cnbi
Defitech Foundation Chair in
Non-invasive Brain-machine Interface

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Project 1
Control grasping degree of an exoskeleton using a Brain Machine Interface

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Neuroscience Background

- One main property of the brain is the ability of neurons to work in synchrony and to be able to generate oscillatory activity

- Changes in the brain rhythms are observed in the sensory-motor area of brain during planning and execution of movements (Pfurtscheller et al.,1999)

What is motor imagery?

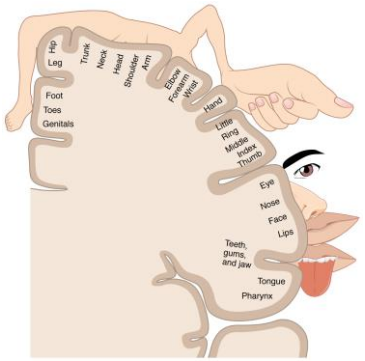
- **Kinesthetic MI**: imagining the feeling associated with performing a movement

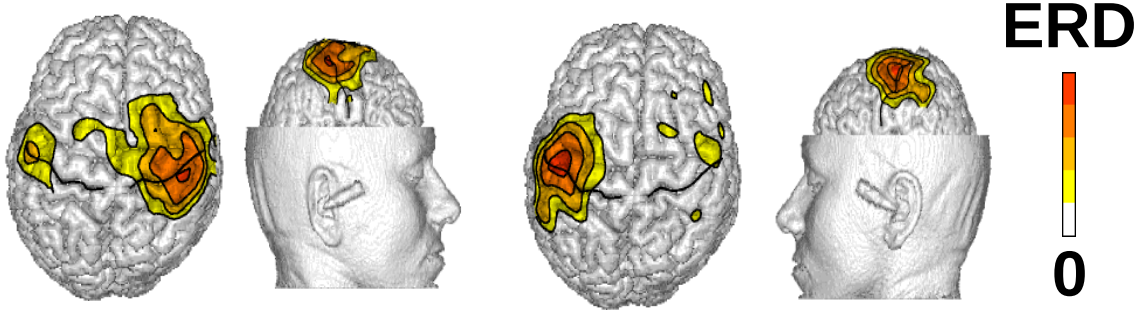
- Motor Imagery (MI) involves activation of the neural system while a person imagines performing a task or body movement without actually physically performing the movement

EEG correlates of motor imagery

Classical EEG correlates of MI: Event related de/synchronization (ERD/ERS)

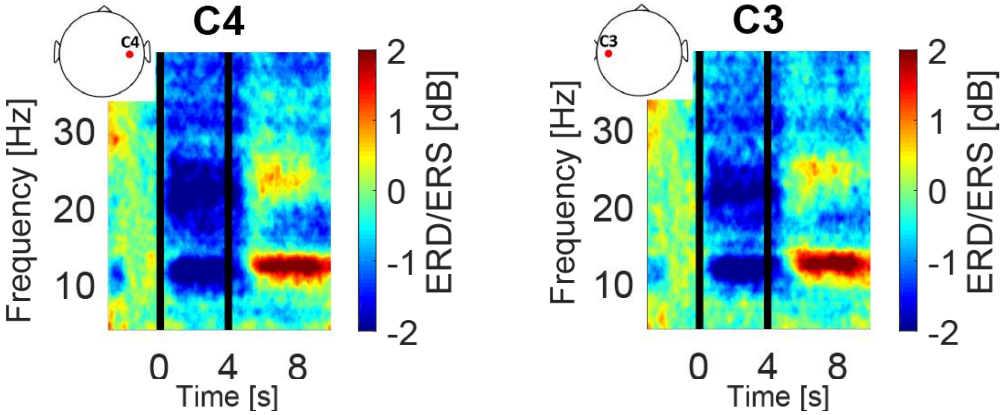
- **Spatio-Spectral characterization** (Pfurtscheller et al.,2006)





- **Spectro-Temporal characterization**

μ (8-12 Hz)
β (13-30 Hz)



Hypothesis

- Most non-invasive BMIs based on voluntary modulations of brain rhythms aim at detecting the initiation of motor imagery (MI).

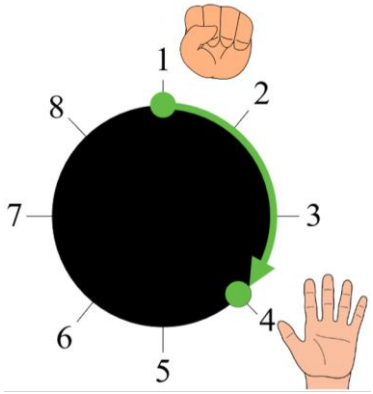
- While decoding of movement initiation is the focus of multiple works, decoding of movement termination has been barely investigated.

Hypothesis: Finer control of neuroprosthetics devices could be reached by combining the decoding of both transitions.

➢ Can we control the grasping degree of an exoskeleton?

Experiment Protocol

MI task

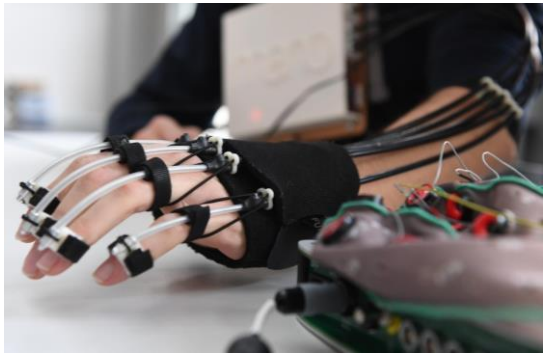


Recording system

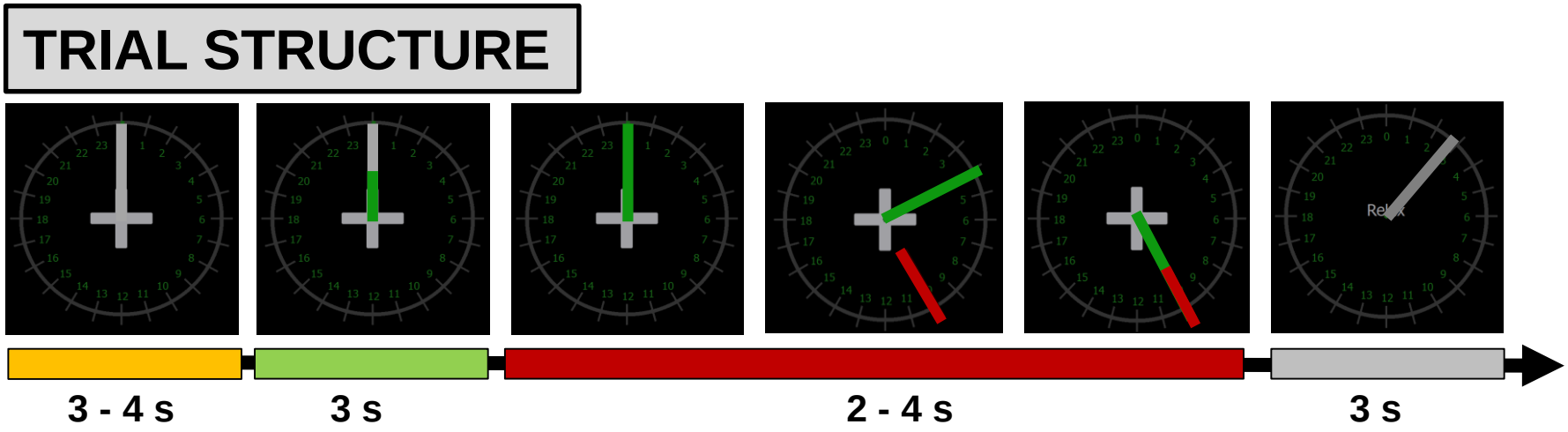
- Gtec USBamp(16 electrodes)
- EMG channels - muscle activity
- Sampling frequency: **512 Hz**

BMI Decoding

Grasping Degree



Training Protocol – Un/Synchronized EXO



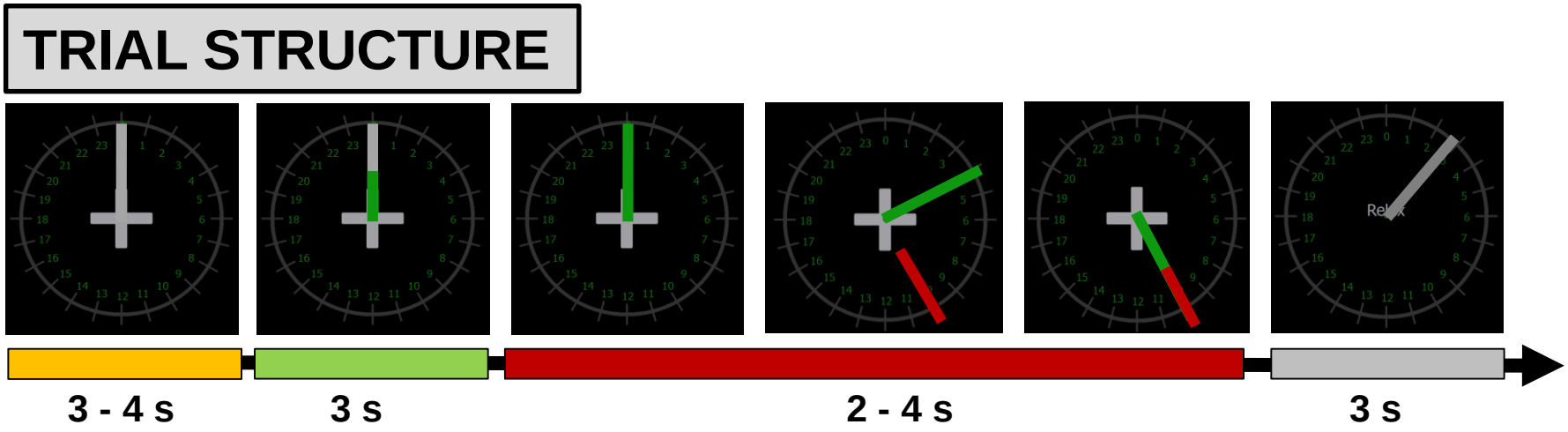
<u>Protocol 1</u>: Unsynchronized EXO (UNSYNC EXO)

- Control of the clock based on MI.
- EXO activated at the end of the trial based on clock

<u>Protocol 2</u>: Synchronized EXO (SYNC EXO)

- EXO is moving synchronously with the clock

Protocol – Un/Synchronized EXO



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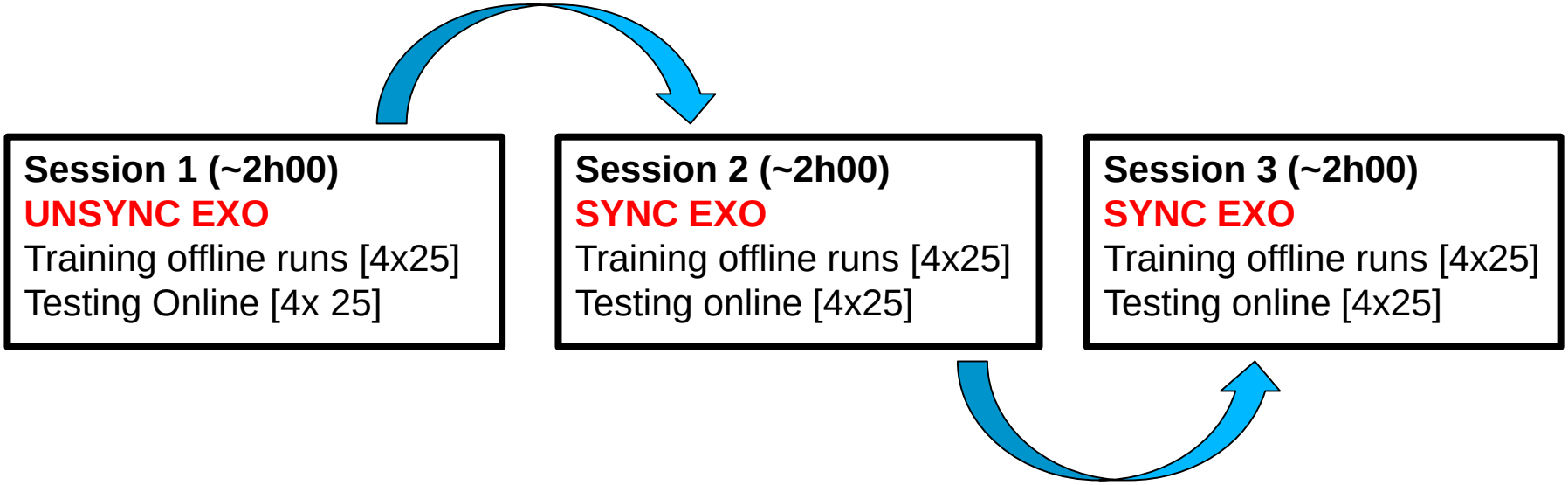
Experiment Design



Data Analysis

Objectives

a) Investigate the neural correlates of MI termination and initiation

b) Develop a BMI for decoding offset transition

c) Control the degree of grasping of an exoskeleton

Pipeline Analysis

1. Load data

- Use sload function (eeglab, common Materials)
- Check header and signal output ? What is important according to you
- Structure your data

2. Preprocessing

- Temporal Filtering ?
- Spatial Filtering: CAR or LSF? (LSF – matrix multiplication, common materials)

3. Epoching for event of interest

- MI-START : 300
- MI-STOP : 555

4. EEG correlates analysis

- Periodogram
- Spectrogram
- Topoplot

Pipeline Analysis

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   - Periodogram
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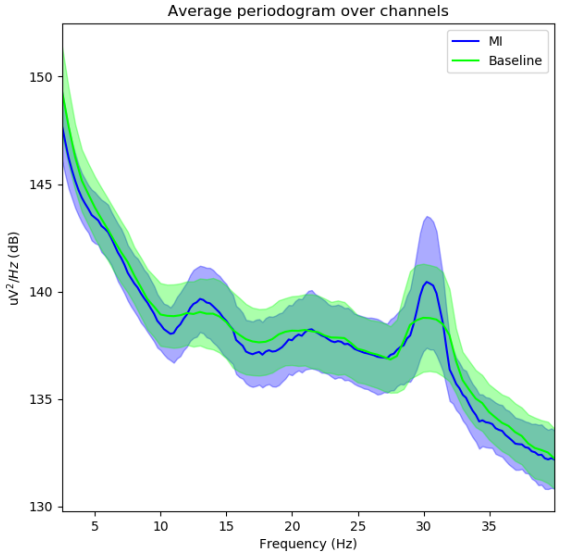
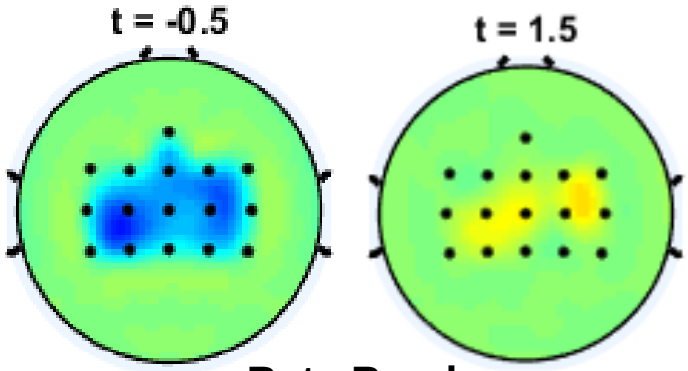
Pipeline Analysis

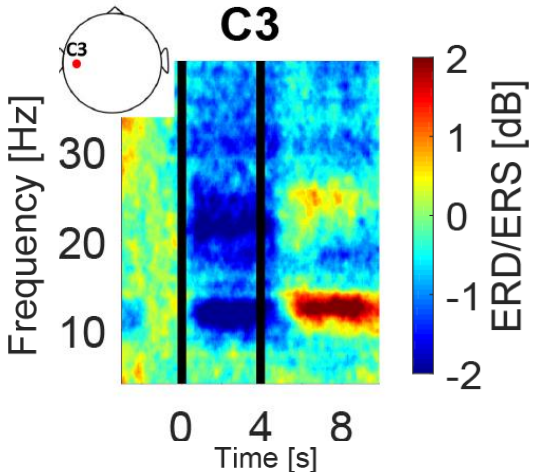
EEG correlates analysis

- Periodogram
- Spectrogram
- Topoplot





Beta Band



Pipeline Analysis

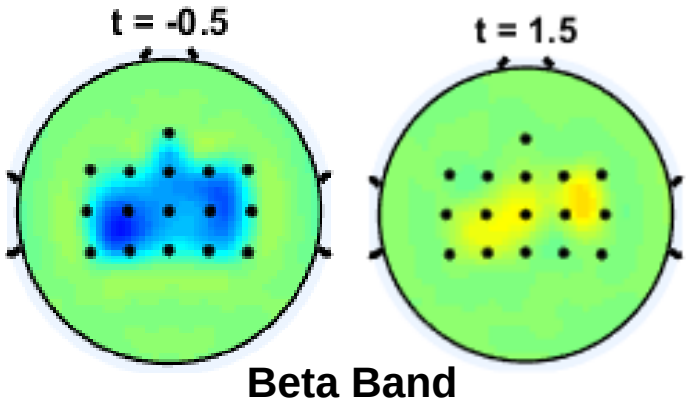
EEG correlates analysis

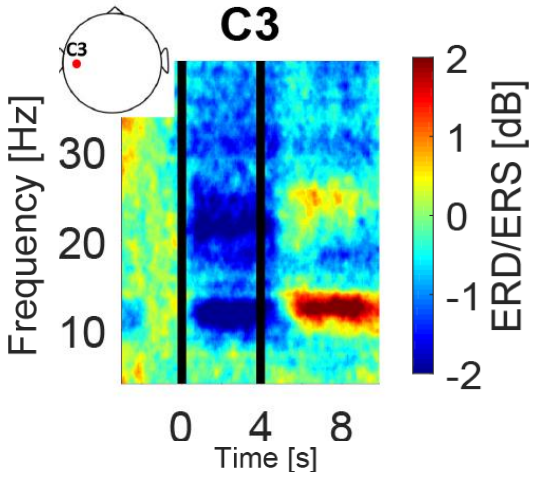
- Periodogram
- Spectrogram
- Topoplot

2 Formulas

$$ERD\% = 100 * \frac{Activity - Baseline}{Baseline}$$

$$ERD(dB) = 10 * log10(\frac{Activity}{Baseline})$$





Pipeline Decoding

1. **Load data**
2. **Preprocessing**
3. **Epoching for event of interest**

4. **PSD computation**
   - *pwelch Matlab* function

   = Power ∀ Freq ∀ Channel
5. **Feature selection**
   - Discriminate between MI and MI-OFFSET
6. **Create classifier & Performance evaluation**
   - Cross-validation
   - Accuracy, AUC/ROC curve
7. **Online classifier & Pseudo-online**

Recording - information

- Fill **google doc**:
- TA info:
  - **Tel:** (+41) 078 737 69 54
  - **Email:** bastien.orset@epfl.ch
- Recording schedule through **DOODLE**:
- 1st Time at Campus Biotech?
  - Entry at biotech require badge, ask one at the reception
  - Call me
- Bring your own shampoo if needed

Thanks for your attention

Questions?

References

Pfurtscheller, G., & Da Silva, F. L. (1999). Event-related EEG/MEG synchronization and desynchronization: basic principles. *Clinical neurophysiology*, *110*(11), 1842-1857.

Pfurtscheller, G., Brunner, C., Schlögl, A., & Da Silva, F. L. (2006). Mu rhythm (de) synchronization and EEG single-trial classification of different motor imagery tasks. *Neuroimage*, *31*(1), 153-159.