Instituts thématiques Inserm — Institut national de la santé et de la recherche médicale
BESANÇON NEUROSCIENCES Intégratives & Cliniques
Universität Konstanz
cnrs
UBFC UNIVERSITÉ BOURGOGNE FRANCHE-COMTÉ
University of St.Gallen
CHRU Besançon centre hospitalier régional universitaire

Support Vector Machines applied to EEG: a reliable pipeline for tough problems

Joucla C.[1], Gabriel D.[1,2], Ortega J-P.[4,5], Haffen E.[1,2,6], Grigoryeva L.[3]

[1] Neurosciences intégratives et cliniques EA 481, Université de Franche-Comté, F-25000 Besançon, France
[2] INSERM CIC 1431, CHRU Besançon F-25000 Besançon, France
[3] Department of Mathematics and Statistics, Universität Konstanz, Germany
[4] Centre National de la Recherche Scientifique (CNRS)
[5] Faculty of Mathematics and Statistics, University of St. Gallen, Switzerland
[6] Service de Psychiatrie de l'adulte, CHRU Besançon, F-25000 Besançon, France

Context

- Machine learning methods based on EEG measurements are increasingly popular in clinical fields.
- Potential outcome: moving from group-level statistical results to personalized diagnosis.

Purpose

The object of the present study is to address the following issues:

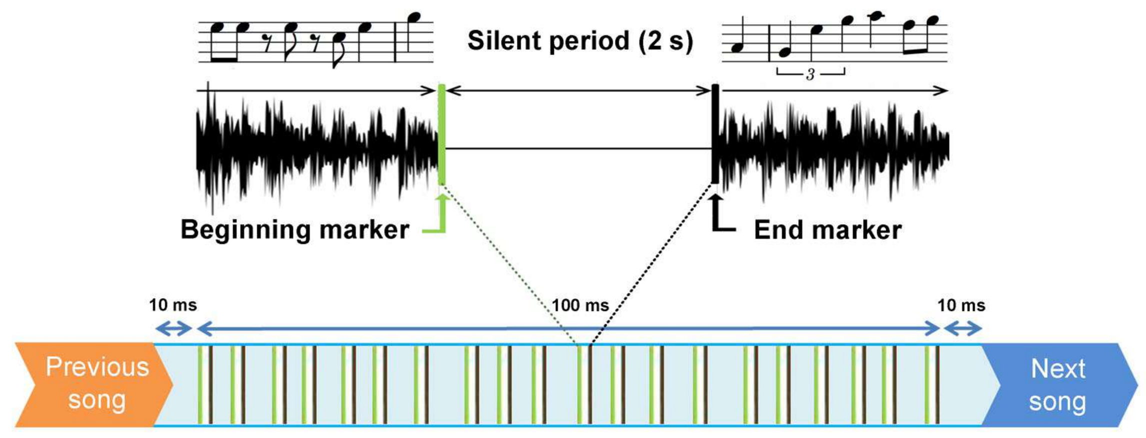
1- Comparing several features extraction methods,

2- Highlighting the importance of hyperparameters choice in standard methods like SVM,

3- Providing a pipeline allowing for reliable results with no overfitting.

Data acquisition

EEG recording using *Electrical Geodesic* Sensor Net, 257 channels.



High resolution ElectroEncephaloGraphy: 257 channels
Sampling rate: 1000 Hz Bandpass: 1-30 Hz

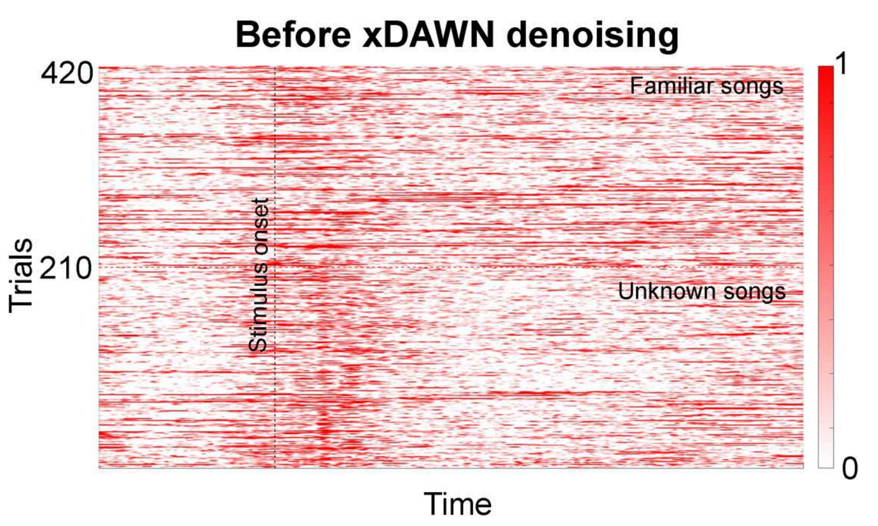
20 subjects listening to 10 familiar songs vs 10 unknown songs
21 silent periods in each song ➡ spontaneous auditory imagery

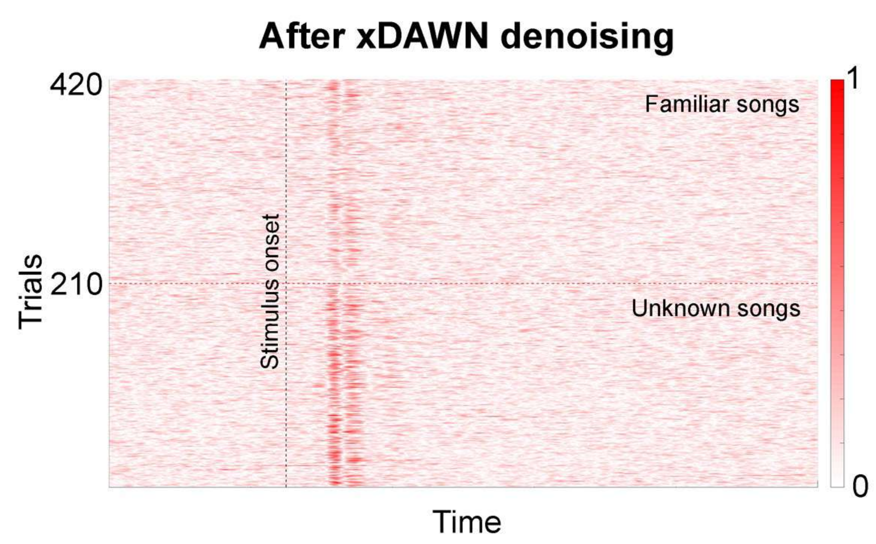
xDAWN denoising

Raw EEG contains the desired ERP, but also:
- unrelated activity of the brain
- muscular and/or ocular artifacts

➡ signal-to-noise ratio very low

➡ detection of target stimuli difficult from single trial





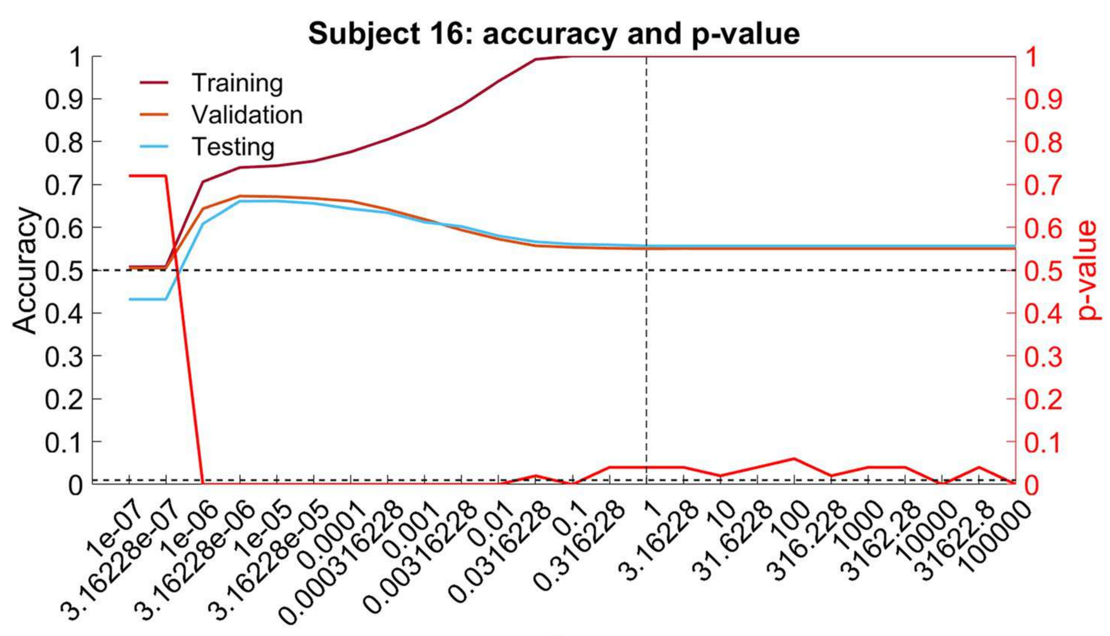
xDAWN algorithm to estimate Evoked Response Potentials subspace:

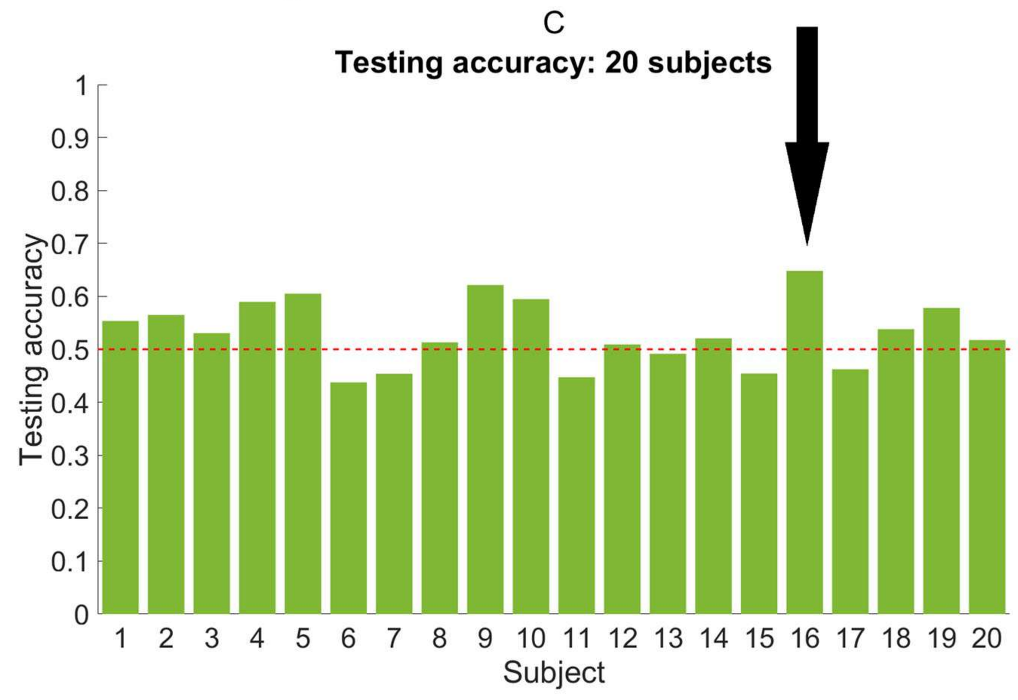
1. Compute QR factorization of X (all trials concatenated): $X = Q_X R_X$
2. Compute QR factorization of D (Toeplitz matrix): $D = Q_D R_D$
3. Compute Singular Value Decomposition of $Q^T_D Q_X$: $Q^T_D Q_X = \Phi \Lambda \Psi^T$
4. Select component (Φ_1, Ψ_1) associated with largest singular value λ_1
5. Estimate spatial filter: $(\hat{u}_1, a'_1) = R^{-1}_X \psi_1, R^{-1}_D \varphi_1 \lambda_1$

SVM classification: linear kernel

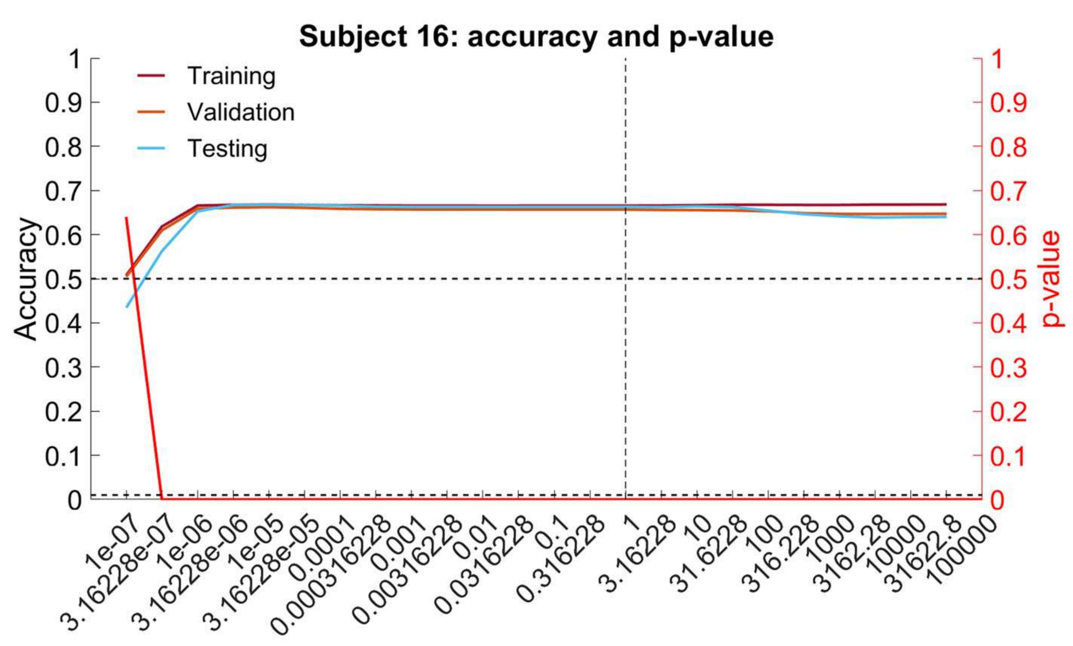
Temporal domain: Global Field Power

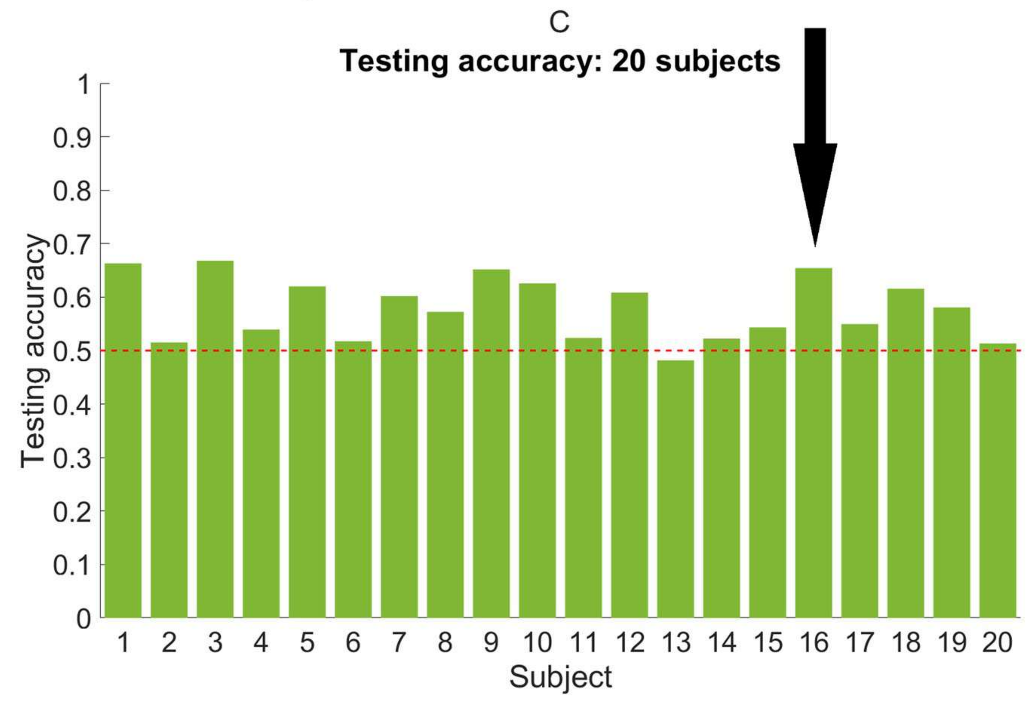
$$GFP = \sqrt{\frac{\sum_1^{nb_{electrodes}} AverageReferencedData_i^2}{nb_{electrodes}}}$$



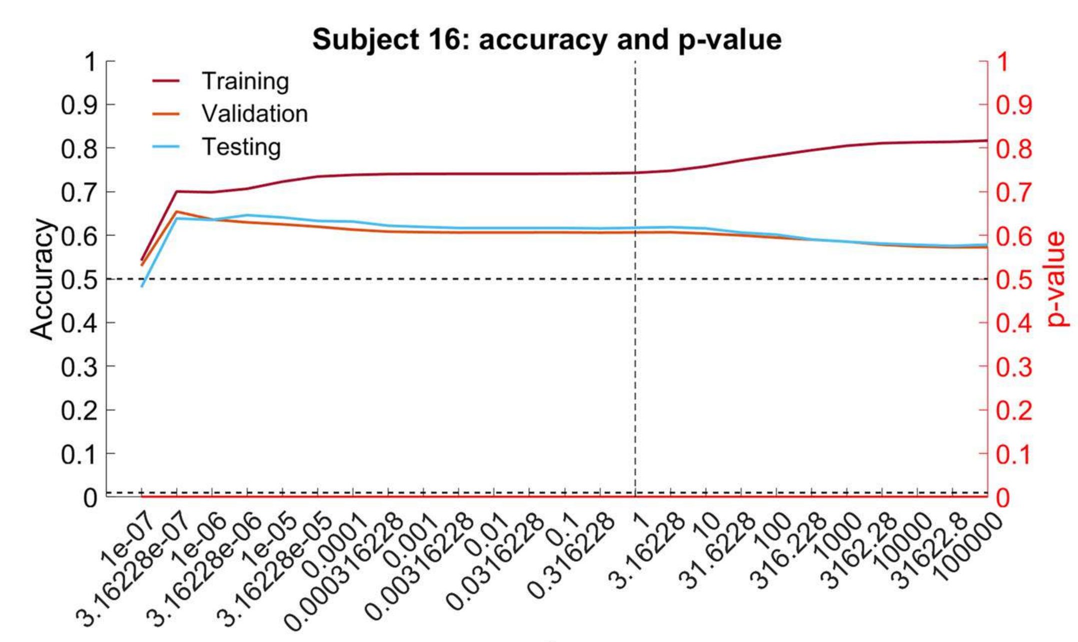


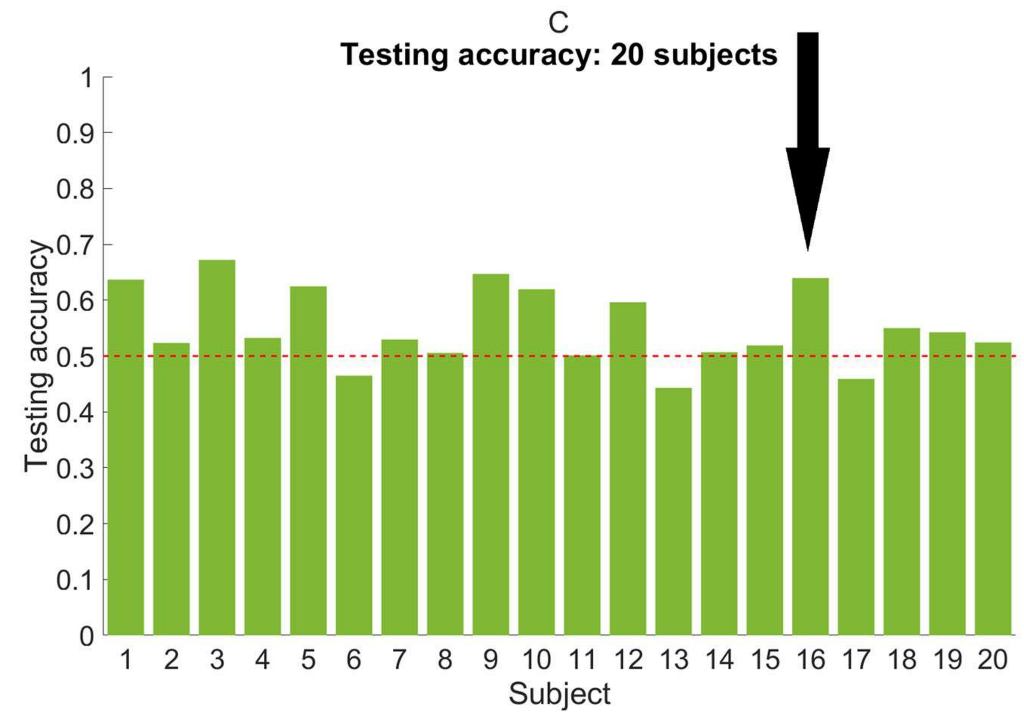
Frequency domain: Fourier transform on 4 bands
θ band: 4-8 Hz,
α band: 8.5-12 Hz,
β_1 band: 12.5-18 Hz,
β_2 band: 18.5-30 Hz.





Frequency domain: Fourier transform
All frequency powers 1-30 Hz





Future directions

- **Selection of spatial regions of interest**
- **Use of genetic algorithm to optimize the window of interest**
- **Radial Basis Function as kernel**
- **Benchmark for Echo State Network**

Contact

coralie.joucla@univ-fcomte.fr

dgabriel@chu-besancon.fr