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Claire Cury, Pierre Maurel, Rémi Gribonval, Christian Barillot

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Can we learn from coupling EEG-fMRI to enhance neuro-feedback in EEG only?

C. Cury1,2, P. Maurel3, R. Gribonval2 and C. Barillot1
1 – CNRS, Inserm, Inria, Univ Rennes, IRISA, Empenn team
2– CNRS, Inria, Univ Rennes, IRISA, Panama team

INTRODUCTION

Neuro-feedback (NF): Learn to control your brain with your brain.

EEG and fMRI, grounds solutions in the context of brain rehabilitation protocols.

EEG and fMRI provide complementary information.

EEG is easy to use, fMRI is a costly and exhausting for patients modality

Bi-modal NF:
- Records and synchronises EEG and fMRI signals, in real time (Mano et al).
- Combines NF-EEG and NF-fMRI advantages
- Improve the quality of NF sessions (Perronnet et al).

→ Can we enhance NF in EEG only, from a previous bi-modal NF session?

METHOD

- Design and strategy: Machine learning mechanism based on bimodal NF scores and EEG signals.

- Model: Non linear structured design matrix X

- Optimisation: structured sparse regularisation following 3 conditions:
  1. Spatial sparsity
  2. Smooth across frequency bands

RESULTS

- Significant information from NF-fMRI can be captured by the model, and enhance EEG only neurofeedback.
- Prediction with NF-predictor S with a median correlation of 0.74

• Method tested on 17 subjects with 3 bimodal neuro-feedback sessions of motor imagery tasks.
• We tested 5 NF-predictors:
  1. \( \hat{Y}_{EEG}(t) = (X, \alpha) \), learned from X and NF\(_C\) = NF-EEG + NF-fMRI
  2. \( \hat{Y}_{EEG}(t) = (X, \alpha) \), learned from X and NF-EEG
  3. \( \hat{Y}_{fMRI}(t) = (X, \alpha) \), learned from X\(_f\) and NF-fMRI
  4. \( \hat{Y}_{EEG}(t) + \hat{Y}_{fMRI}(t) \)
  5. \( \hat{y}_C(t) + \hat{y}_C(t) \), with \( y_C(t) = \) NF-EEG(t)

References:

Average and absolute activation patterns over all subjects and frequency bands

Example of prediction

EEG + fMRI NF

Estimated by the model

Application to learning set

Application to testing set

Detailed analysis of all conditions: Spatial Sparsity, Smooth across frequency bands, Group selection of frequency bands.