December 14th 2022

OpenViBE: an open source BCI software suite

Concluding Remarks - Research

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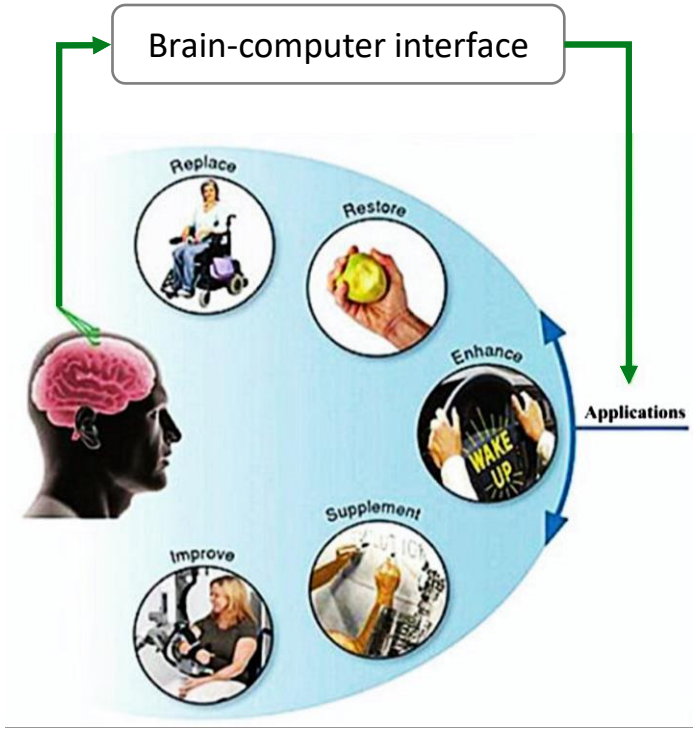
PART 3 – Concluding remarks & perspectives

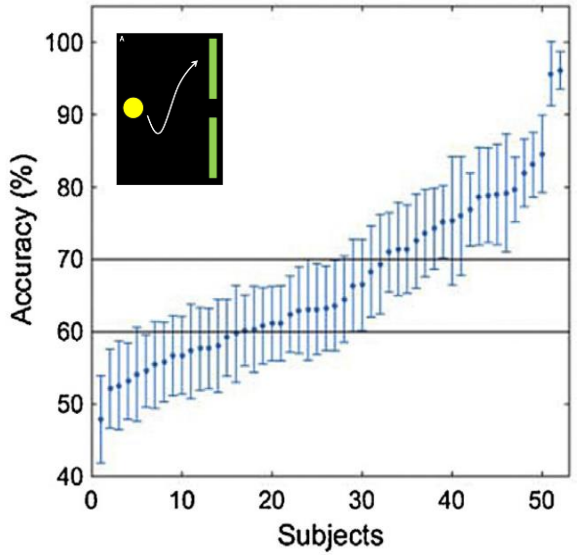
3.3 – BCI Research

BCI Inefficiency Challenge

Great potential



Poor usability



(Ahn & Jun, 2015)

Problem : Current BCIs fail to detect the mental intentions in ~30% of users

BCI Inefficiency Challenge – State-of-the-art

- **Machine-centered approaches**
  - Signal conditioning (Ang et al, 2012)
  - Classification algorithms (Lotte et al, 2018)

➔ Rely on EEG signals

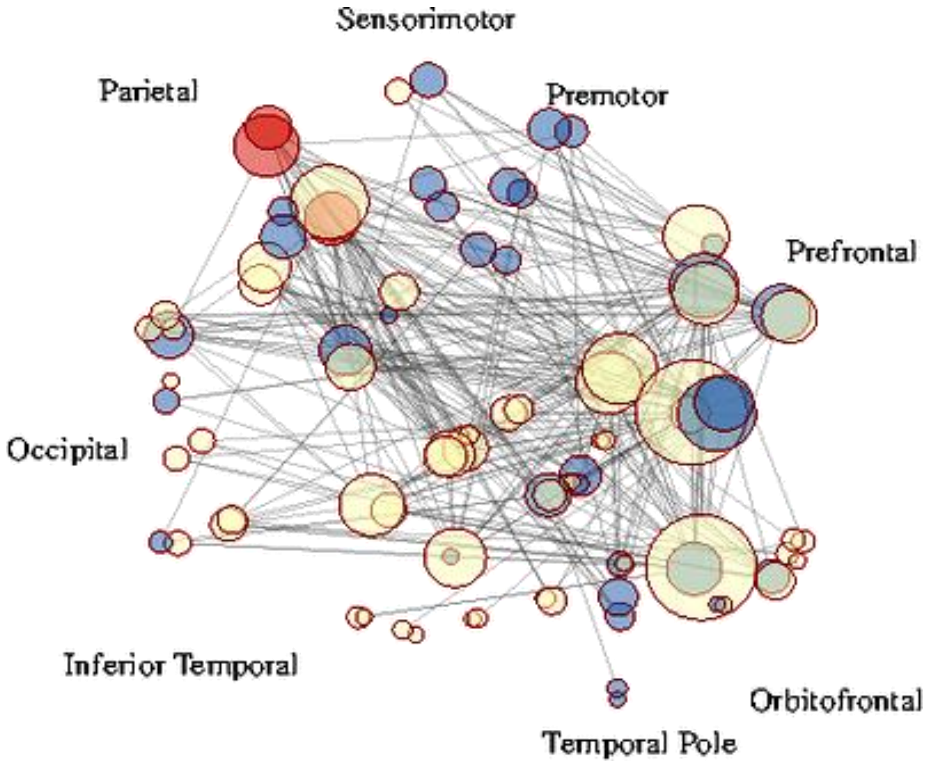
- **User-centered approaches**
  - Search for neurophysiological patterns (Blankertz et al, 2010)
  - Human factors (Jeunet et al, 2015)

➔ Lack of reliable markers

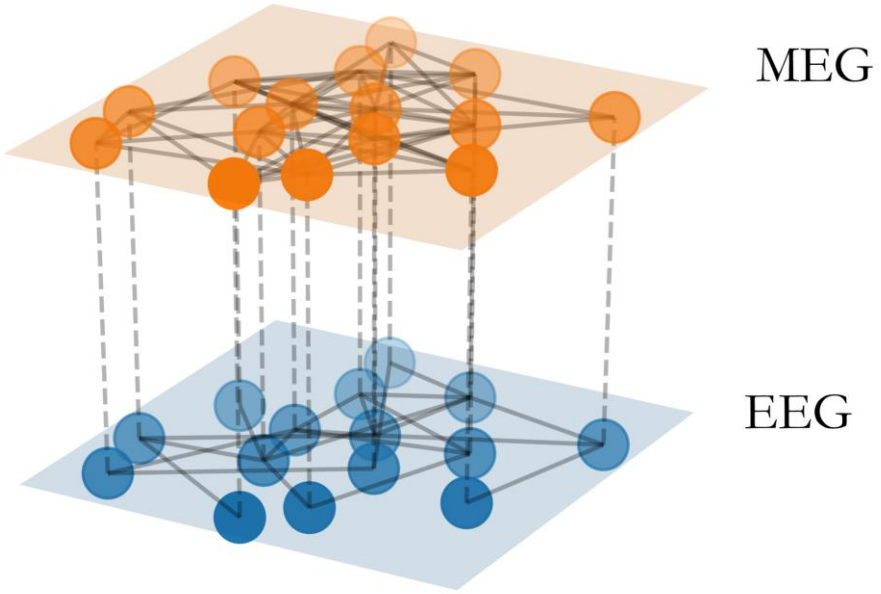
➔ Neural mechanisms underlying BCI learning **poorly understood**

➔ Do not consider the **interconnected** nature of the brain functioning

BCI Inefficiency Challenge – Network Approach

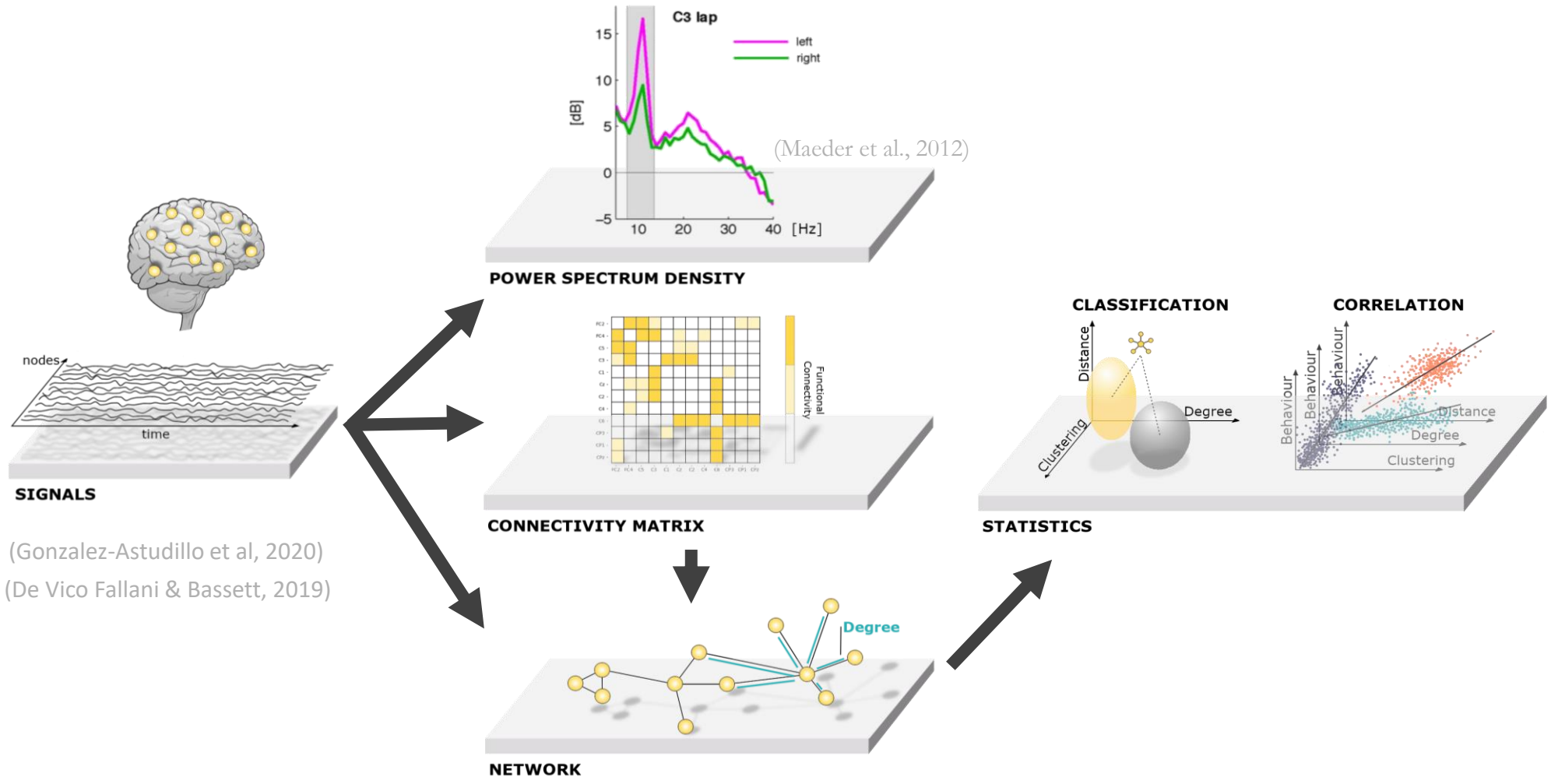


(Varela et al, 1999)



Use of multimodal brain networks to identify alternative features & BCI learning patterns

Network Metrics for Mental States Characterization

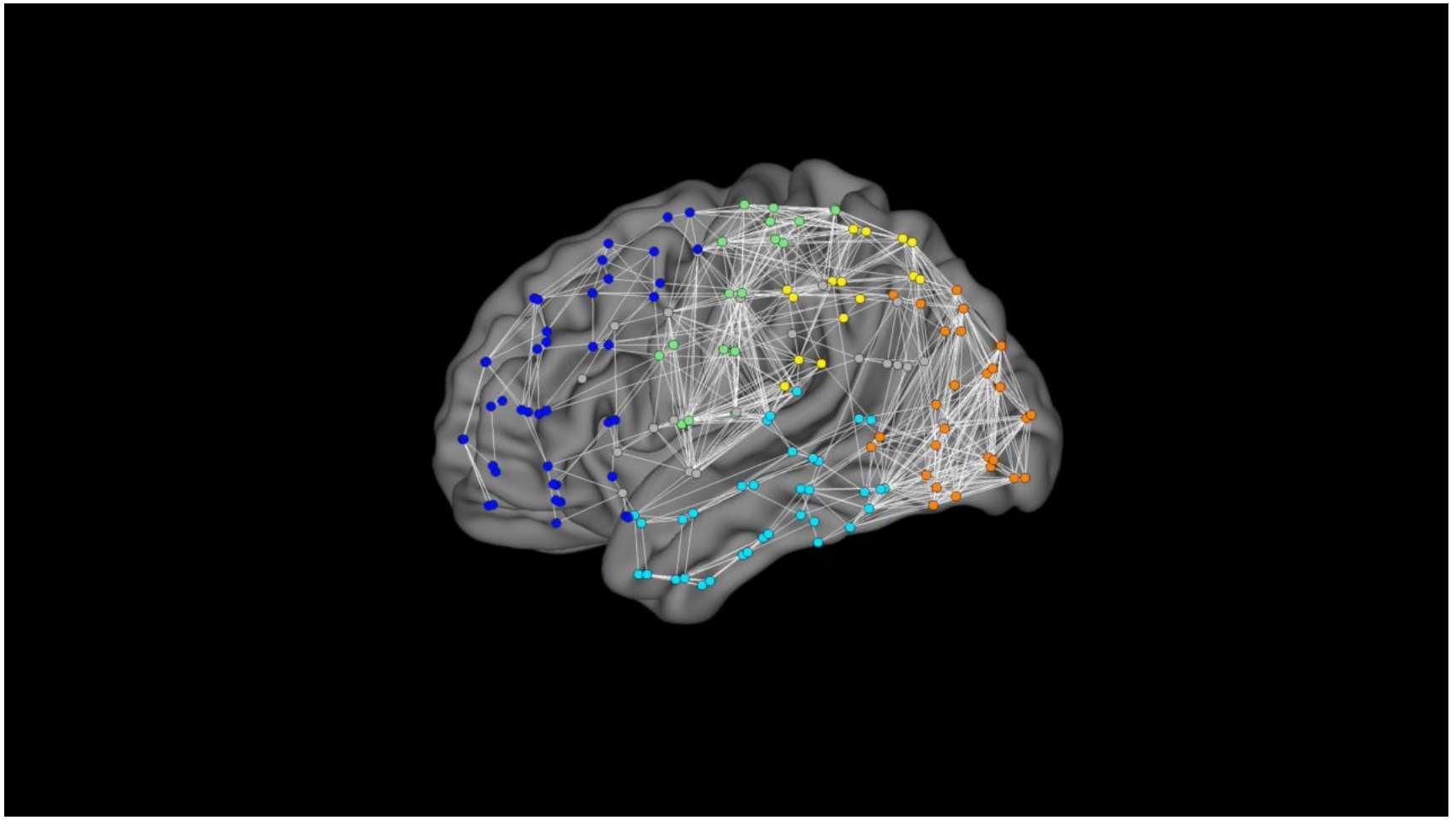


(Maeder et al., 2012)

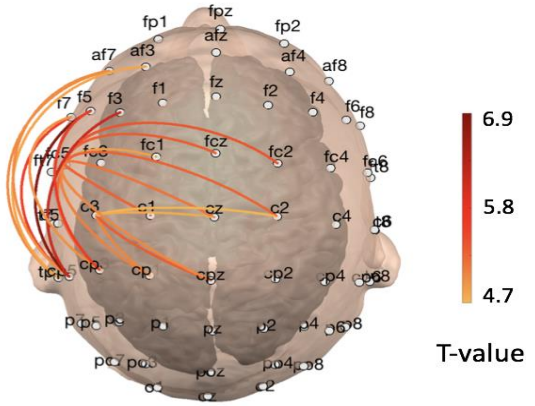
(Gonzalez-Astudillo et al, 2020)

(De Vico Fallani & Bassett, 2019)

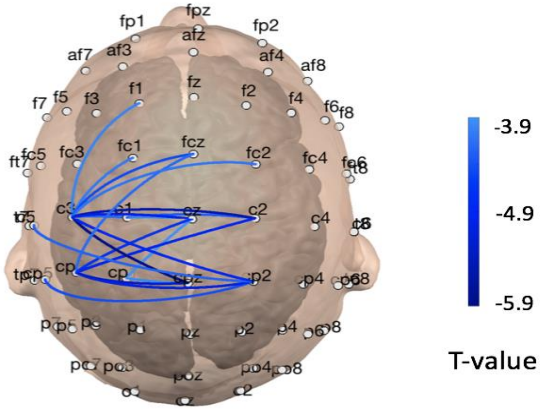
Network Metrics for Mental States Characterization



Brain Connectivity Changes in MI-BCI

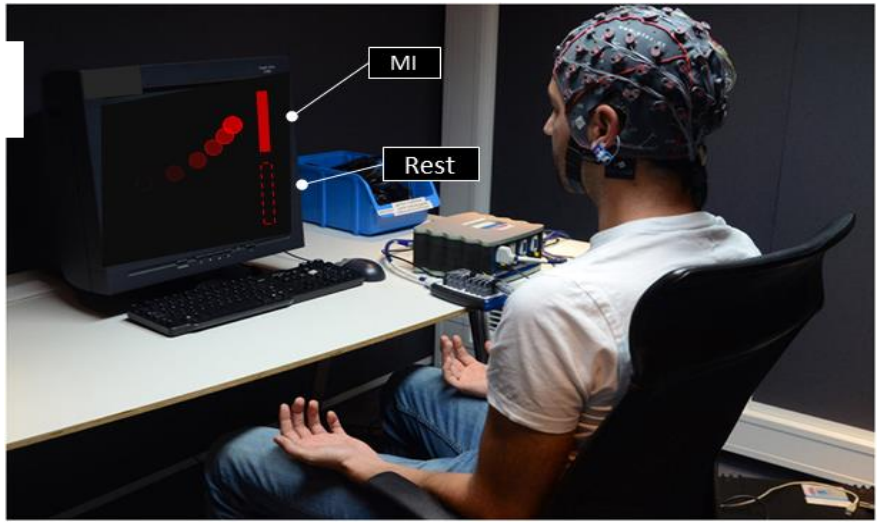


Amplitude synchronization



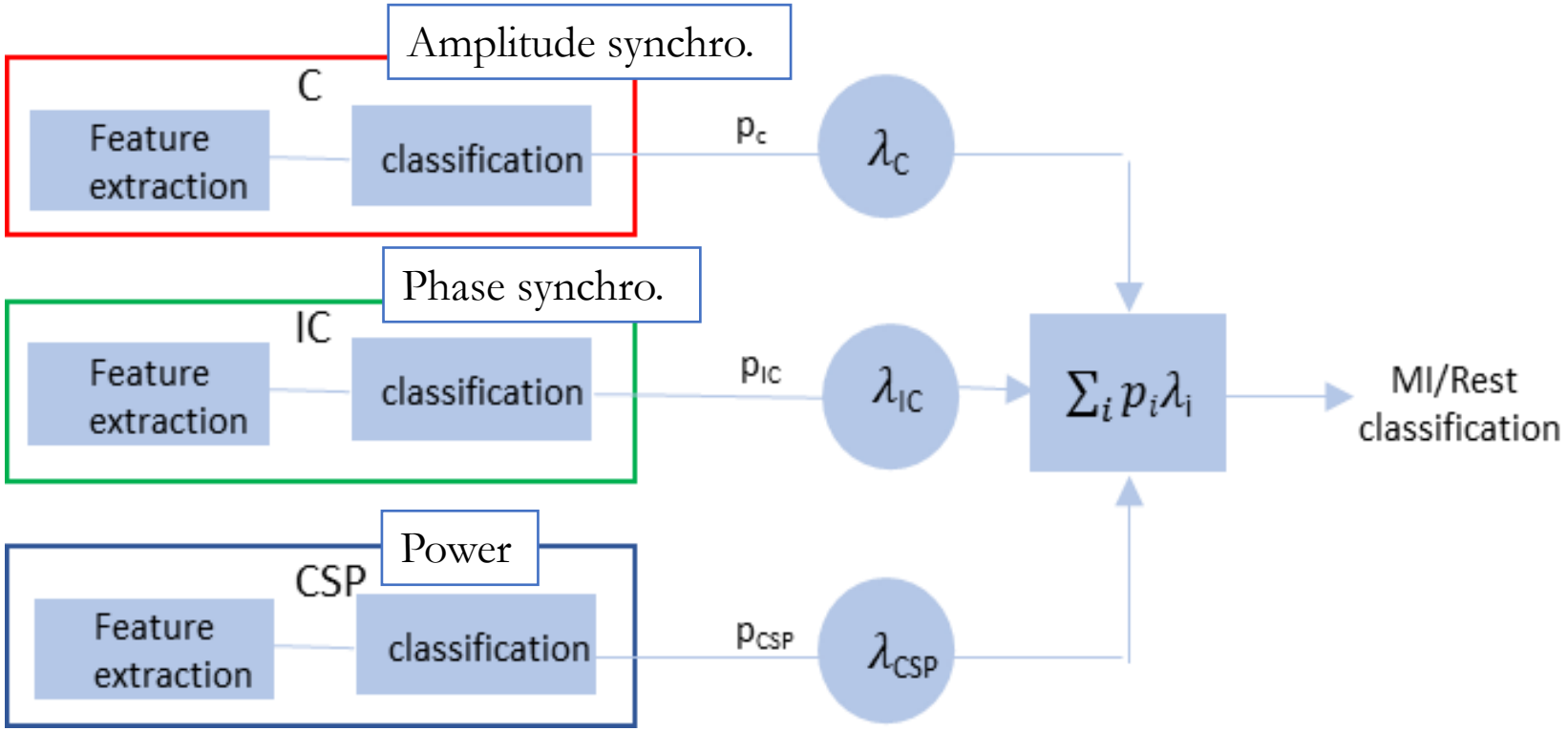
Phase synchronization

Motor imagery
VS
Resting state



(Cattai et al, IEEE TNSRE, 2021)

Merging information to improve classification



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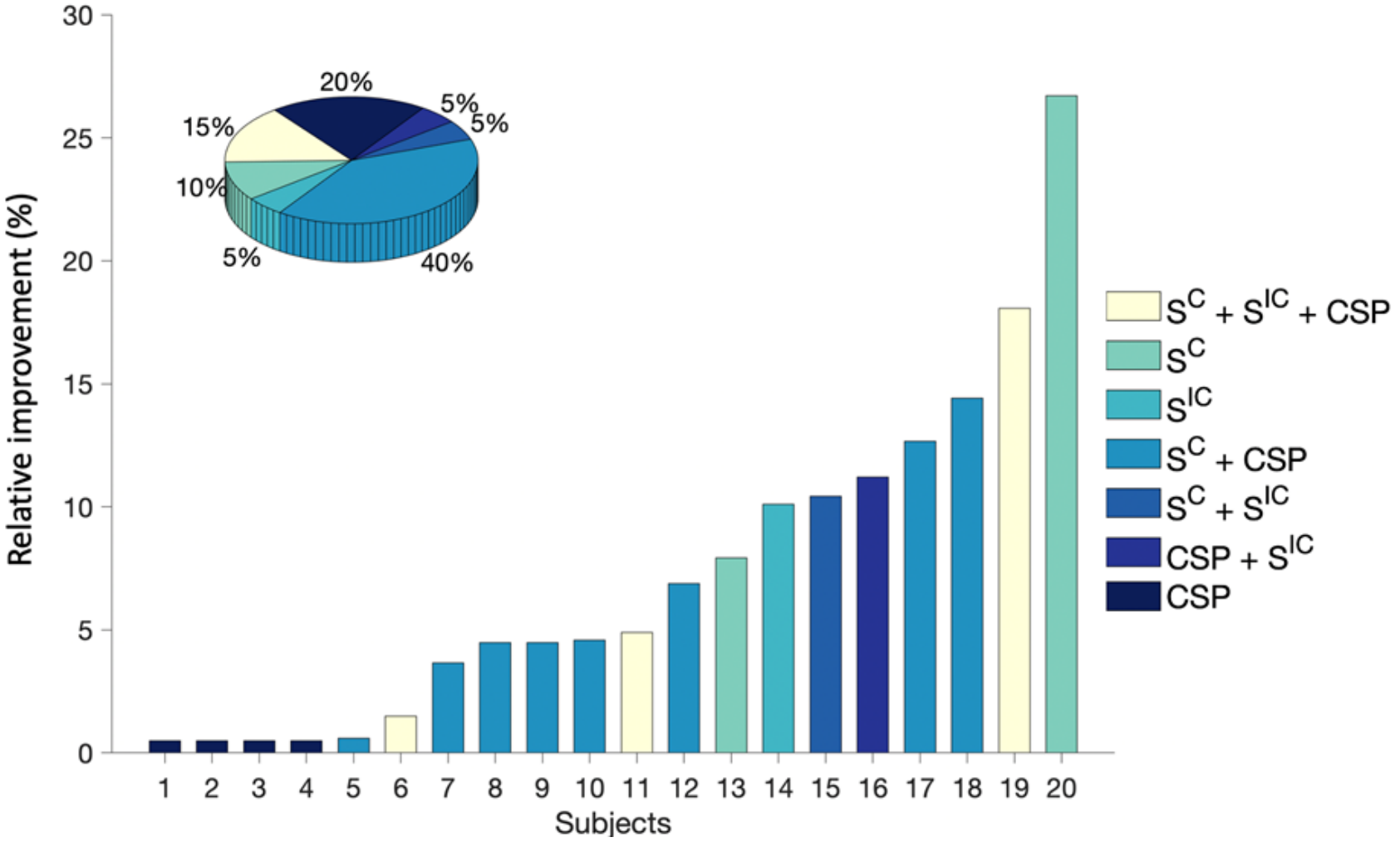
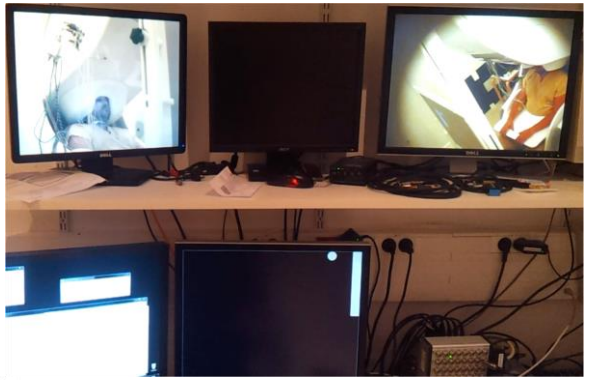
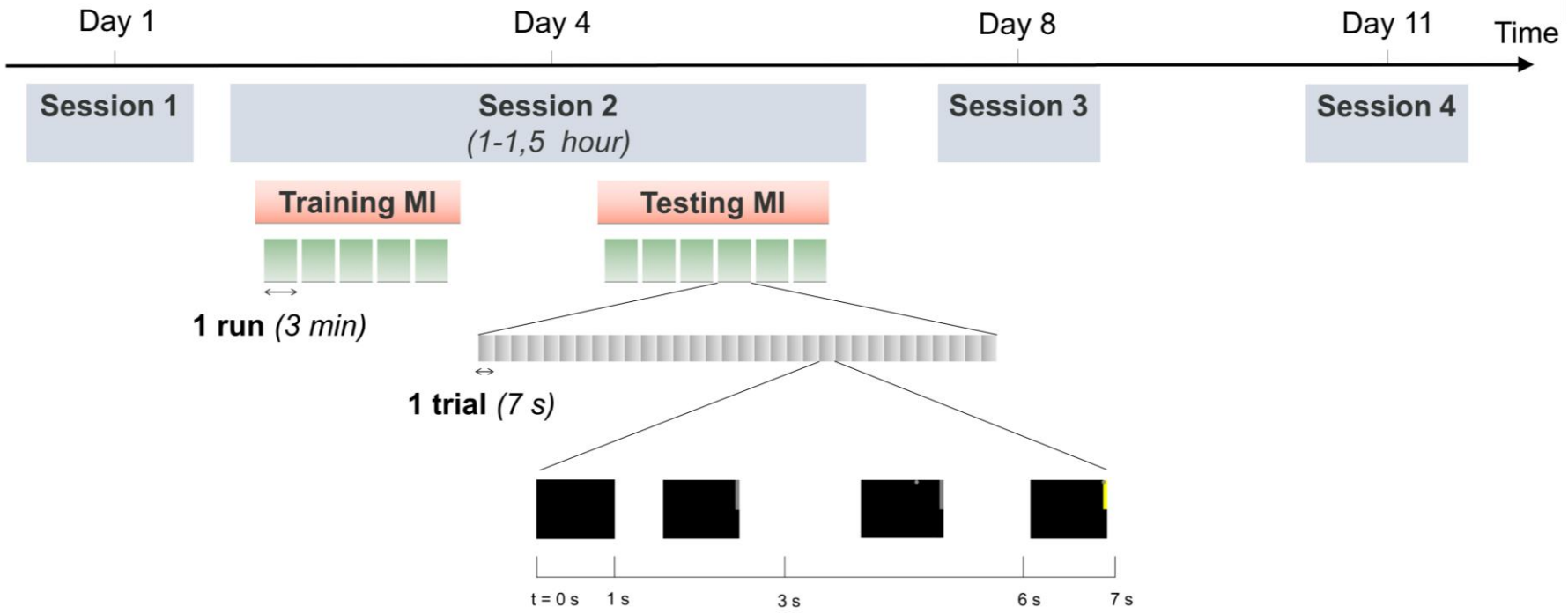


(Cattai et al, IEEE TNSRE, 2021)

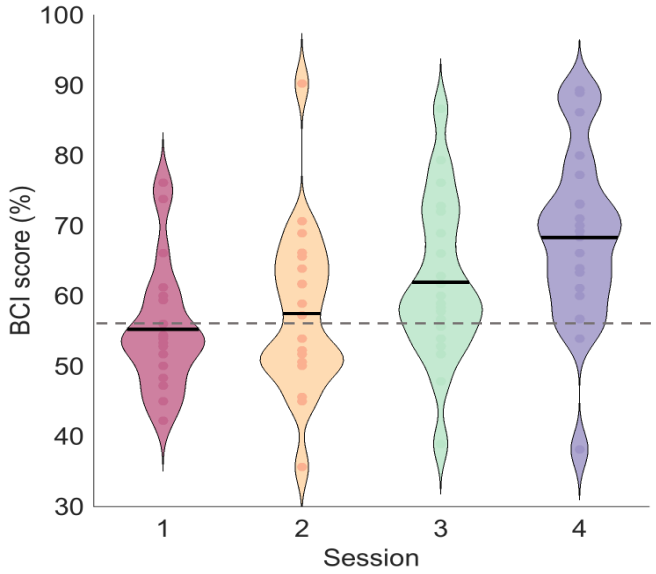
How does one learn to control a BCI?

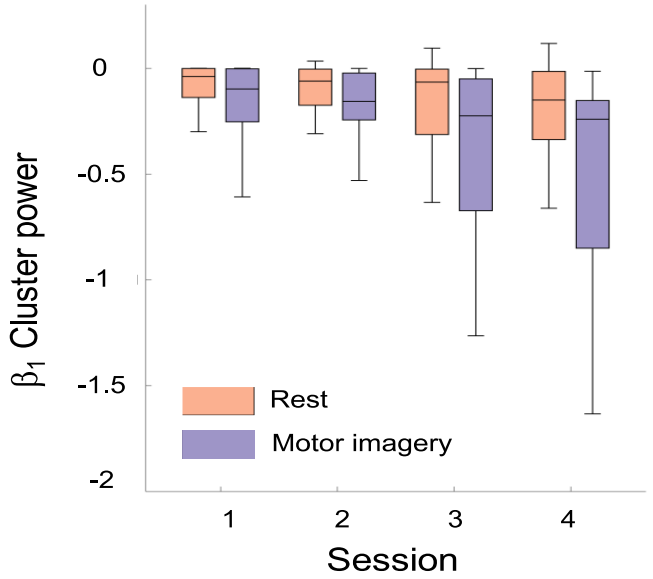
NETBCI project

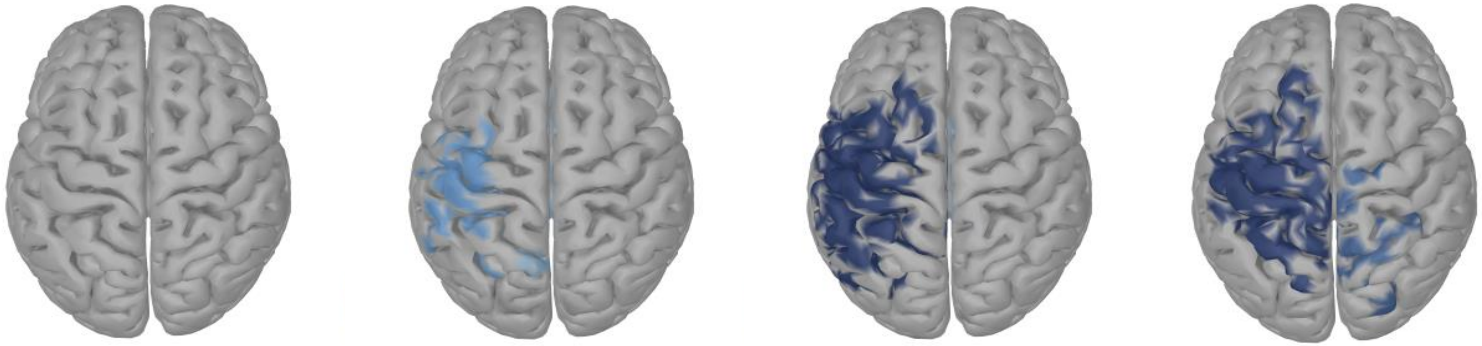




Reinforcement of Motor-Related Activity

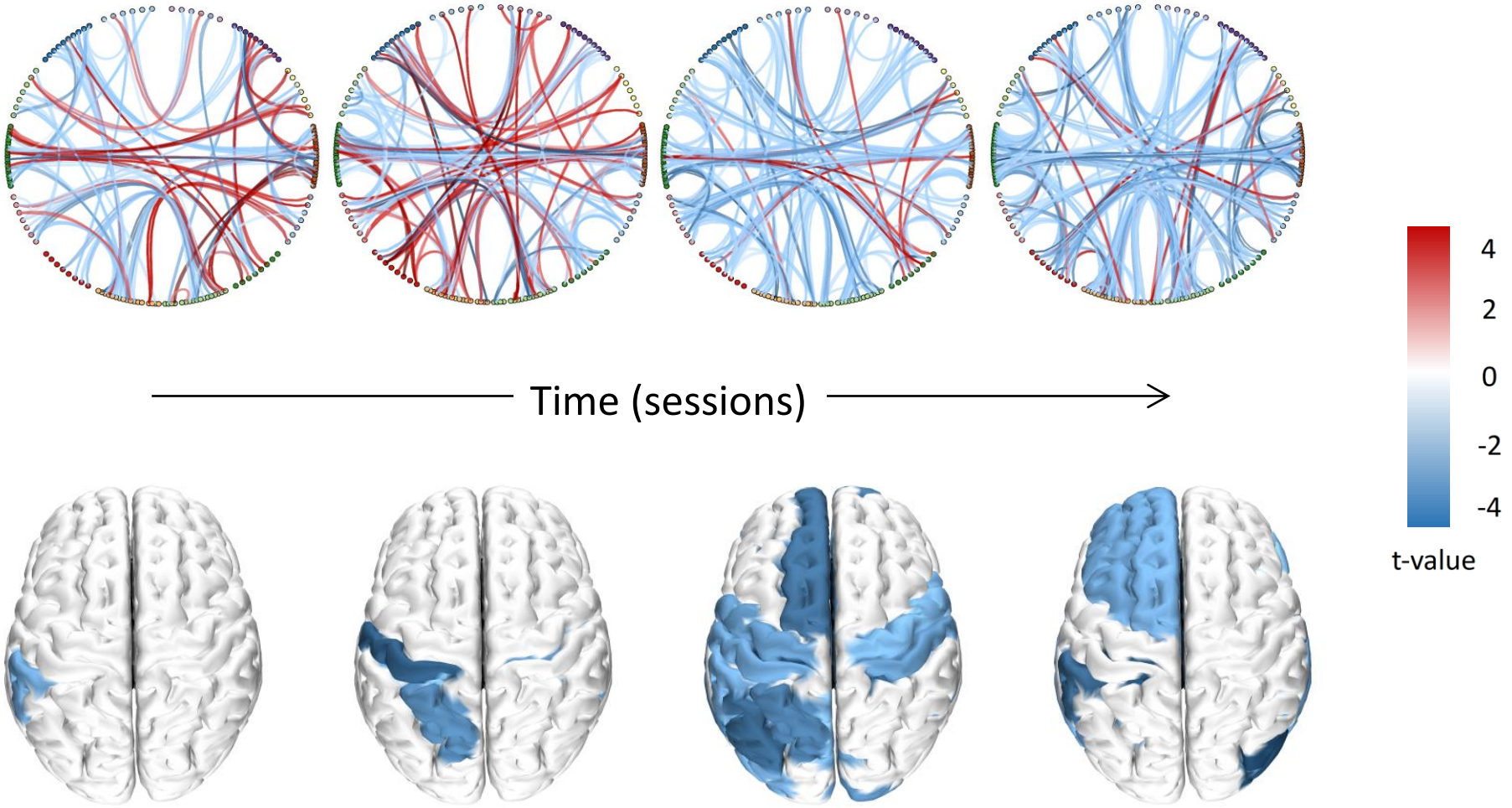






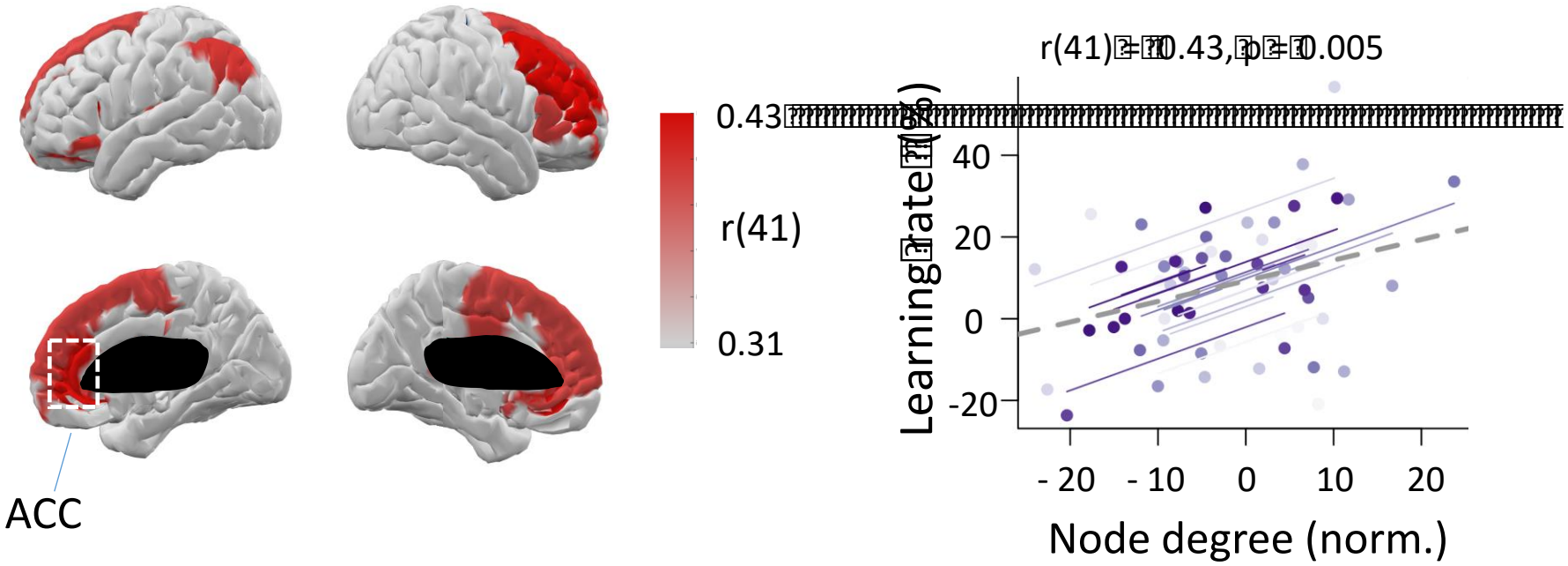
(Corsi et al, 2020)

Functional Disconnection of Associative Areas



(Corsi et al, 2020)

Node Strength Predicts BCI Learning Rate

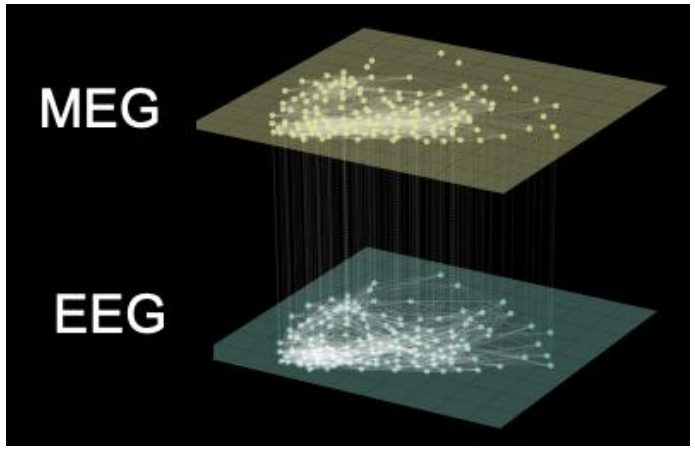


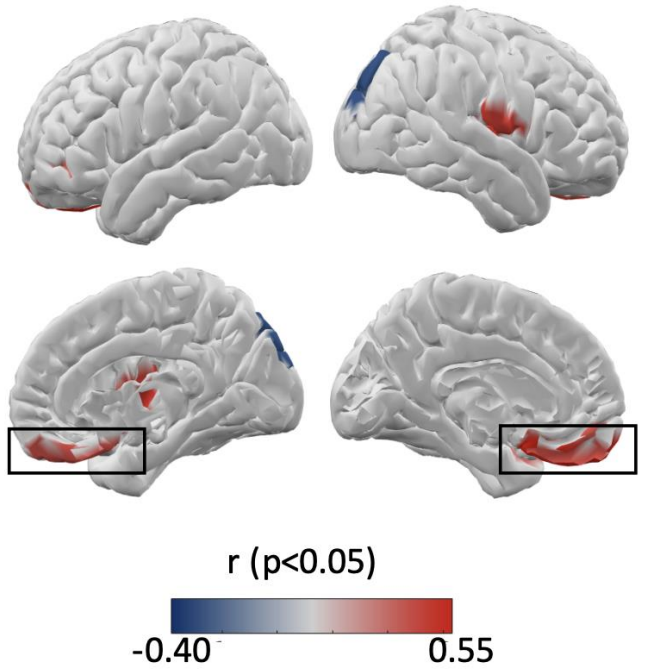
The *reserve* effect

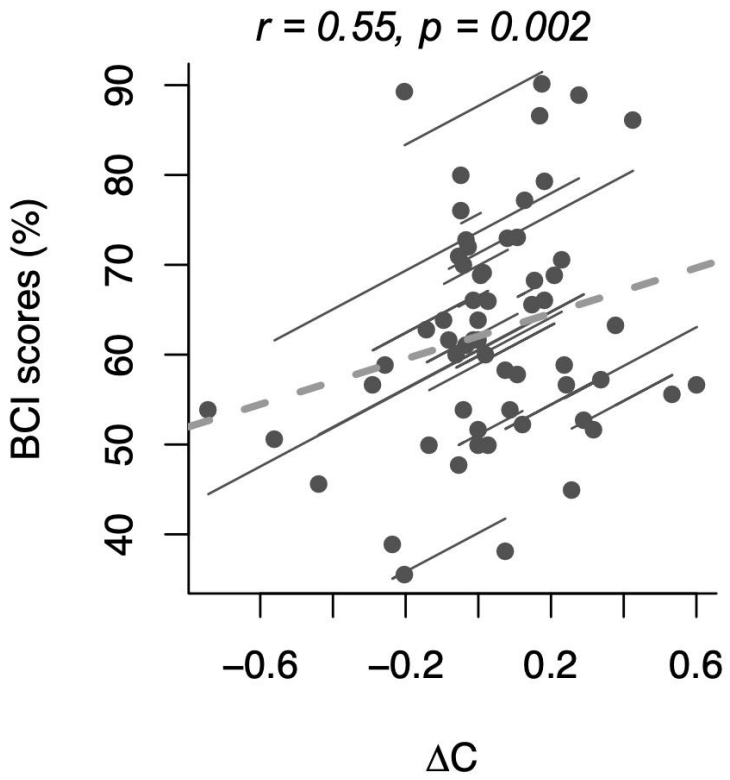
Higher connectivity → higher *potential* to disconnect (learning)

(Corsi et al, 2020)

Multiplex Coreness associated with BCI Perf.

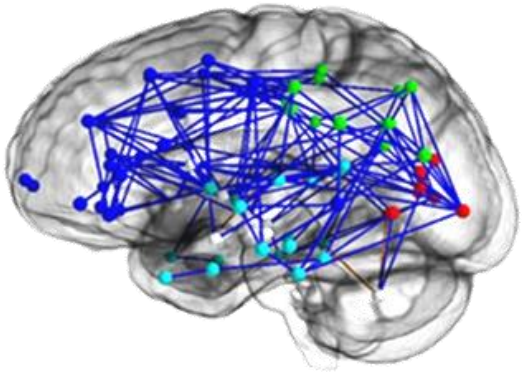




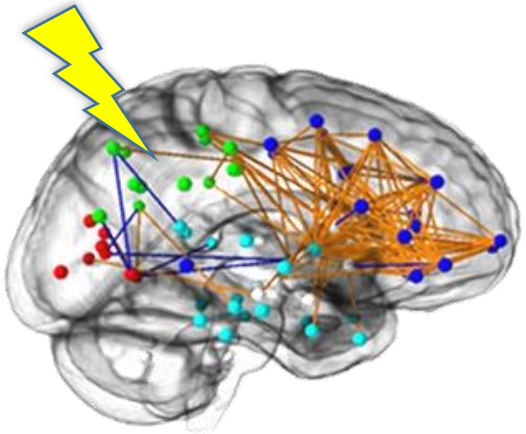


(Corsi et al, 2021)

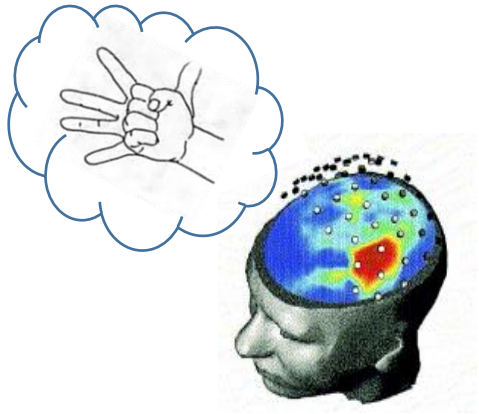
Stroke - Cortical Reorganization



Disability

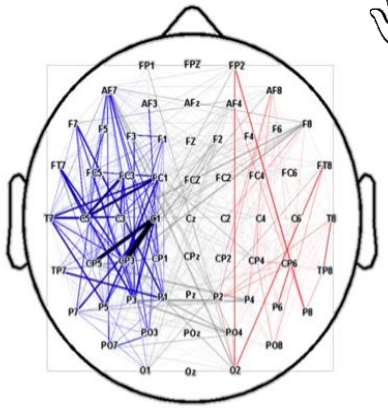


Motor Imagery

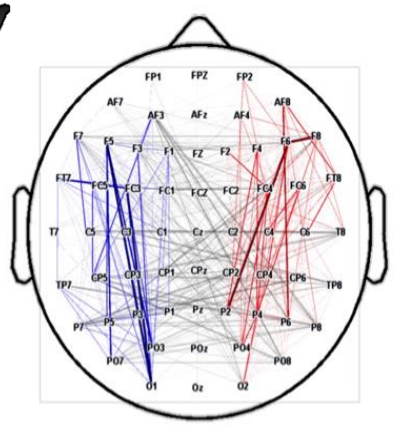


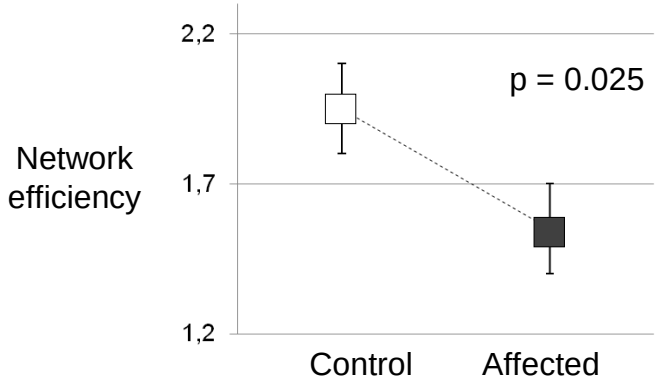
Stroke - Inter-hemispheric Connectivity & Efficiency

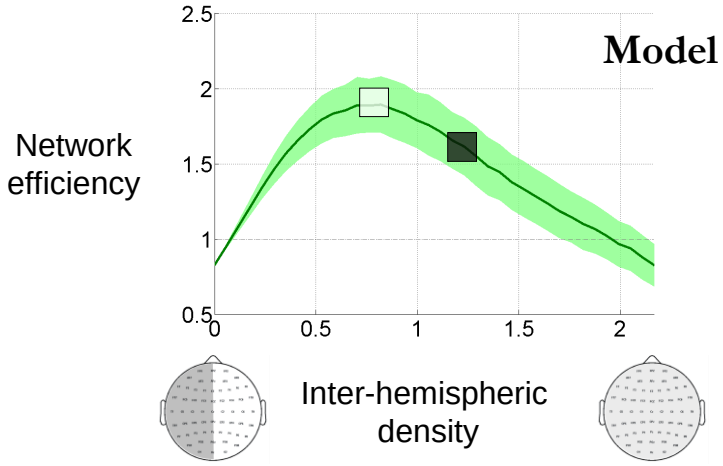
Control



Affected

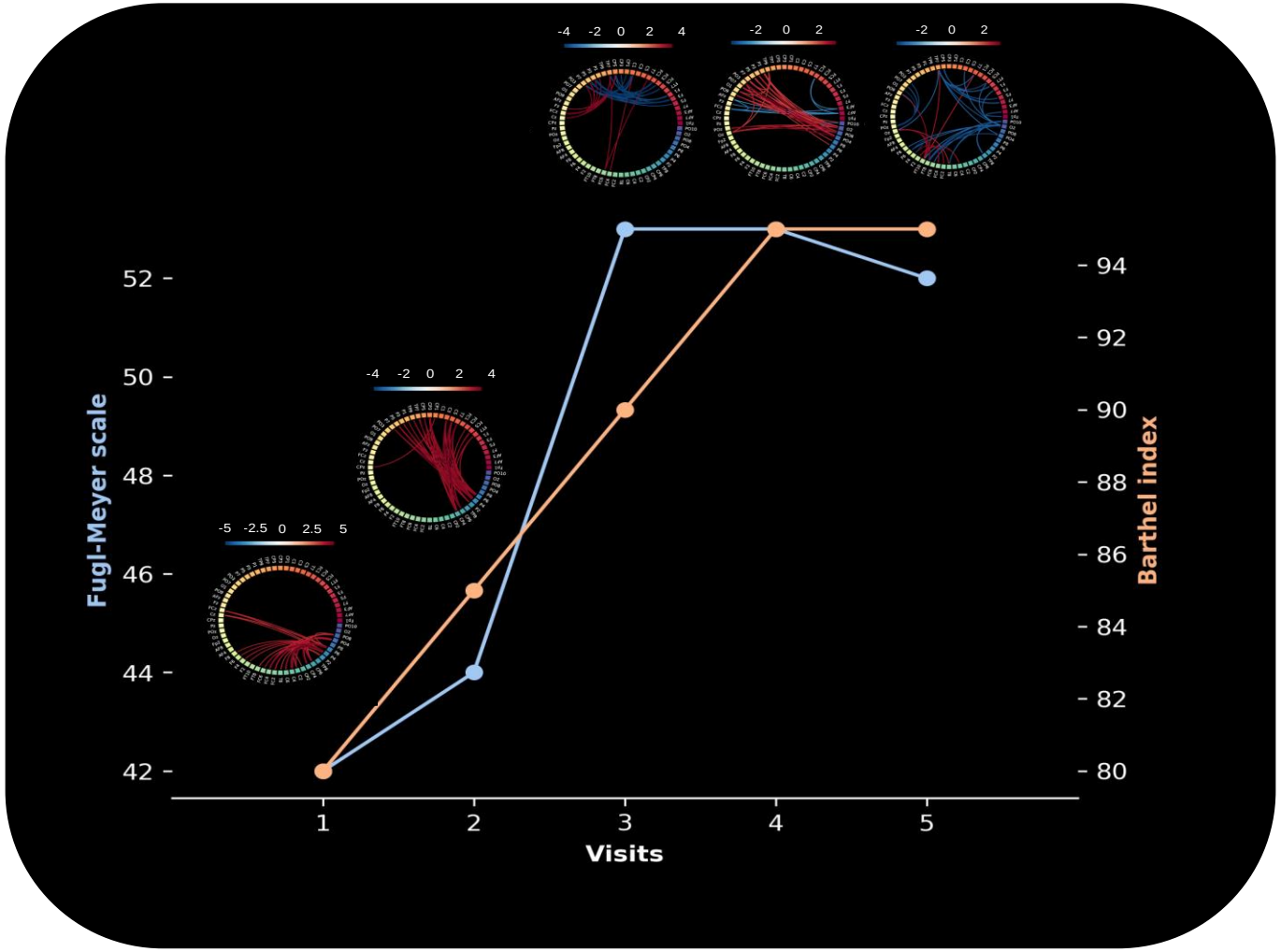






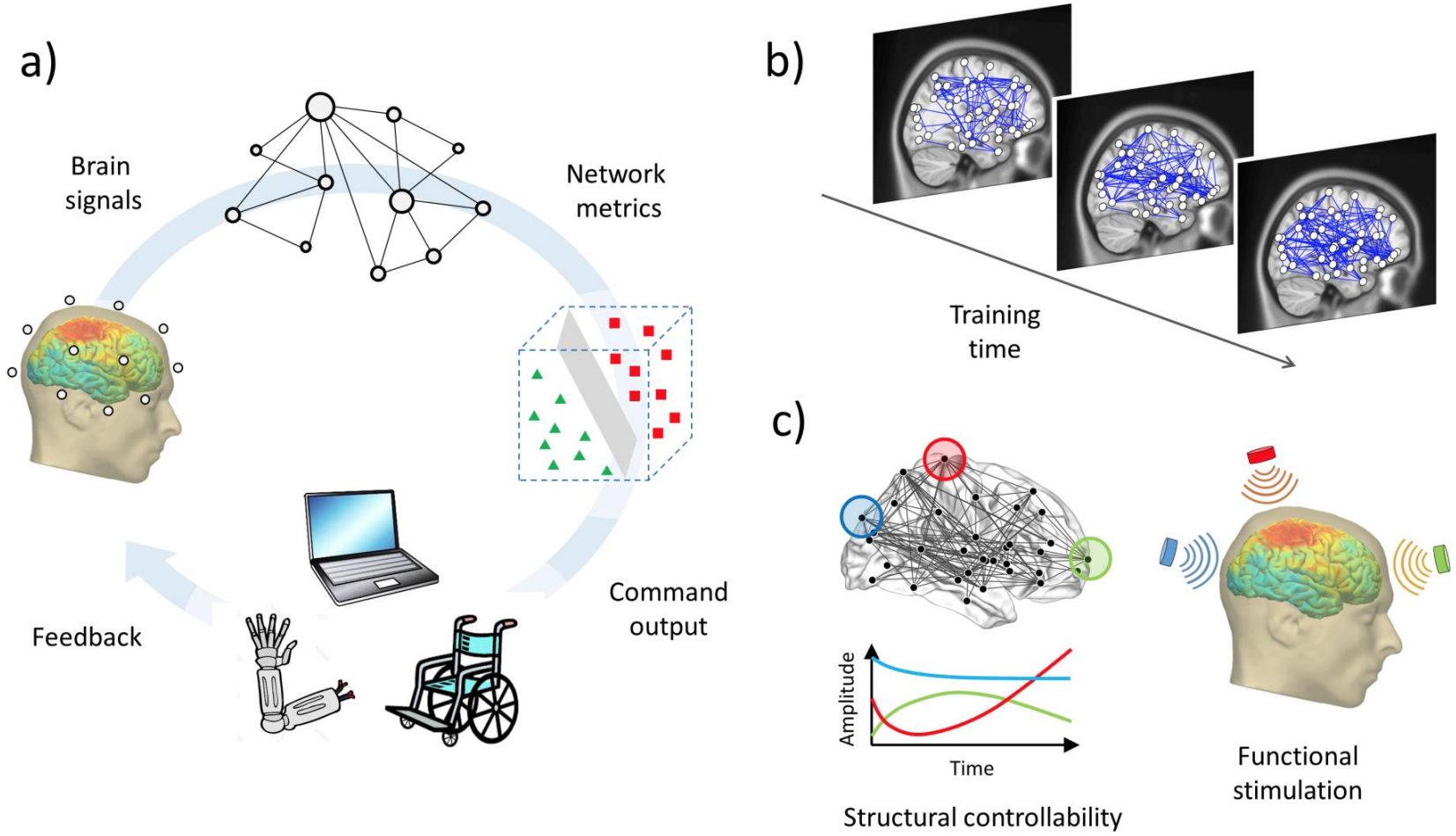
(De Vico Fallani et al, 2013)

Stroke - Searching for alternative features…



Neurophysiological patterns of stroke recovery over 1 year (ongoing project w/ AP-HP)

New Perspectives for Optimizing BCIs



(De Vico Fallani & Bassett, 2019)

Take Home Messages

- **BCI**
  - Promising tool for clinical applications
  - Multidisciplinary domain
  - Growing interest in the last few years with the AI
- **BCI learning & inter-subject variability**
  - Improving the classifier / signal processing
  - Improving instructions
  - Finding (new) subject-related predictors
- **Groups & events**
  - International: BCI society, international society
  - Cybathlons: competitions to promote BCI and to test the finest algorithms with **end users !**
  - In France: CORTICO, French association to promote BCI

To Go Further

- **Python tools – with many tutorials**
  - Performing online experiments : OpenViBE, an Inria software
  - Open datasets to test algorithms & check their replicability: MOABB
  - M/EEG data analysis : MNE-Python
  - Classification tools : Scikit-learn
- **Available demos (available soon)**
  - Visualize E/MEG data
  - Data extraction (ERD/S)
  - Classification

Part3 - Q&A

BCI Motor Imagery with OpenViBE in X-Men: First Class

Thanks for your attention! Any questions?