

CONCLUDING REMARKS & PERSPECTIVES

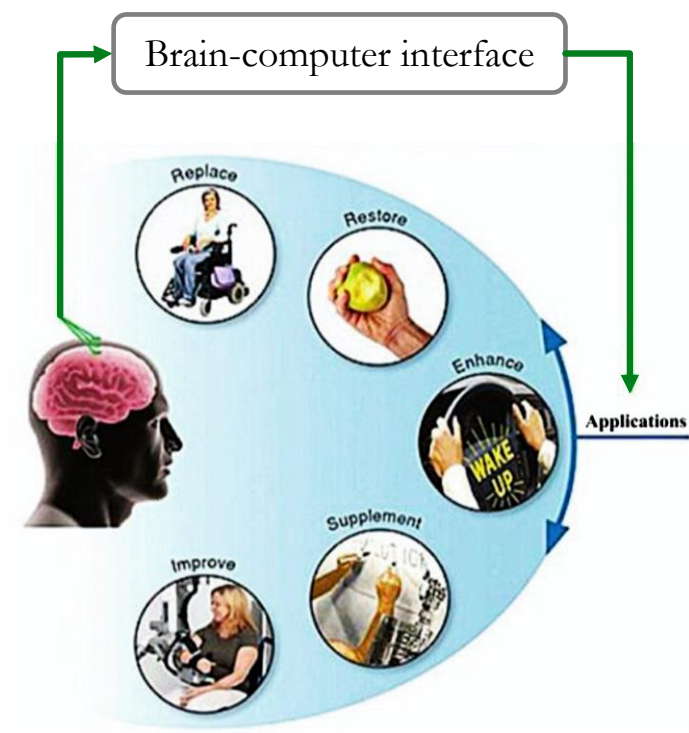
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BCI RESEARCH

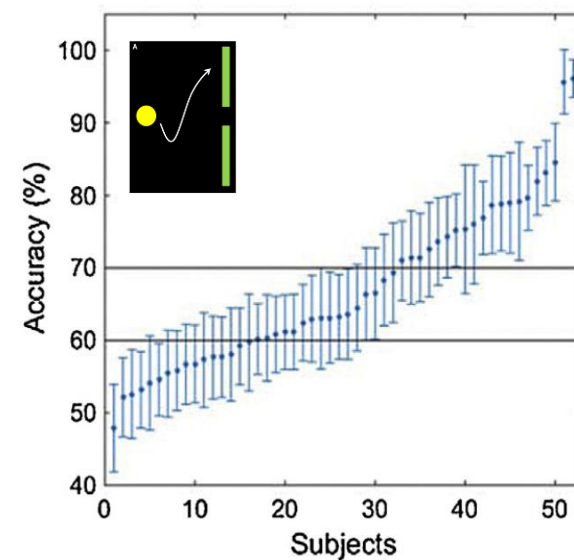


BCI INEFFICIENCY CHALLENGE

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)

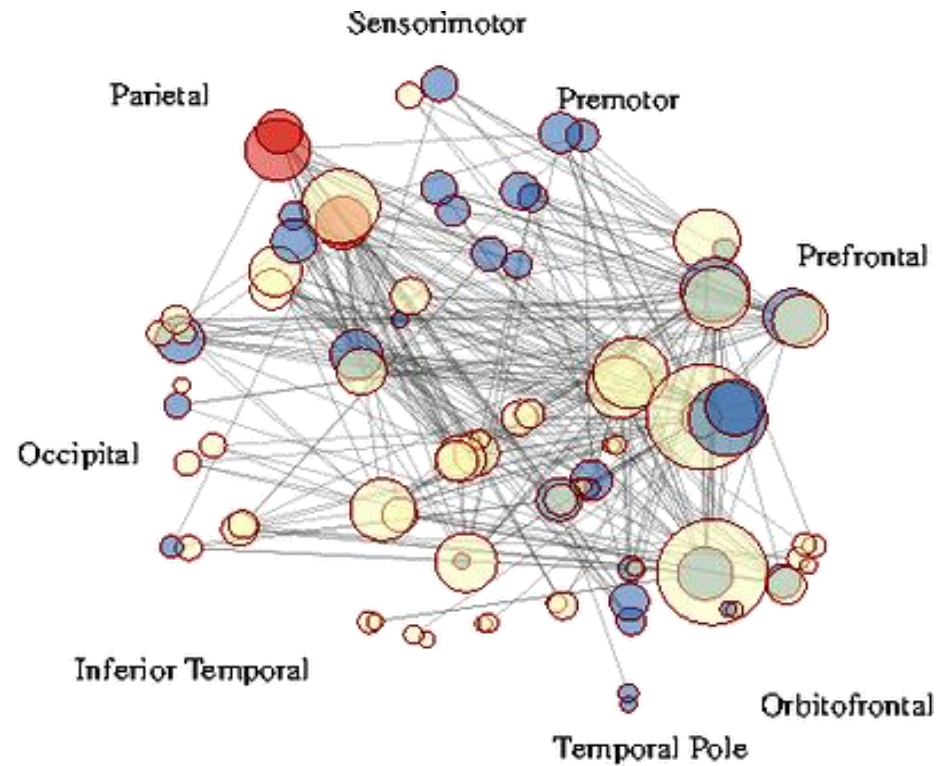
- Human factors (Jeunet et al, 2015)

⇒ Lack of reliable markers

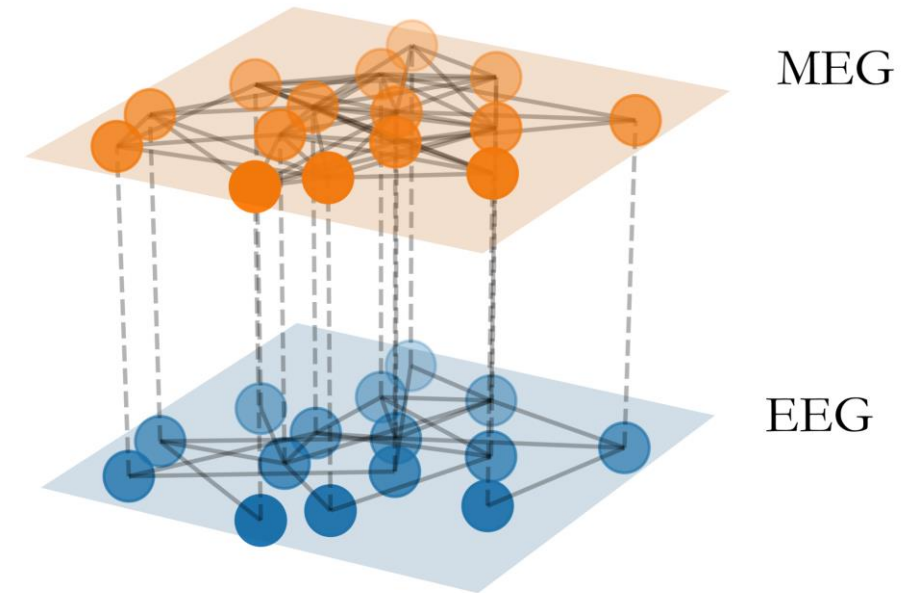
⇒ Neural mechanisms underlying BCI learning **poorly understood**

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

BCI INEFFICIENCY CHALLENGE – NETWORK APPROACH

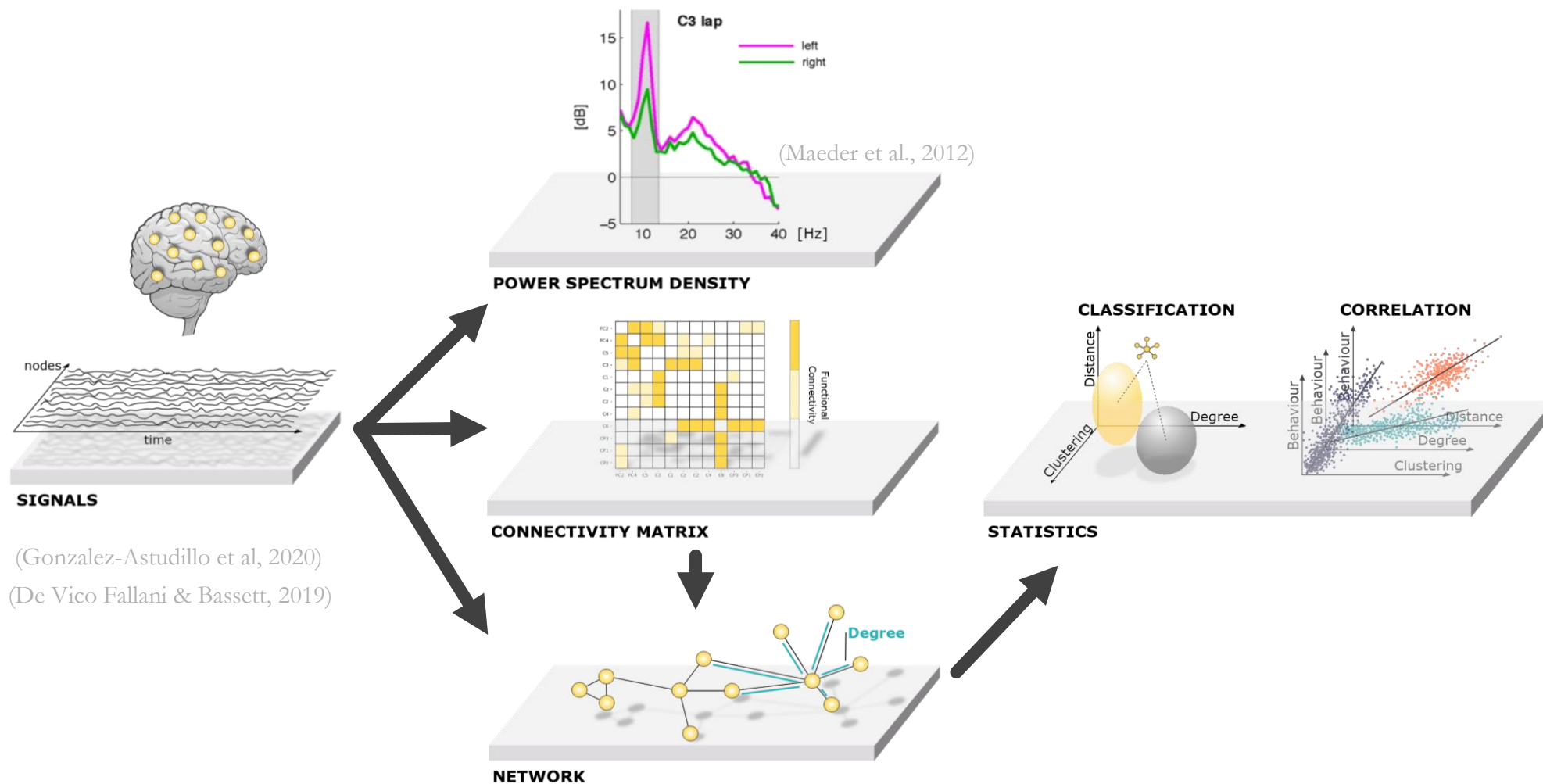


(Varela et al, 1999)

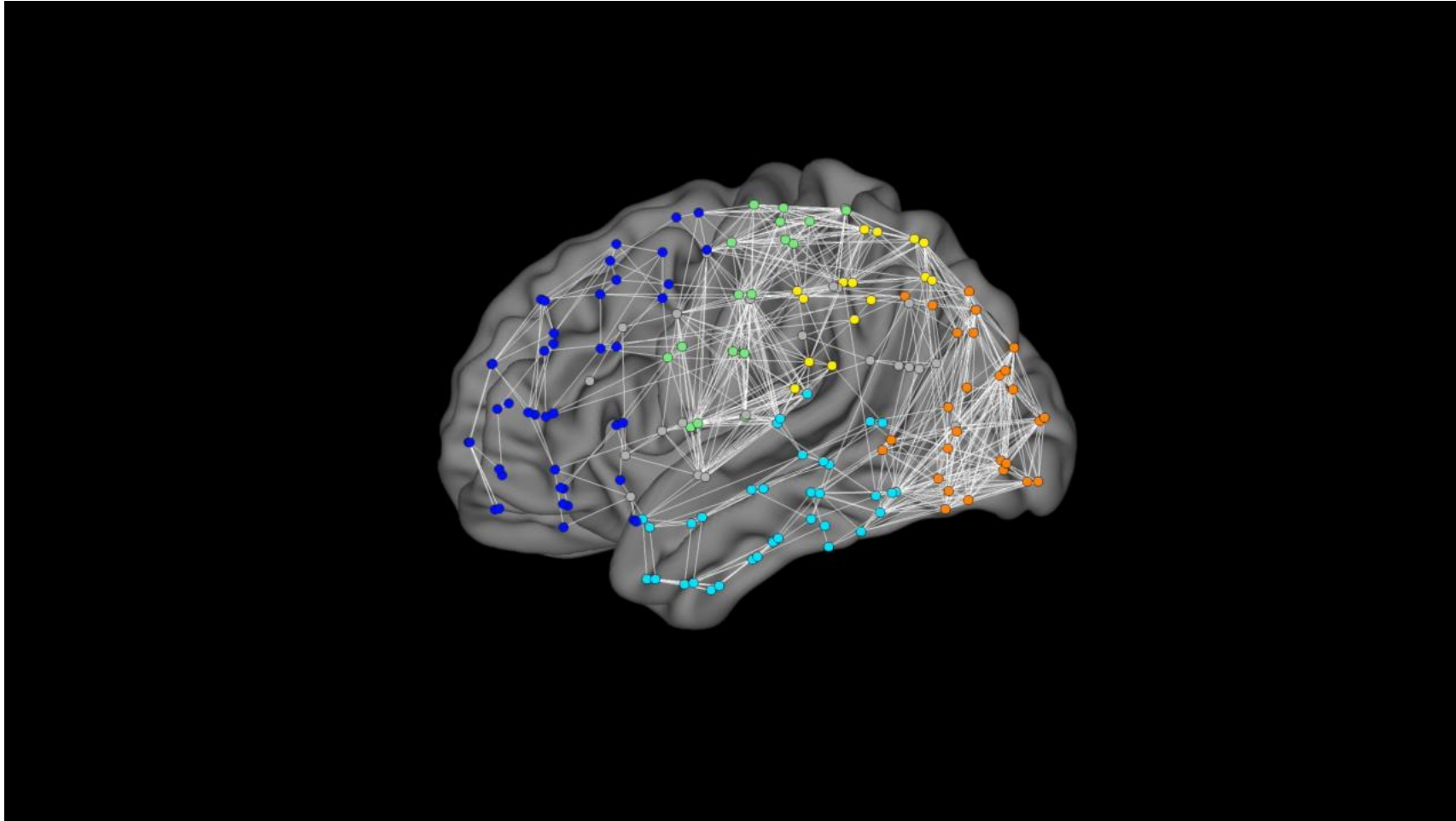


Use of multimodal brain networks to identify alternative features & BCI learning patterns

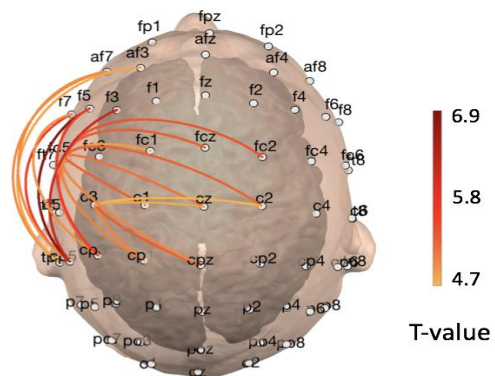
NETWORK METRICS FOR MENTAL STATES CHARACTERIZATION



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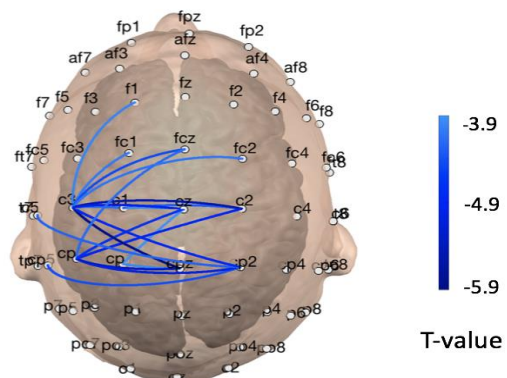


BRAIN CONNECTIVITY CHANGES IN MI-BCI

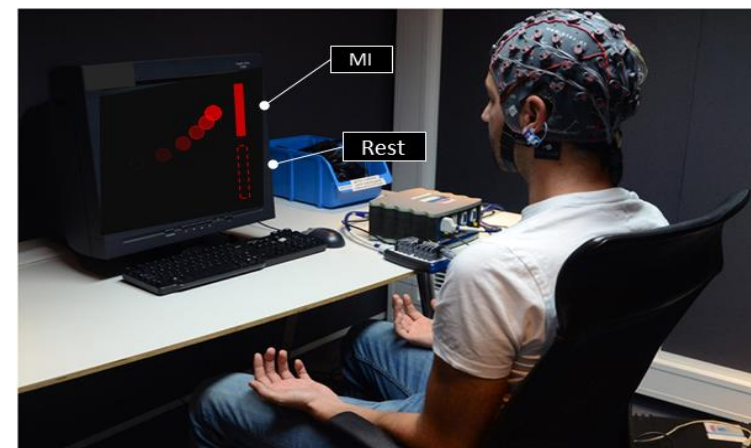


Motor imagery
VS
Resting state

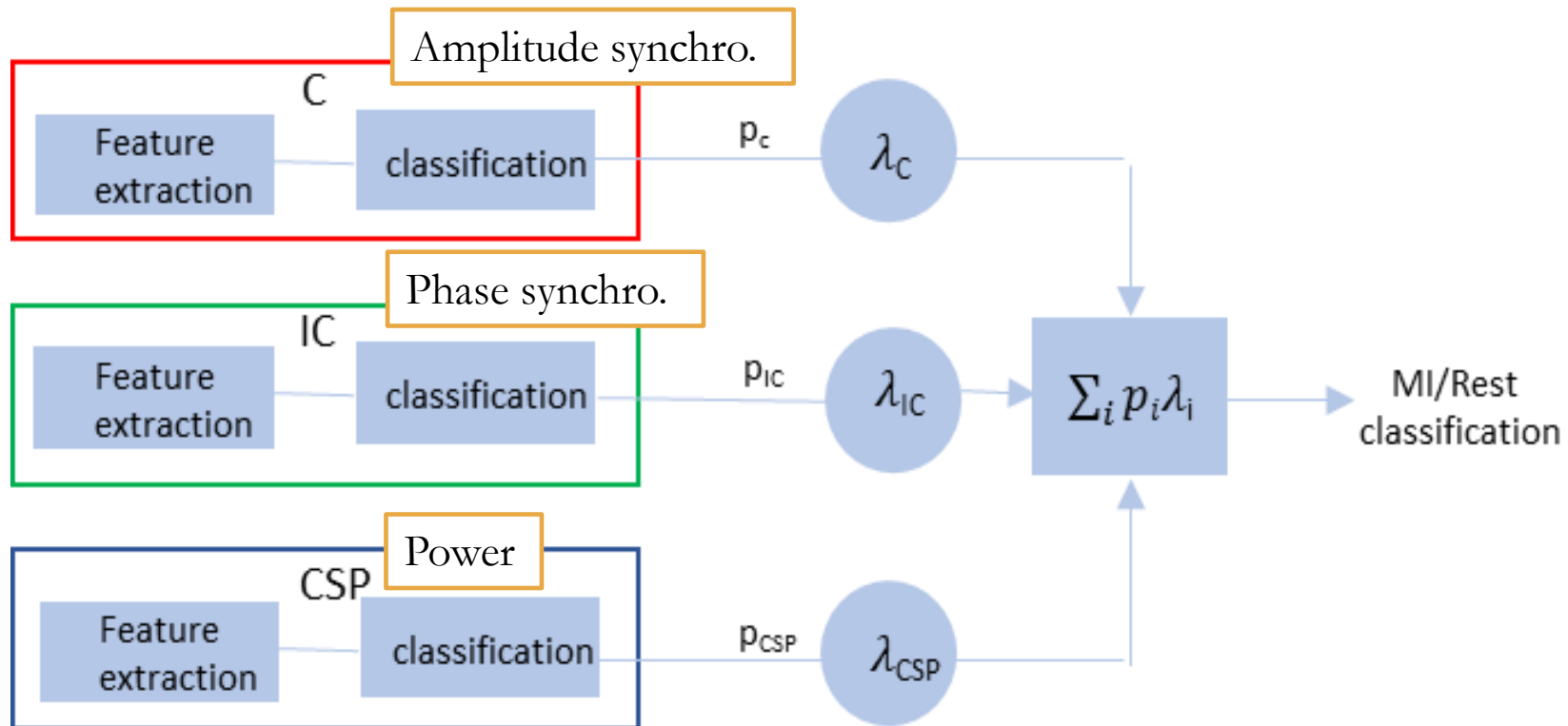
Amplitude synchronization



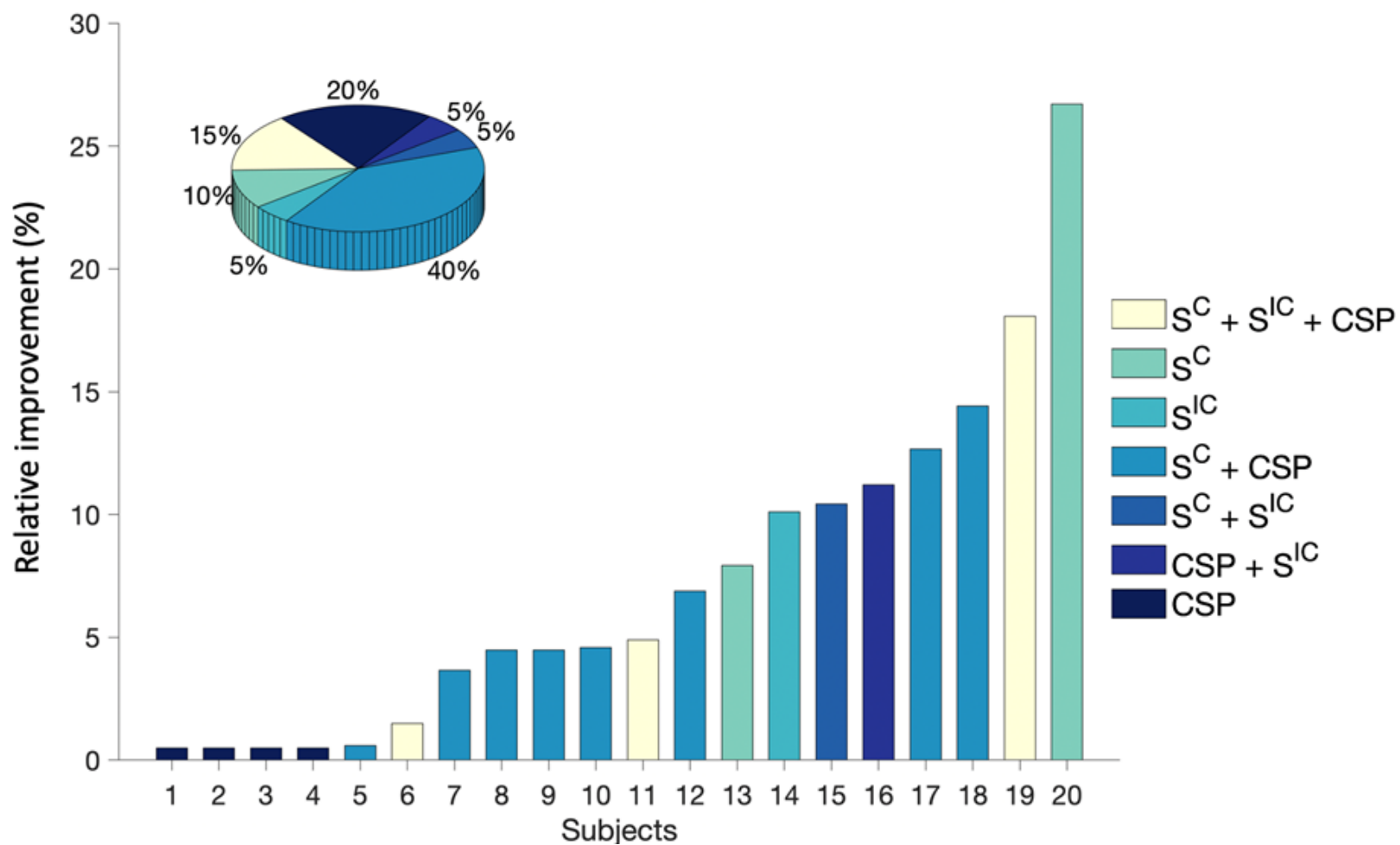
Phase synchronization



FUSING INFORMATION TO IMPROVE THE CLASSIFICATION



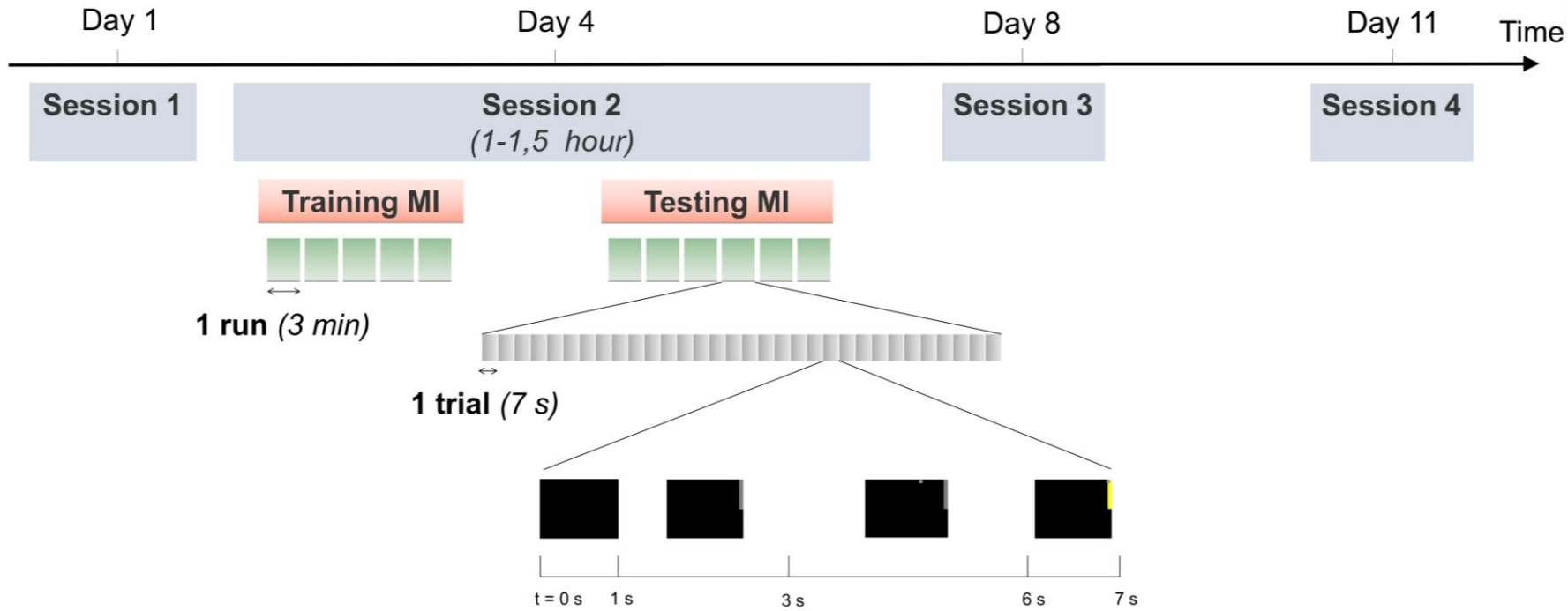
FUSING INFORMATION TO IMPROVE THE CLASSIFICATION



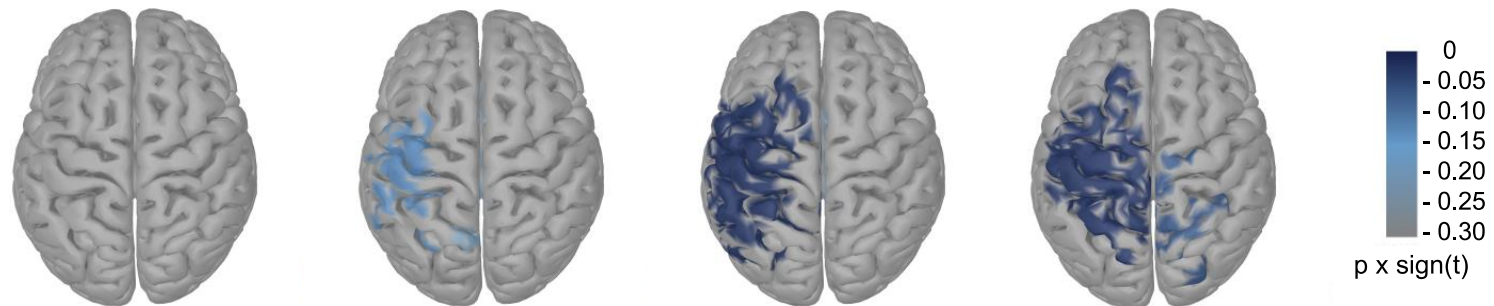
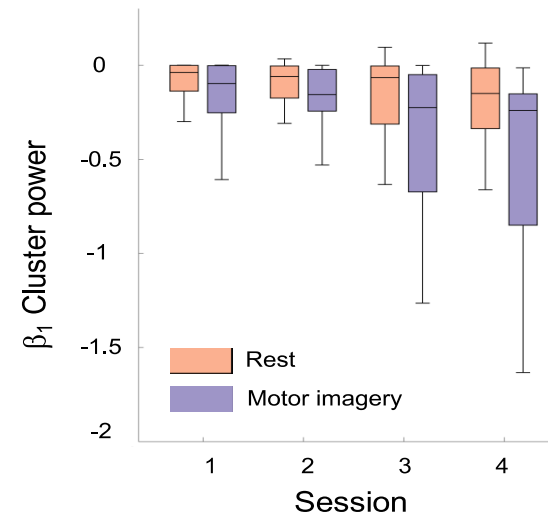
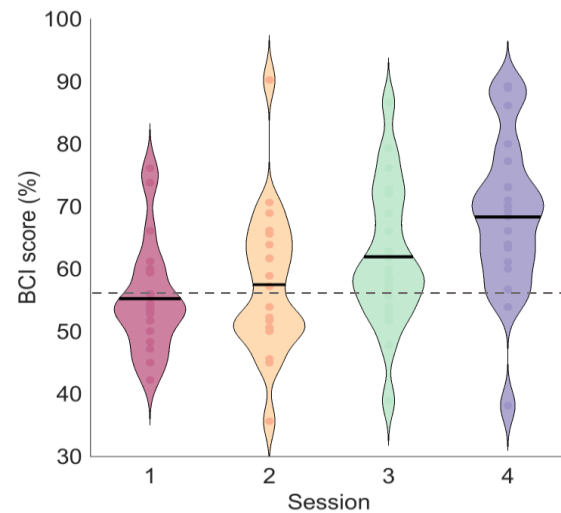
HOW DO WE LEARN TO CONTROL A BCI ?



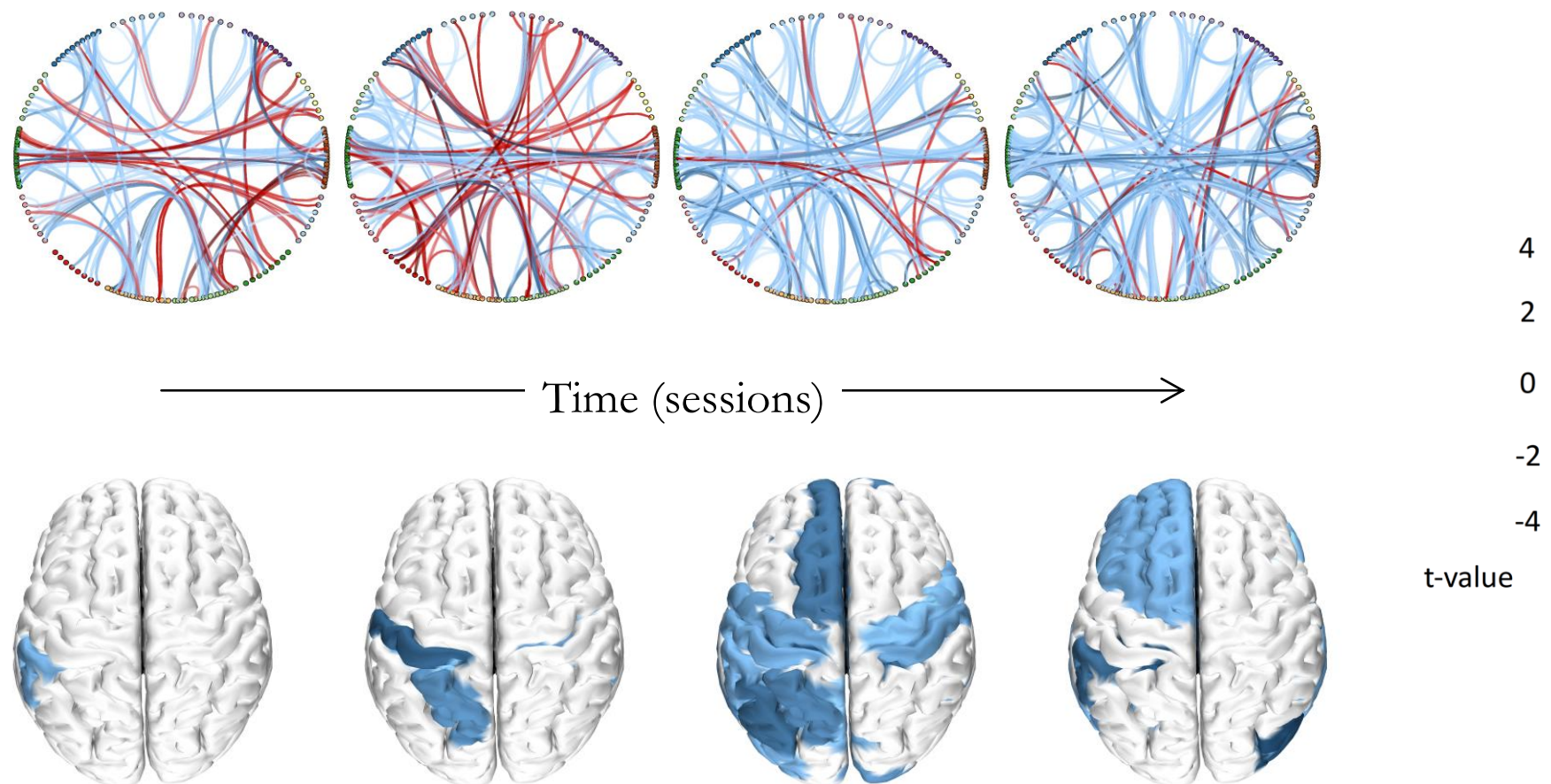
NETBCI project



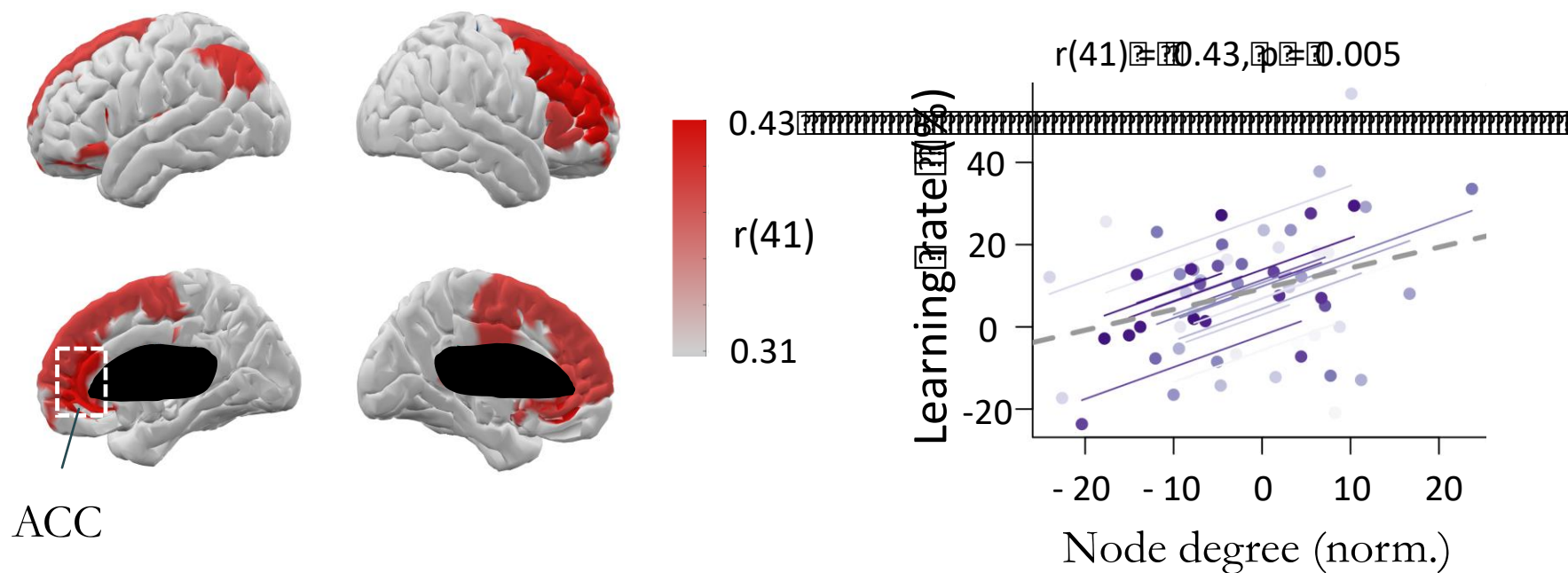
REINFORCEMENT OF MOTOR-RELATED ACTIVITY



FUNCTIONAL DISCONNECTION OF ASSOCIATIVE AREAS



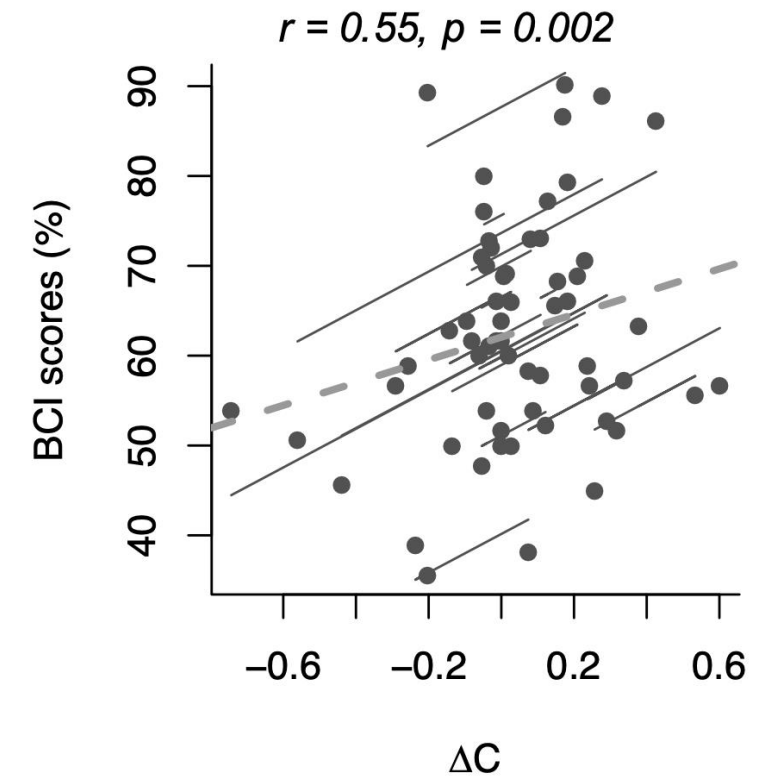
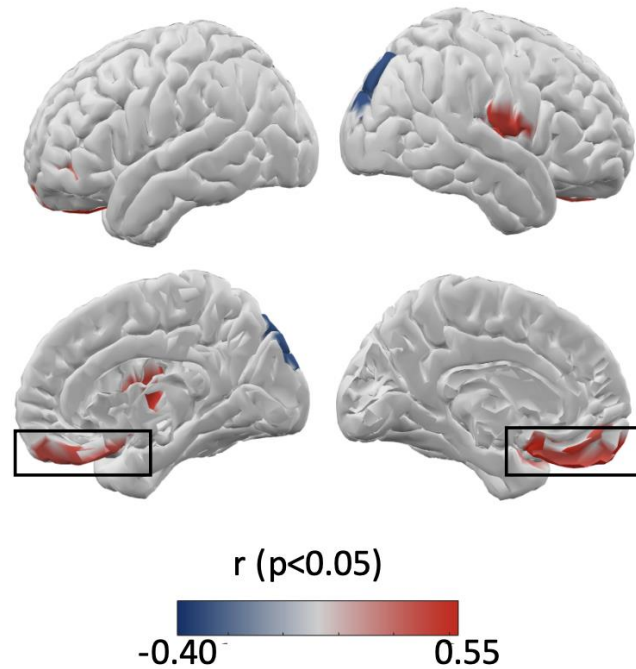
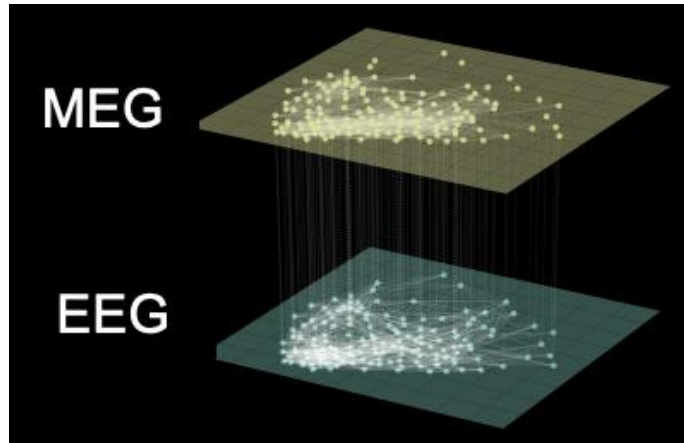
NODE STRENGTH PREDICTS BCI LEARNING RATE



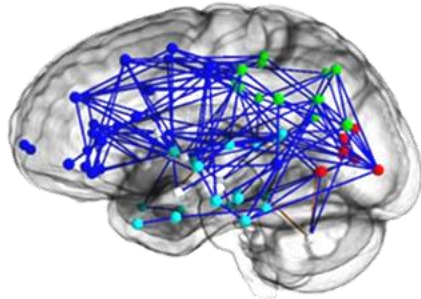
The *reserve* effect

Higher connectivity \rightarrow higher *potential* to disconnect (learning)

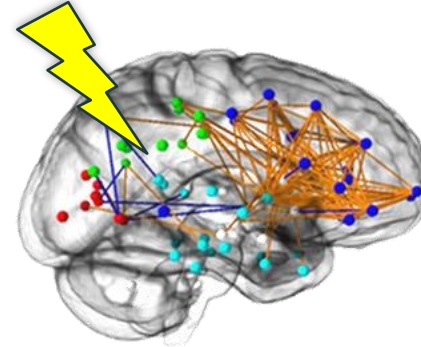
MULTIPLEX CORENESS ASSOCIATED WITH BCI PERFORMANCE



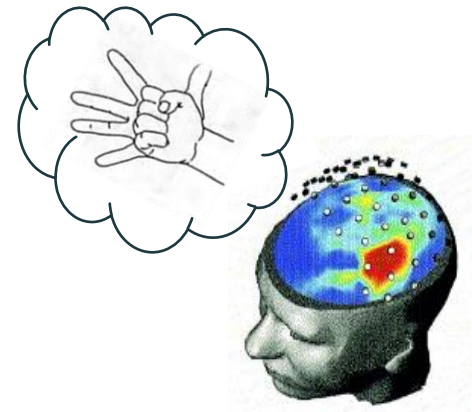
STROKE – CORTICAL REORGANIZATION



Disability

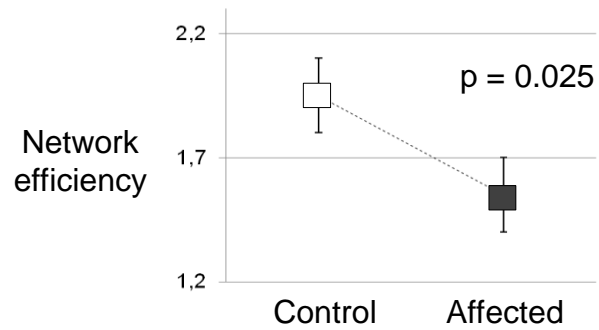
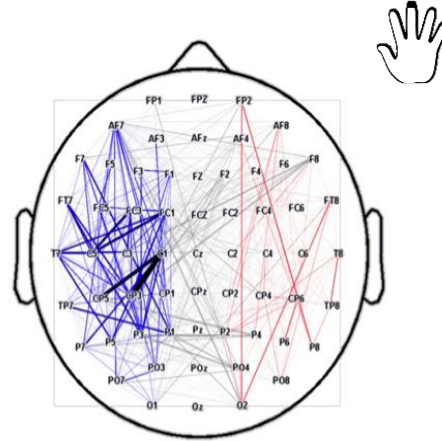


Motor Imagery

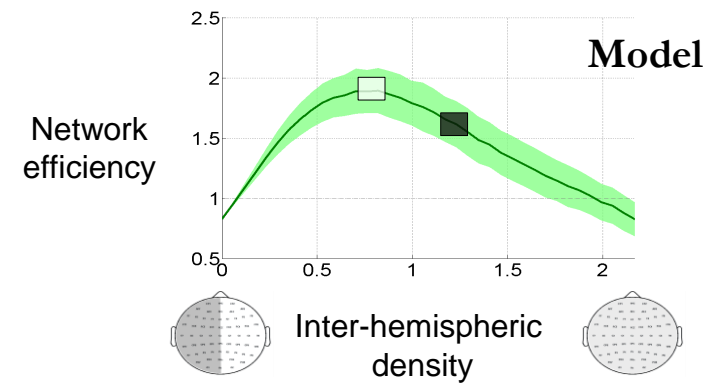
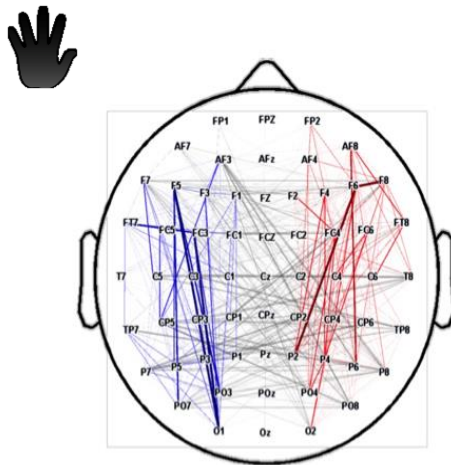


STROKE – INTER-HEMISPHERIC CONNECTIVITY & EFFICIENCY

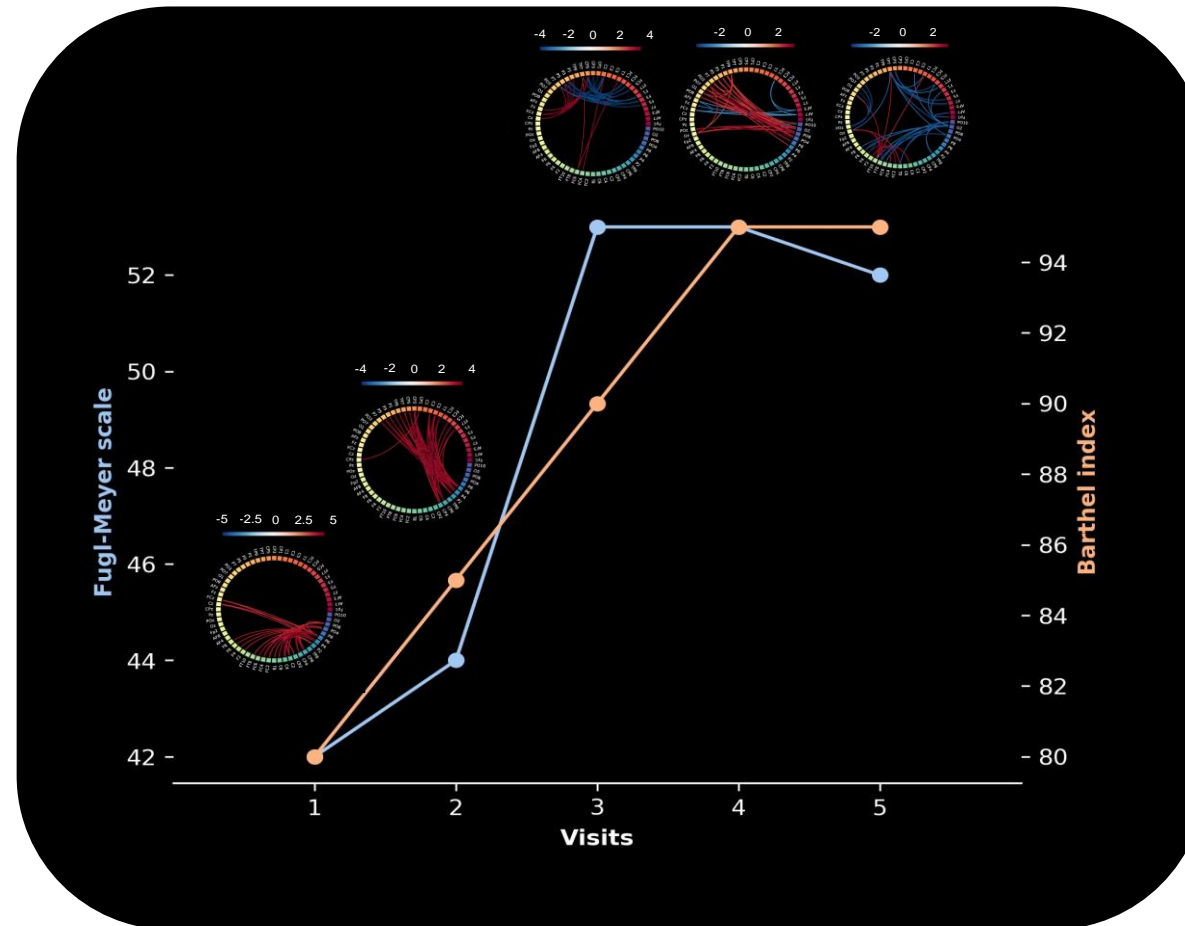
Control



Affected

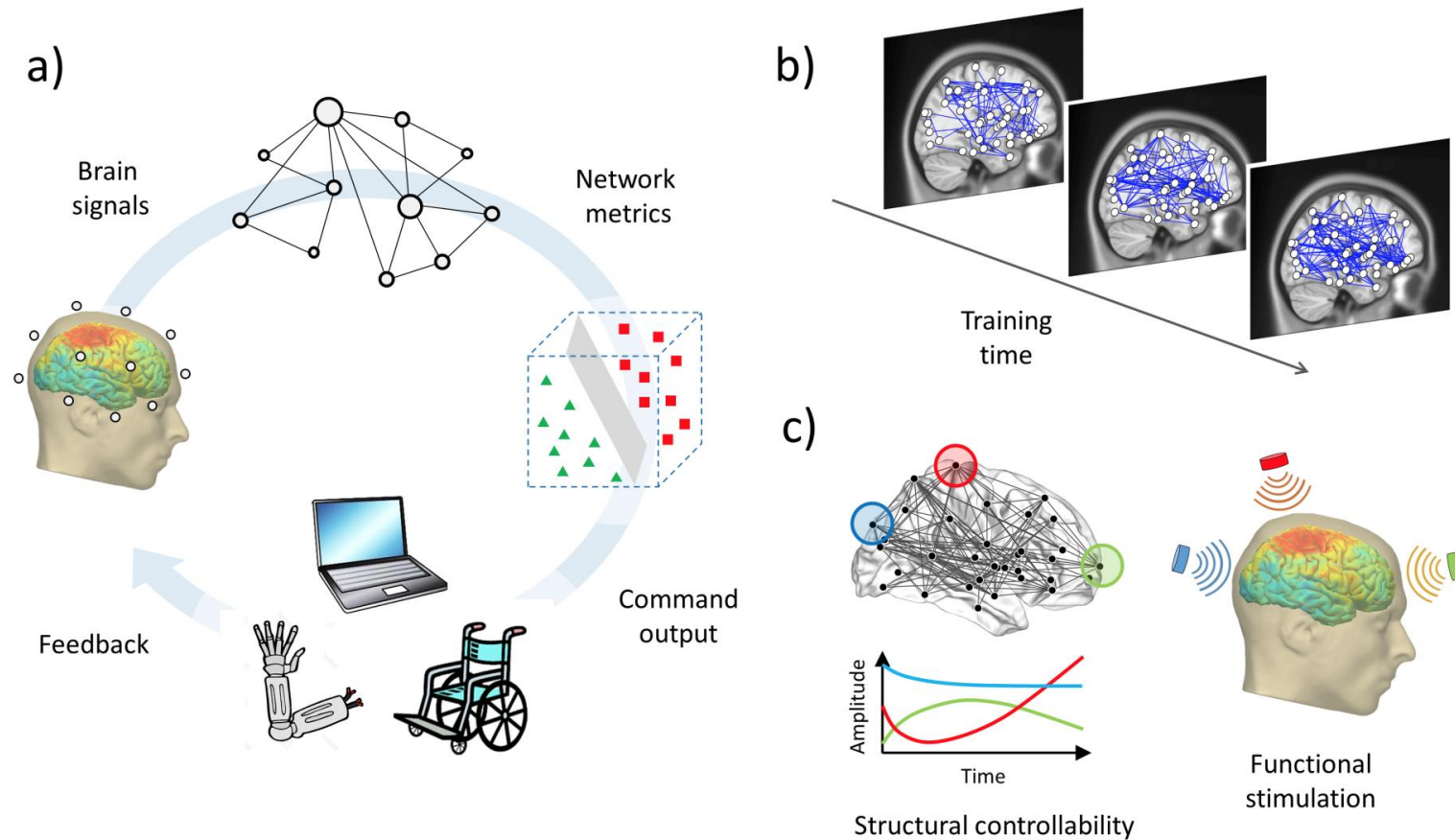


STROKE – SEARCH FOR ALTERNATIVE FEATURES



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

NEW PERSPECTIVES FOR OPTIMIZING BCIS



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