PEPERONI: Portable and Personalized Neurofeedback for Stroke Rehabilitation
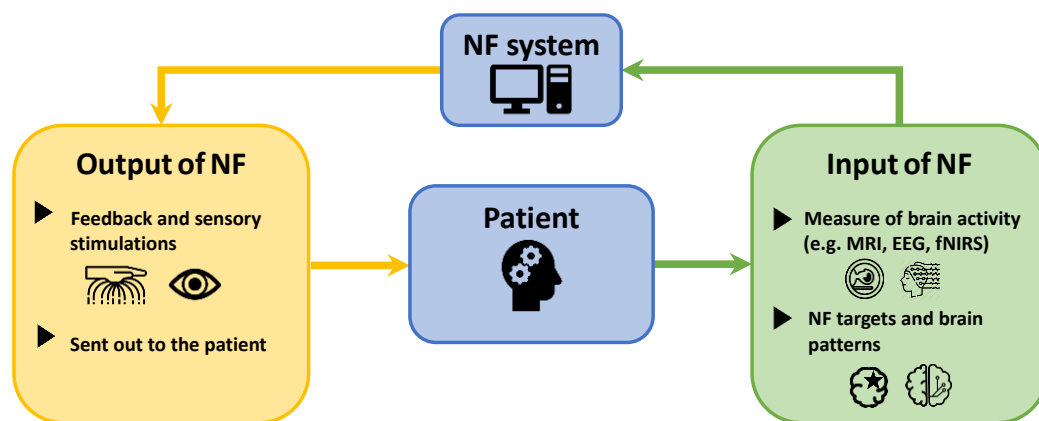
Neurofeedback (NF)

- consists in presenting a subject with a stimulus directly related to his/her current brain activity
- can be used to teach subjects to regulate their own brain functions
- Previous studies showed that multimodal NF is promising for the treatment of various neuronal pathologies.
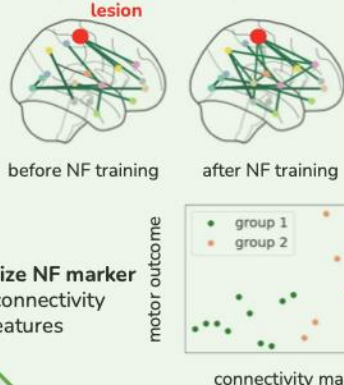

NF system

Output of NF
- ▶ Feedback and sensory stimulations
- ▶ Sent out to the patient

Patient

Input of NF
- ▶ Measure of brain activity (e.g. MRI, EEG, fNIRS)
- ▶ NF targets and brain patterns

PEPERONI project : 2022-2024

NF for PRECISION MEDICINE

PERSONALIZED: adapted to patient profile

1. CONNECTIVITY NF INPUT
lesion
before NF training — after NF training
personalize NF marker with connectivity features
group 1 — group 2
motor outcome / connectivity marker

2. MULTISENSORY NF OUTPUT
adapt the feedback (visual + haptic) to the patient and the task to facilitate neuromodulation
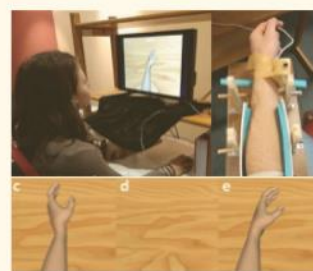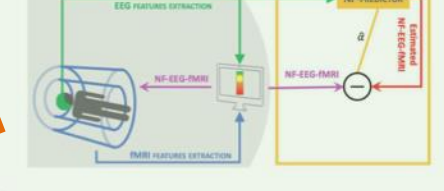
Methodological development
EEG+fMRI datasets (N=60)

New NF Protocols
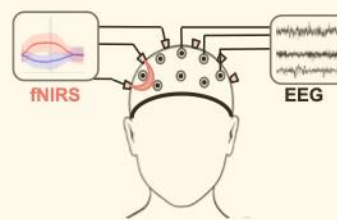*Proof of concept on stroke patients*

1. EEG-only, fMRI "enriched"
Learn a joint EEG-fMRI model to predict fMRI connectivity in EEG-only setting
ongoing PhD Thesis
Bi-modal NF session

2. EEG + fNIRS
High spatial (fNIRS) and temporal (EEG) resolution with lighter solutions, more adapted to clinical use
fNIRS — EEG

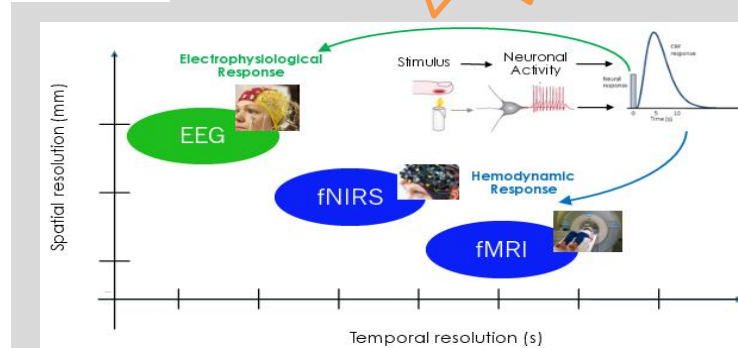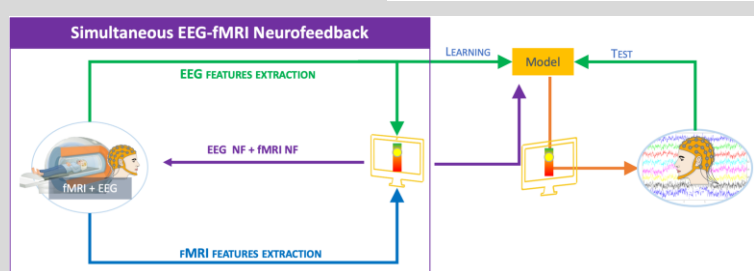**PORTABLE: adapted to clinical practice**

Left column

- **New PhD, starting in Oct. 2022** funded at 75% by CominLabs, A.Lamouroux, in Brest.
- On existing data : assessing changes induced by NF training on brain networks organization
- identify novel NF (connectivity biomarkers).
- design personalized NF target estimation, adapted to each patient, based on its own brain anatomy and function

- Preliminary work during former CominLabs project Hemisfer
- **Ongoing PhD in Empenn** (C.Pinte, started in 2021), not funded by CominLabs
- Investigating long short-term memory (LSTM) and temporal convolutional neural networks (CNN)

Simultaneous EEG-fMRI Neurofeedback
EEG FEATURES EXTRACTION
EEG NF + fMRI NF
fMRI FEATURES EXTRACTION
LEARNING — Model — TEST

Right column

- **20-month postdoc, Hybrid-Empenn**
- current systems: mostly visual feedback
- adapted feedback: reduce the time required to learn to control the system and their brain activity.
- adaptation depending on : personal characteristics of the user, evolution of his results

Open Position

- **20-month postdoc, Empenn-CHU**
- fNIRS and fMRI measure the hemodynamic response
- Study impact of fNIRS for NF
- propose a new EEG-fNIRS NF

Open Position

Electrophysiological Response — EEG
Stimulus — Neuronal Activity
fNIRS
Hemodynamic Response
fMRI
Spatial resolution (mm) / Temporal resolution (s)

Consortium

- Empenn U1228 (Inria/Inserm/CNRS/UR1)
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  - Claire Cury, CR Inria
  - **Pierre Maurel**, MCF UR1
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