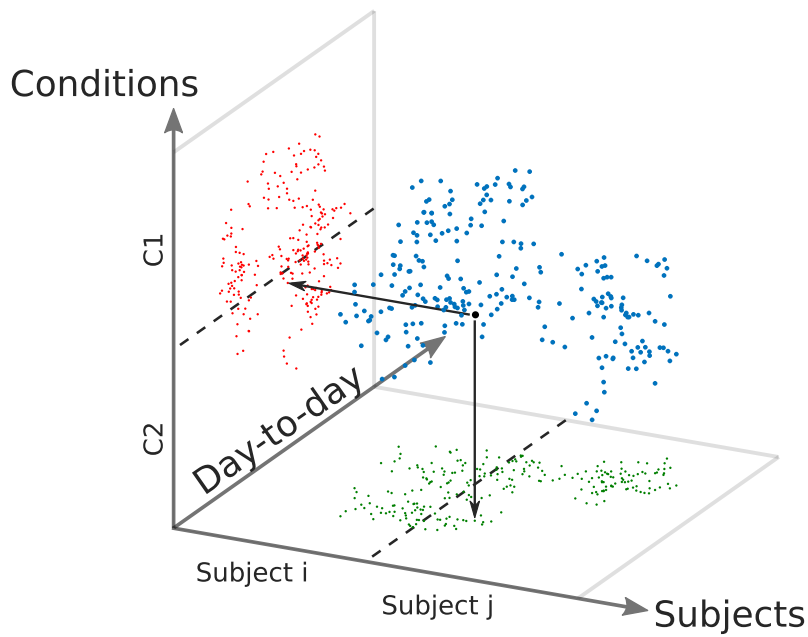
Characterization of whole brain networks underlying "mental" states

- Separate different sources of varibility



Characterization of whole brain networks underlying "mental" states

- Separate different sources of varibility
  - classify subjects
  - classify conditions
  - extract networks underlying each classification



Datasets

Dataset name	Acquisition	Number of subjects	Sessions per subject	Session duration
Dataset A1	Day2day project	6	40-50	5 minutes
Dataset B	CoRR	30	10	10 minutes
Dataset C	Gilson et al. 2017, Mantini et al. 2012	19	3 resting; 2 movie	10 minutes

Subjects classification

Subjects classification

- Finn (Nat. Neuro. 2015): FC of ~ 100 subjects, 5 sessions per subject, Nearest Neighbor, 54-94% accuracy

Subjects classification

- Finn (Nat. Neuro. 2015): FC of ~ 100 subjects, 5 sessions per subject, Nearest Neighbor, 54-94% accuracy
- Comparison between FC and EC

Subjects classification

- Finn (Nat. Neuro. 2015): FC of ~ 100 subjects, 5 sessions per subject, Nearest Neighbor, 54-94% accuracy
- Comparison between FC and EC
- Multinomial logistic regression (interpretability of fitted classifier)

Subjects classification

- Finn (Nat. Neuro. 2015): FC of ~ 100 subjects, 5 sessions per subject, Nearest Neighbor, 54-94% accuracy
- Comparison between FC and EC
- Multinomial logistic regression (interpretability of fitted classifier)
- **Test-retest** dataset:

Subjects classification

- Finn (Nat. Neuro. 2015): FC of ~ 100 subjects, 5 sessions per subject, Nearest Neighbor, 54-94% accuracy
- Comparison between FC and EC
- Multinomial logistic regression (interpretability of fitted classifier)
- **Test-retest** dataset:
  - accurate assessment of test accuracy

Subjects classification

- Finn (Nat. Neuro. 2015): FC of ~ 100 subjects, 5 sessions per subject, Nearest Neighbor, 54-94% accuracy
- Comparison between FC and EC
- Multinomial logistic regression (interpretability of fitted classifier)
- **Test-retest** dataset:
  - accurate assessment of test accuracy
  - impact of training set size

Acknowledgments

Vicente Pallares

Matthieu Gilson

Ana Sanjuan

Simone Kuhn

Dante Mantini

Gustavo Deco

Acknowledgments

Vicente Pallares

Matthieu Gilson

Ana Sanjuan

Simone Kuhn

Dante Mantini

Gustavo Deco