

# RNN-LSTM neural network for predicting fMRI neurofeedback scores from EEG signals



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## Introduction

- Neurofeedback (NF) training is more effective with **simultaneous EEG-fMRI** acquisitions [1].
- However, **the use of MRI is expensive** and draining for the subject.
- So, we need to **reduce its use**.

→ We propose a method based on a **long short-term memory (LSTM) recurrent neural network (RNN)**. With this model, we aim to predict fMRI information from EEG recordings.

## Objective

Learning a **neural network model** from simultaneous EEG-fMRI data to **predict NF-fMRI scores** from **EEG signals alone**.

## Methods

1. **Data:** We acquired **simultaneous EEG-fMRI data** on 15 healthy subjects in a motor imagery context, described in [2]. This includes fMRI and EEG data for three NF runs of five minutes per subject, with their respective NF scores.
2. **Preprocessing:** We extract **usual features for each EEG electrode**, such as mean, standard deviation, skewness, kurtosis,  $\alpha$ ,  $\beta$ , and  $\sigma$  band powers.
3. **Training:** We **train the RNN-LSTM model**. The training, validation, and test datasets are each composed of 15 runs, one per subject.
4. **Analysis:** After the model is trained, **NF-fMRI scores are predicted**, to which the true NF-EEG scores are added for comparison with the NF-EEG-fMRI ground truth.

## Discussion

We are currently working on improving the correlations, which are negatively impacted by:

- Sensitivity to the neural network **hyperparameters**
- Noisy nature of the **EEG modality**
- **Lack of data**

## Conclusion

- The interest of this method compared to the previous modeling [3] is to train a single **deep learning model** for all subjects, which would eventually allow the use of the model to predict these fMRI scores directly online.
- An important aspect of the issue is to **interpret this model**, in order to understand links between EEG and fMRI.

# Can neural networks help improve portability of combined EEG – fMRI neurofeedback?



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## Results

	NF-fMRI	NF-fMRI + NF-EEG
Mean RMSE	0.41	1.34
Mean correlation	0.10	0.59
Min-max correlation	(-0.15 → 0.36)	(0.38 → 0.72)

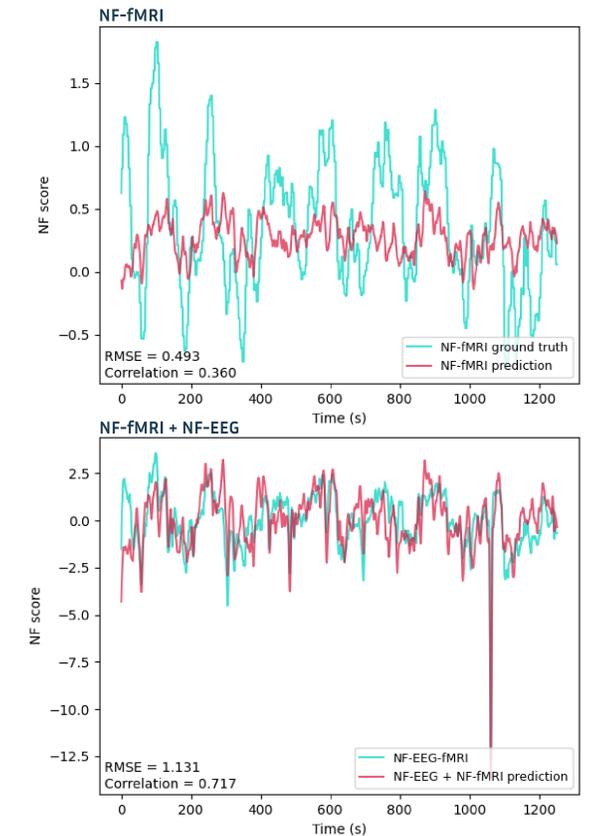


Fig. 1: Comparison between NF-fMRI ground truth and NF-fMRI prediction for the best subject (top), to which the true NF-EEG scores are added, and compared with the true combined NF-EEG-fMRI scores (bottom).



1. Perronnet et al. "Unimodal versus bimodal EEG-fMRI neurofeedback of a motor imagery task." (2017)
2. Lioi et al. "Simultaneous EEG-fMRI during a neurofeedback task, a brain imaging dataset for multimodal data integration." (2020)
3. Cury et al. "A sparse EEG-informed fMRI model for hybrid EEG-fMRI neurofeedback prediction." (2020)



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