Hybrid EEG and fMRI platform for multi-modal neurofeedback

Marsel Mano[1,2,4,5,6], Elise Bannier[2,3,4,5,6], Lorraine Perronnet[1,2,4,5,6], Anatole Lécuyer[1,2,5,6], Christian Barillot[2,4,5,6]

[1]Inria, Hybrid Team, Rennes, France
[2]Inria, VisAGeS Projec-Team, Rennes, France
[3]Service de Radiologie, CHU Pontchaillou, Rennes, France
[4]VisAGeS U1228, Inserm, F-35042 Rennes, France
[5]UMR CNRS 6074, IRISA, Rennes, France
[6]University of Rennes I, Rennes, France

Introduction

- Neurofeedback (NF) is defined as the self-regulated change of a particular brain activity that is reflected in the change of one or several neurosignals captured by brain activity measurement technologies such as electroencephalography (EEG), functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG), or near-infrared spectroscopy (NIRS).

- In this work, we propose a hybrid EEG-fMRI platform that we have developed for our NF experiments, including its hardware/software components and their roles
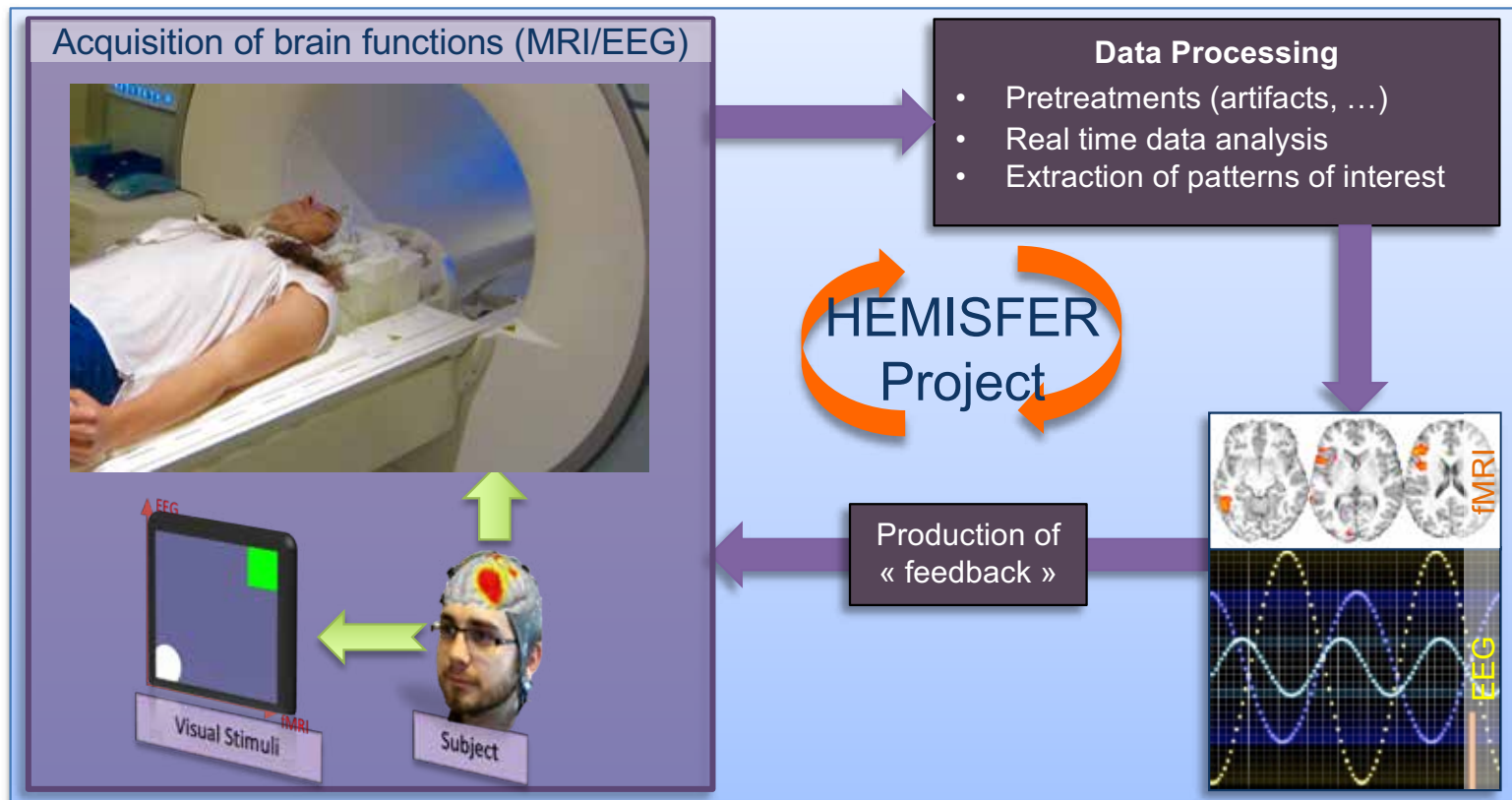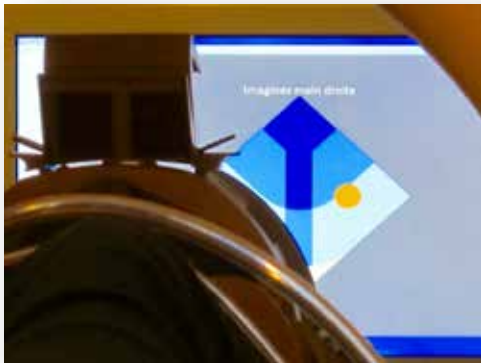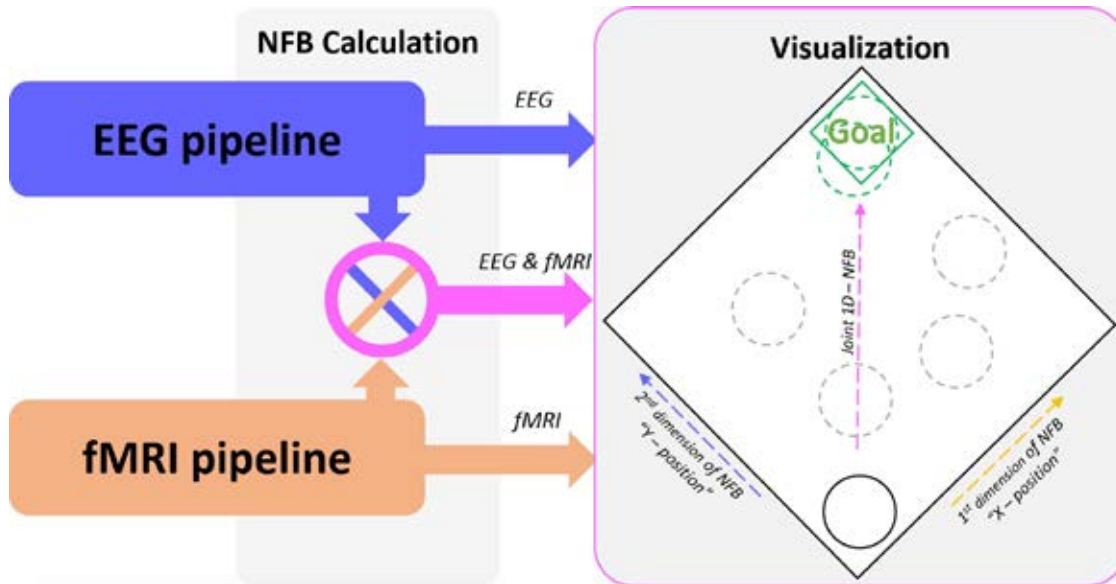
The Hybrid EEG-MRI Neurofeedback system @ Neurinfo
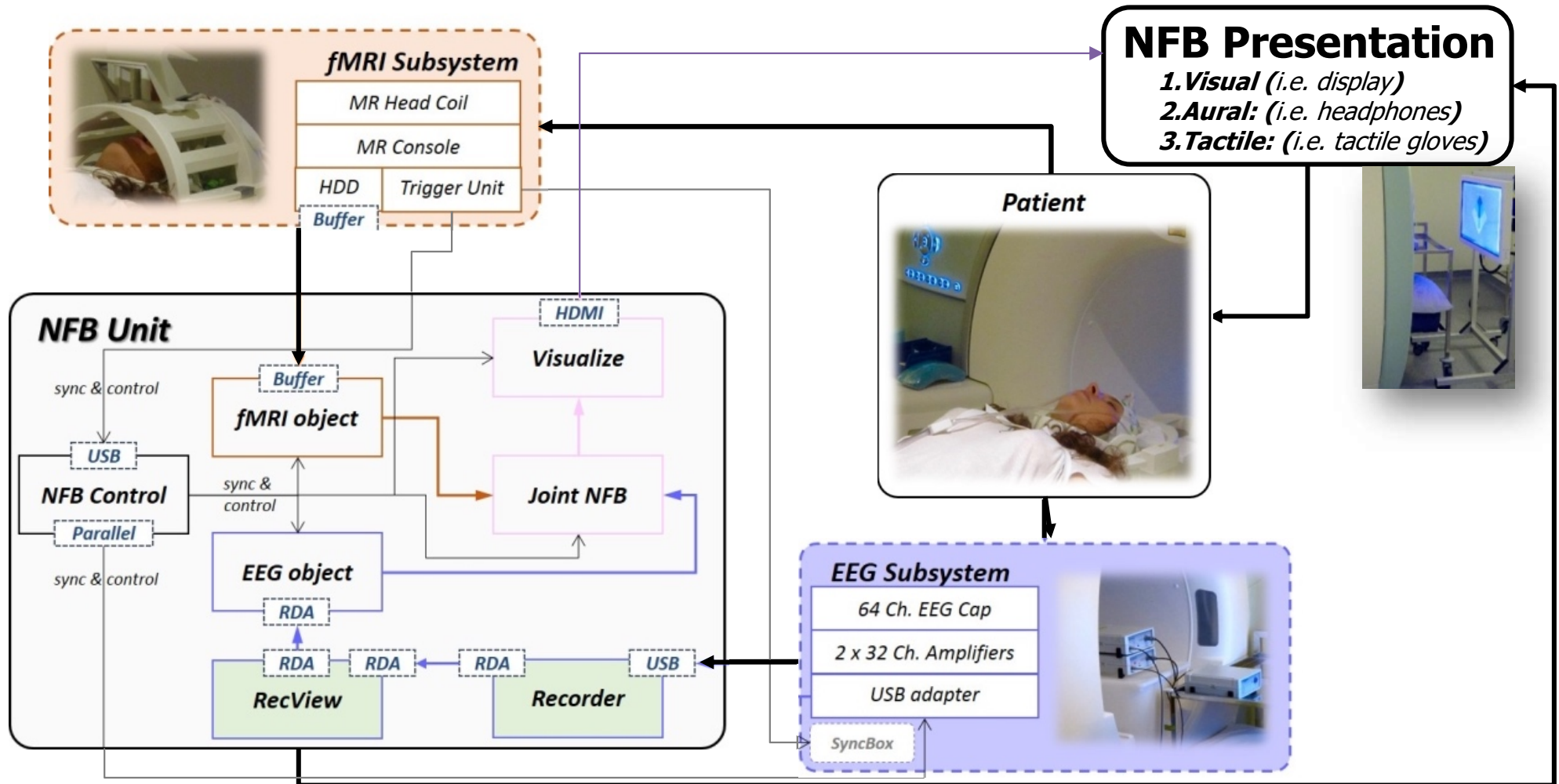
[Mano et al, OHBM 2016, Frontiers in Neurosciences 2017]

3

Experiments and Results

Results

- Our platform showed very good real-time performance when tested with various pre-processing, filtering, and NF estimation and visualization methods.

- The entire fMRI processing from acquisition to NF estimation in all scenarios takes less than 200ms, well below the TR of regular EPI sequences (2s). The same processing for EEG, is done at 2ms (~50Hz).

- Various NF tasks scenarios for regulating the measured brain activity were tested with subjects. In particular, the platform was used for a NF study on 10 subjects with over 50 sessions using three NF protocols based on motor imagery related brain activity.

Experiment study #1: EEG-fMRI neurofeedback of a motor imagery task

- **Motivation:** Proof-of-Concept of HEMISFER

- **Challenge:**
  - Able to provide real-time neurofeedback (NF) from simultaneous EEG/fMRI real-time recording on motor imagery (never done)
  - Investigate new neurofeedback hybrid paradigm

- **Contributions:** [Perronnet et al, OHBM 2016, Frontiers in Neurosciences 2017]
  - Use the real-time processing environment
  - Propose a new bimodal NF paradigm
  - Experimented on 10 normal controls
  - Confirm Hypothesis :

- **EEG activations** : EEG-NF ≥ EEG-fMRI-NF > fMRI-NF
- **fMRI activations** : fMRI-NF ≥ EEG-fMRI-NF > EEG-NF

Recorded multimodal EEG/fMRI NF
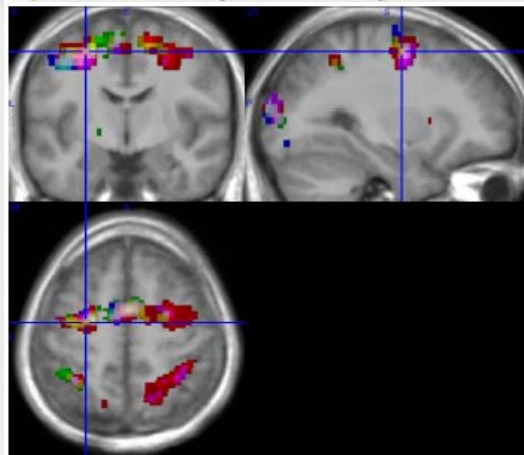
BOLD activation maps at group level (TASK > REST; p < 0.001)
- **A: EEG-NF**
- **B: fMRI-NF**
- **C: EEG-fMRI-NF**
- Light blue: A+B
- Yellow: A+C
- Magenta: B+C
- White: A+B+C

Activations in premotor cortex (left and right), supplementary motor area, inferior parietal lobule, and visual cortex.

Post-hoc EEG

Post-hoc fMRI