

Median nerve stimulation to predict Motor Imagery-BCI performances

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Why predict Motor Imagery (MI)-BCI performances?

- About 30% of users cannot use MI-BCI (**BCI illiteracy or deficiency**) [1, 2].
- To **adapt BCI parameters proactively** and maintain high levels of the subject's motivation [3].
- Identify subjects prior to an experiment according to their BCI performance.

[1] Allison and Neuper, Elsevier, 2010.

[2] Vidaurre et al Brain Topogr, 2009.

[3] Lotte et al. J.Neural Eng., 2018.

Predicting future BCI performances: open research question

- Questionnaires [4, 5, 6, 7, 8]
- SMR predictor (eyes open μ peak power w.r.t noise floor) [9]: $r = 0.53$ (80 subjects)
- PPFactor (ratio of α , β , θ , γ power during non-task related state) [10]: $r = 0.48$
- Spectral entropy (eyes closed) [11]: $r = 0.65$ but $r = 0.23$ in other datasets
- MeanSP (pairs of sensorimotor sources with synchronized μ and β rhythms) [12]: $r=0.53$
- Combined resting state (eyes closed & open power) [13]: $r=0.71$ but $r=0.5$ if outliers not removed

[4] Jeunet et al. PLOS ONE, 2023.

[5] Malouin et al, Neurol. Phys. Ther, 2007.

[6] Cattell and Cattell, Educ. Psychol. Meas, 1995.

[7] Vandenberg and Kuse, Percept. Mot. Skills, 1978

[8] Hammer et al, Biol. Psychol, 2012.

[9] Blankertz et al. NeuroImage, 2010.

[10] Ahn et al. PLOS ONE, 2013.

[11] Zhang et al, Brain Topogr, 2015.

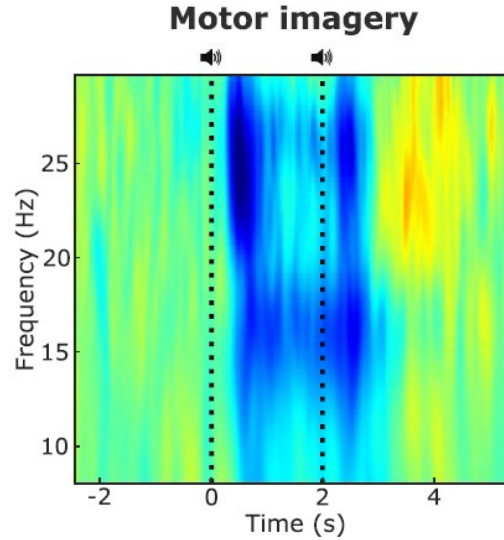
[12] Jorajuría et al, IEEE Trans Neural Sys Rehab Eng, 2023

[13] Kwon et al, Electronics, 2020

Reliable predictor of BCI motor imagery performance using median nerve stimulation

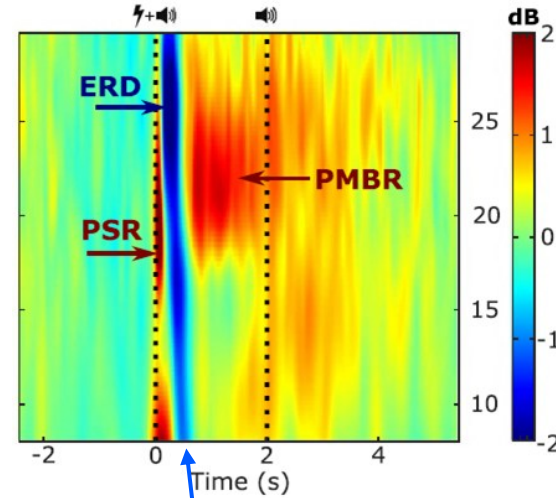
Valérie Marissens Cueva^{1,2,*} , Laurent Bougrain² , Fabien Lotte¹  and Sébastien Rimbart^{1,*} 

Predictor based on MNS



ERD during MI in $\mu+\beta$
ERS after MI in β

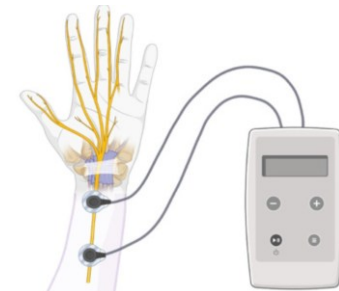
Median nerve stimulation



Minimum ERD value
200:800ms after MNS in
 $\mu+\beta$ (LapC3)

?

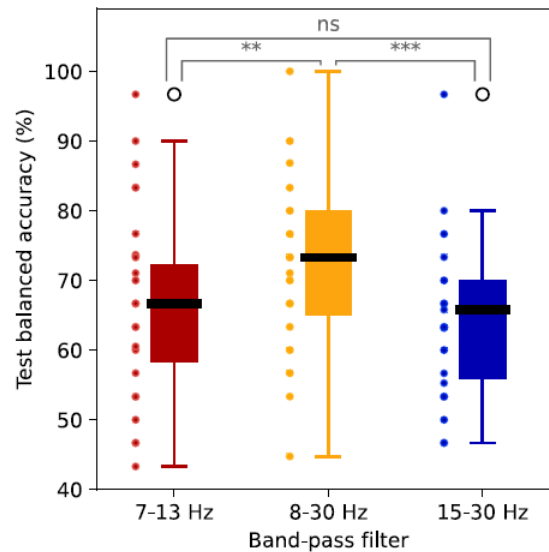
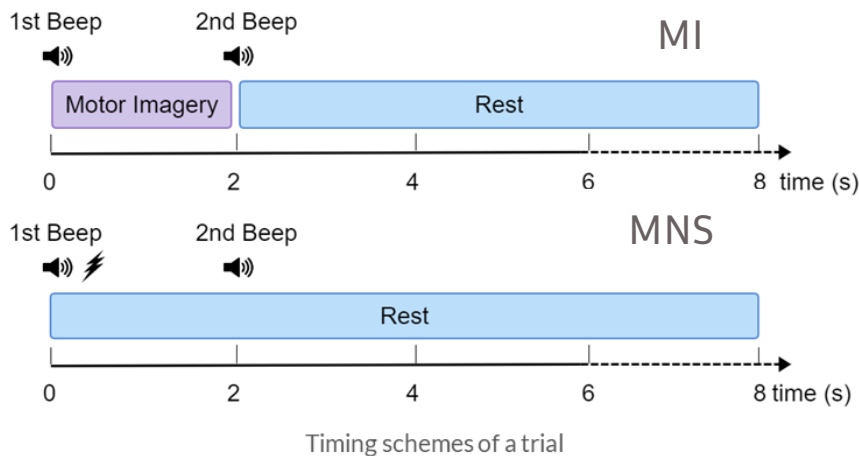
MI-BCI
performances



Thomas Hendry, Neuromod, 2024

Motor Imagery (MI) and Median Nerve Stimulation (MNS)

- 31 right-handed subjects from 2 datasets, closed eyes
- Offline MI vs REST performances
- Tangent Space Logistic Regression

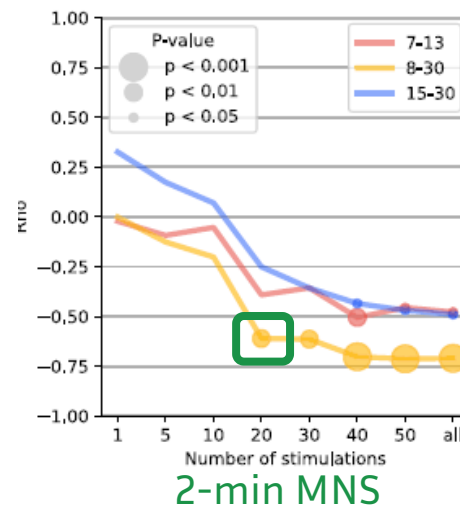


From MNS-feature to MI-BCI performances

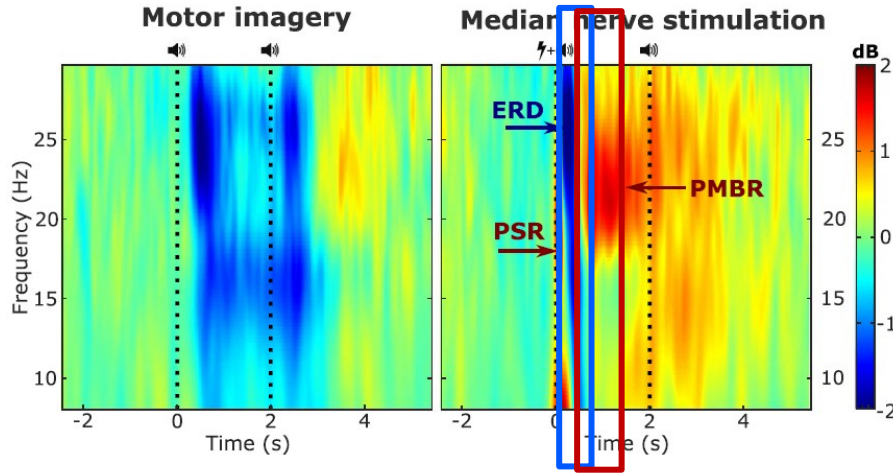
		LapC3 ERD-MNS		
		mu	mu + beta	beta
MI-BCI performance	mu	-0.41*	-0.60**	-0.35
	mu + beta	-0.48*	-0.71***	-0.49*
	beta	-0.16	-0.41*	-0.54**

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Correlation:
MNS-feature & MI-BCI
performances



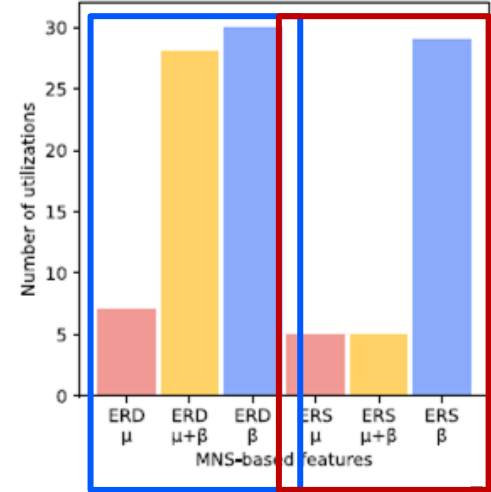
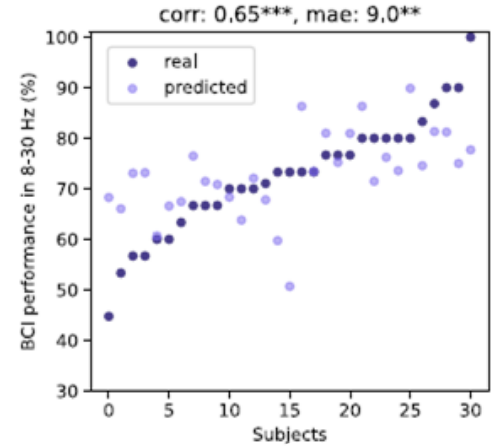
From MNS-feature to MI-BCI performances



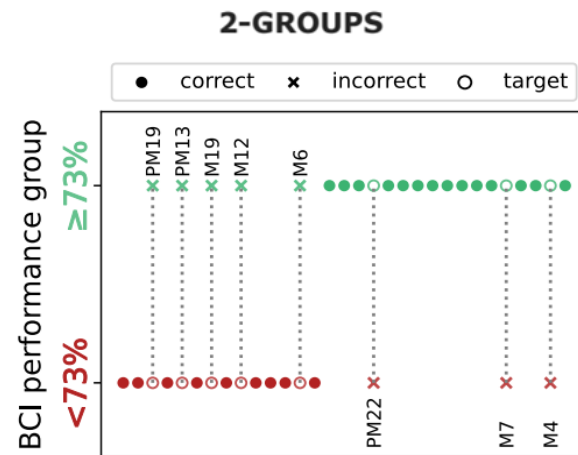
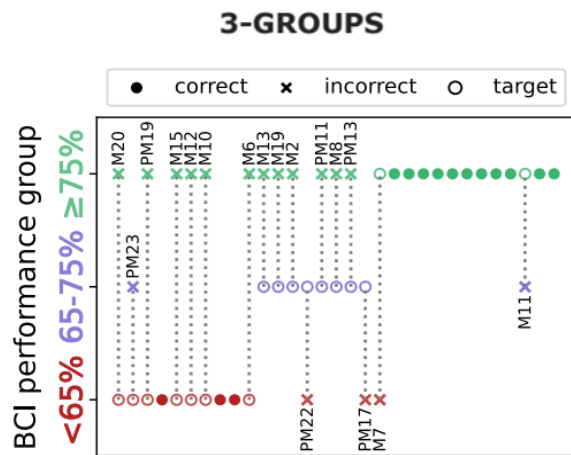
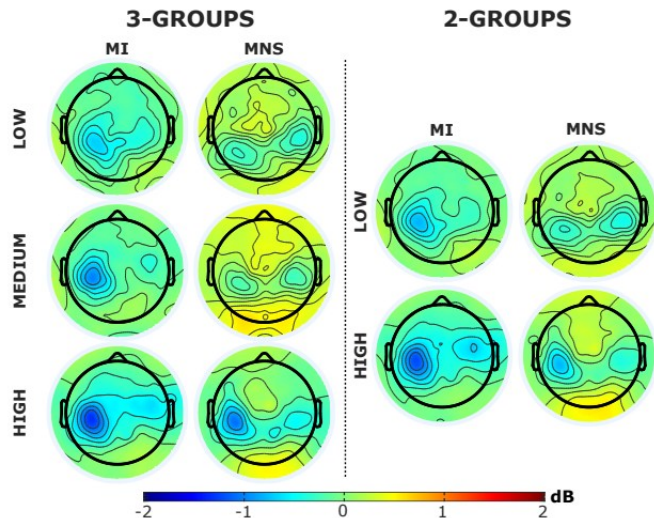
Correlation:
MNS-feature & MI-BCI
performances

Accuracy
prediction
with a LASSO
regression

200-800 ms
150-500 ms



From MNS-feature to MI-BCI performance group



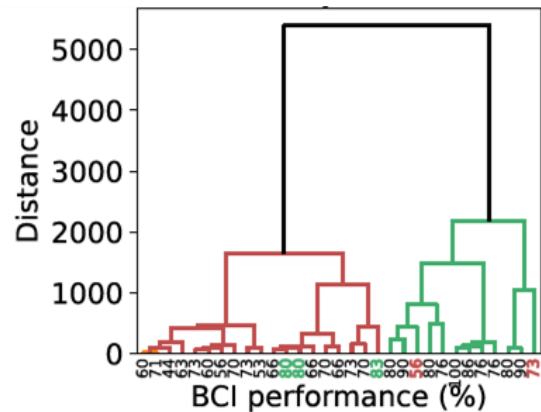
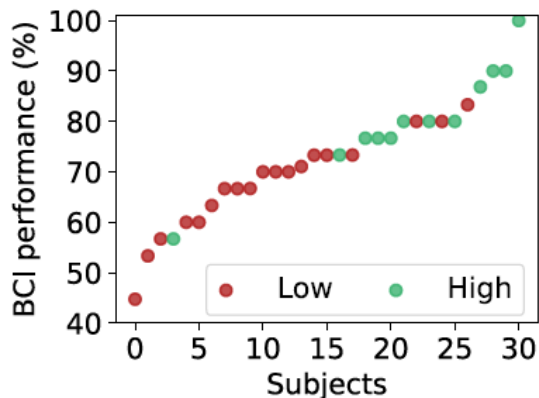
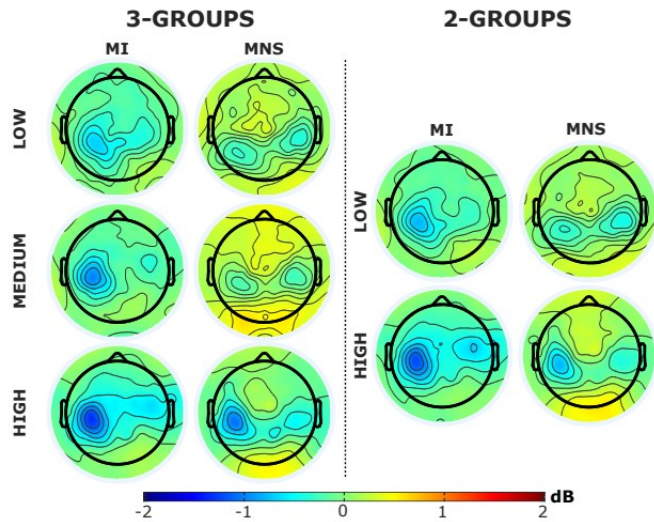
	LDA	LASSO	ElasticNet
low vs. high performers	74.19*	74.19*	58.06
low vs. medium vs. high performers	58.06	45.16	45.16

Correlation:
MNS-feature & MI-BCI
performances

Accuracy
prediction
with a LASSO
regression

Group
prediction
with a LASSO
classifier

From MNS-feature to MI-BCI performance group



Hierarchical Clustering
using only post-MNS ERD features
(83% accuracy w.r.t BCI performance groups)

Correlation:
MNS-feature & MI-BCI
performances

Accuracy
prediction
with a LASSO
regression

Group
prediction
with a LASSO
classifier

Takeaways

- **New predictor of MI-BCI performances:** minimum ERD value post-MNS (200:800 ms) at C3 with small Laplacian.
- There might be **(neuro)physiological and/or anatomical predispositions to successfully use MI-BCIs.**
- Future: integrate **multiple neurophysiological predictors**, such as spectral entropy and the mu peak in the resting state with eyes open, to further enhance MI-BCI performance prediction.

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Inria Center at the University of Bordeaux

BCI4IA: A New BCI Paradigm To Detect Intraoperative Awareness During General Anesthesia



Workshop: Exploring the Clinical Integration of BCI Technology in General Anesthesia Monitoring



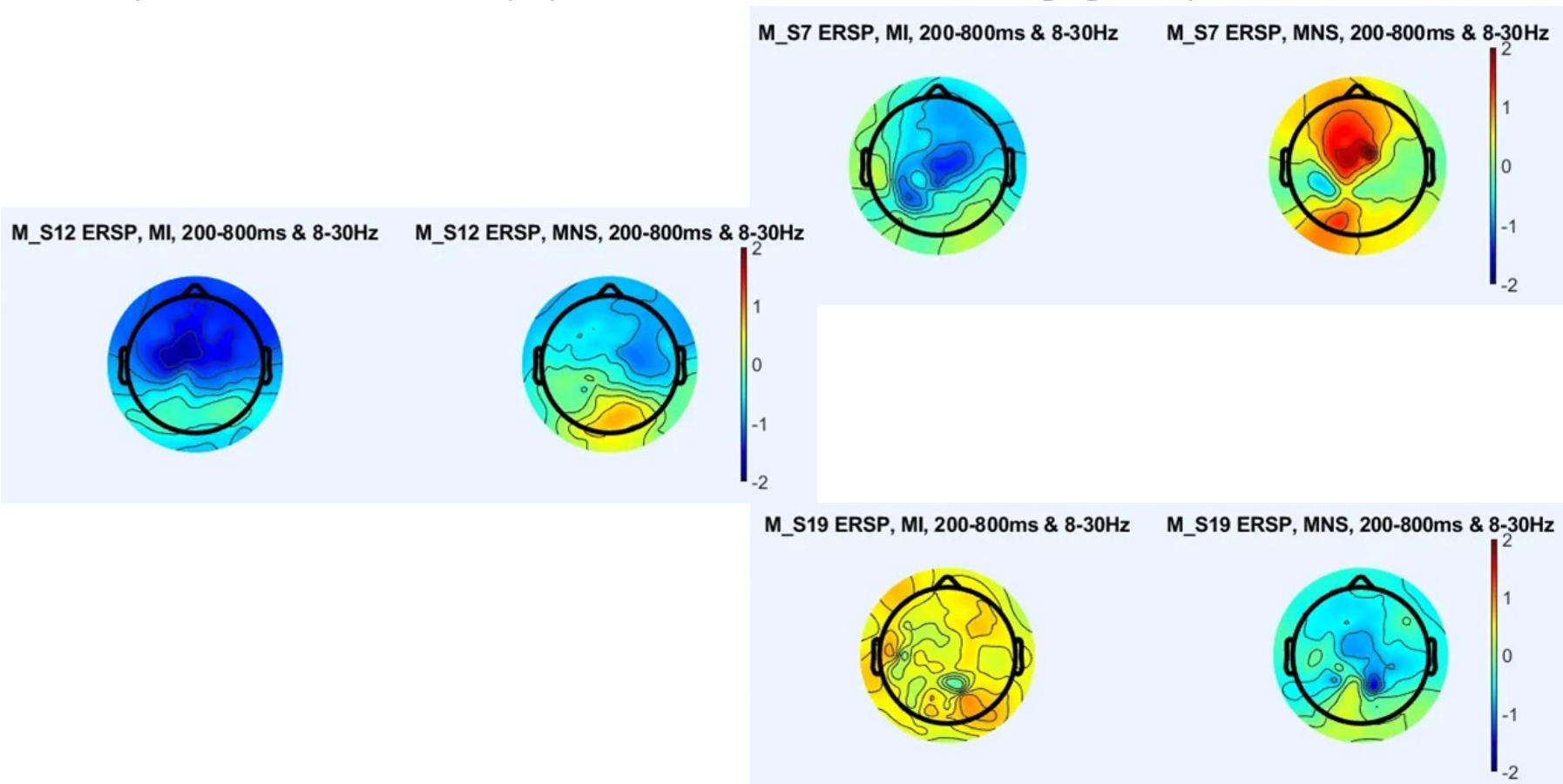
Workshop: Exploring Altered States of Consciousness Through EEG and Brain-Computer Interfaces



Looking for post-doc students !



Subjects consistently predicted in the wrong group

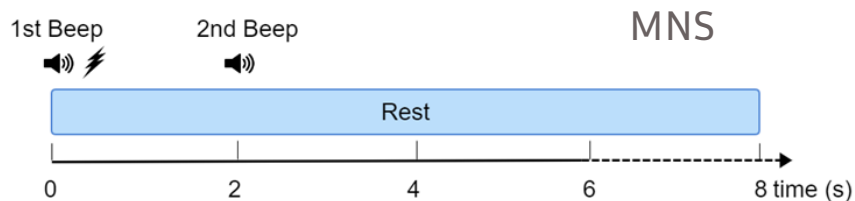
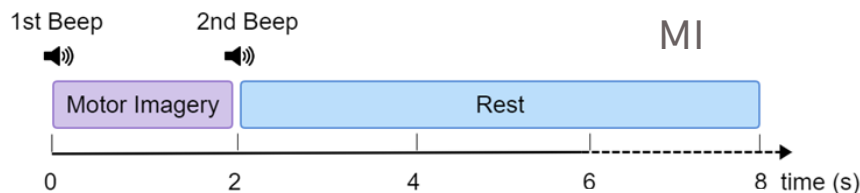


Current limits

- Both datasets with eyes closed during MNS and MI tasks
- MI vs REST performances, whereas most predictors contrast two MI classes
- Only 31 right-handed healthy subjects

Motor Imagery (MI) and Median Nerve Stimulation (MNS)

- MI vs REST
- 31 right-handed subjects from 2 datasets
- Closed eyes
- 40 sensorimotor electrodes
- Tangent Space Logistic Regression
- Train 35:44 trials and test 15:19 trials



Timing schemes of a trial

