Can we learn from coupling EEG-fMRI to enhance neuro-feedback in EEG only?
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**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 ty use, fMRI is a costly and exhausting for patients modality.

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

**METHOD**

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

- **Model**: Non linear structured design matrix $X$

  \[
  X = [X_0; X_3; X_4; X_5] \in \mathbb{R}^{T \times 4 \times 8}, \text{ with } X_i \in \mathbb{R}^{T \times 4 \times 8}
  \]

  $X_3(t, e, b) = \text{Freq}(\text{EEG}(e, l, B), F_b), \forall t \in \{1, ..., T\} \text{ and } \forall b \in \{1, ..., B\}$

  $X_4(e, b) = X_0(e, b) + \text{HRF}(4)$

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

\[
\hat{\alpha} = \arg \min_{\alpha} \sum_{t=1}^{T} \frac{1}{2} (\text{NF}(t) - \langle X(t), \alpha \rangle)^2 + \lambda \|\alpha\|_2 + \rho \|\alpha\|_1
\]

Cond 1 and 2. Cond 3.

**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 neurofeedback sessions of motor imagery tasks.**
  - We tested 5 NF-predictors:
    1. $\hat{y}_{NF}(t) = \langle X, \alpha \rangle$, learned from $X$ and $NF_{EEG} = NF_{EEG} + NF_{fMRI}$
    2. $\hat{y}_{NF}(t) = \langle X, \alpha \rangle$, learned from $X$ and NF-EEG
    3. $\hat{y}_{NF}(t) = \langle X, \alpha \rangle$, learned from $X$ and NF-fMRI
    4. $\hat{y}_{NF}(t) + \hat{y}_{E}(t)$
    5. $y_{E}(t) + \hat{y}_{NF}(t)$, with $y_{E}(t) = NF_{EEG}(t)$

- **Example of prediction**
  - Average and absolute activation patterns over all subjects and frequency bands.

**References**


