HEMISFER

Hybrid Eeg-MrI and Simultaneous neuro-FEedback for brain Rehabilitation

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Participating Teams
Visages U746
Hybrid
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General objectives of HEMISFER

- Make full use of neurofeedback (NF) paradigm for brain self-regulation/stimulation in:
  - Rehabilitation (ADHD, Strokes, …)
  - Psychiatric disorders (anxiety, schizophrenia, resistant mood disorders, ….)
- Main Challenges:
  - Learn a coupling model associating functional and metabolic information from simultaneous Magnetic Resonance Imaging (fMRI) and Electro-encephalography (EEG)
  - Enhance the NF paradigm from the coupling model
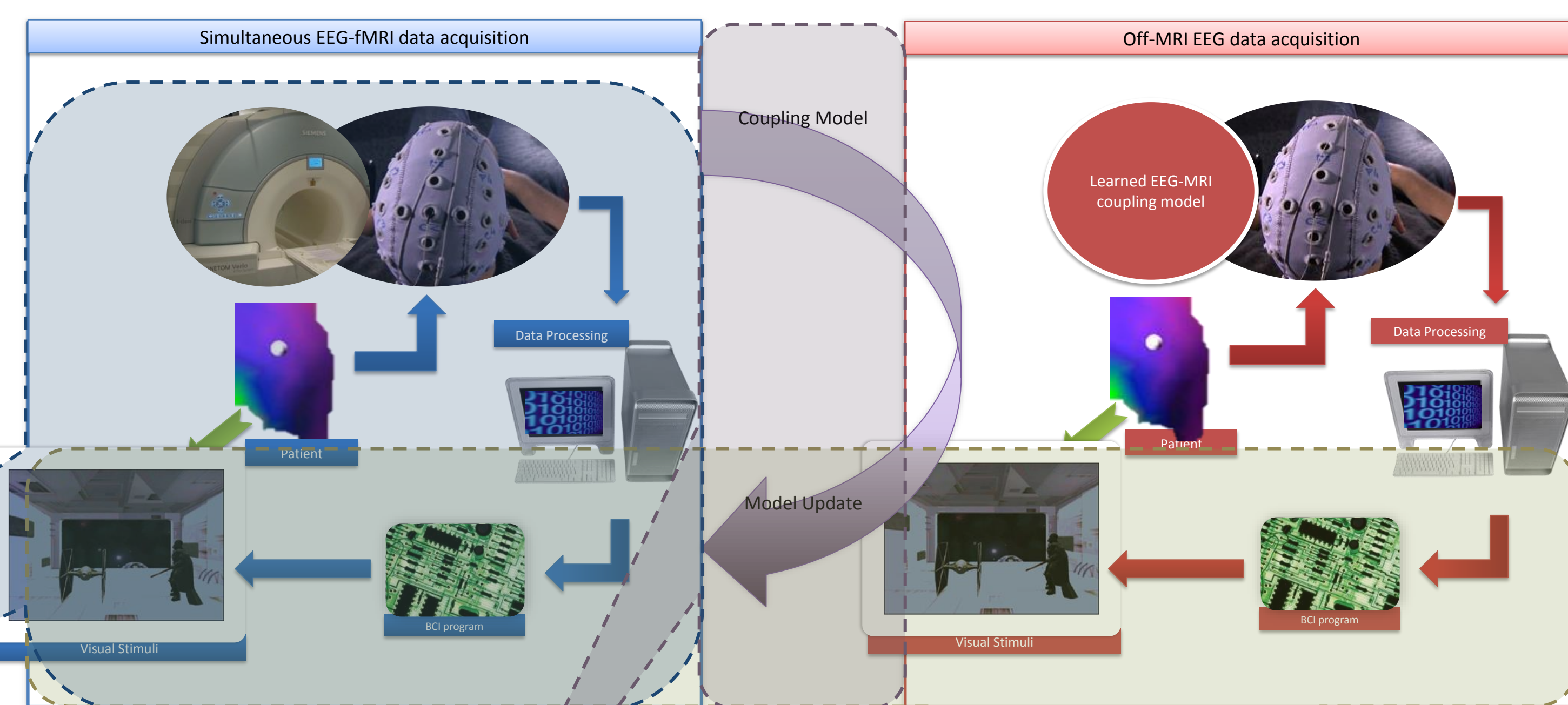
Context

From Imaging Biomarkers to Therapeutic Concept
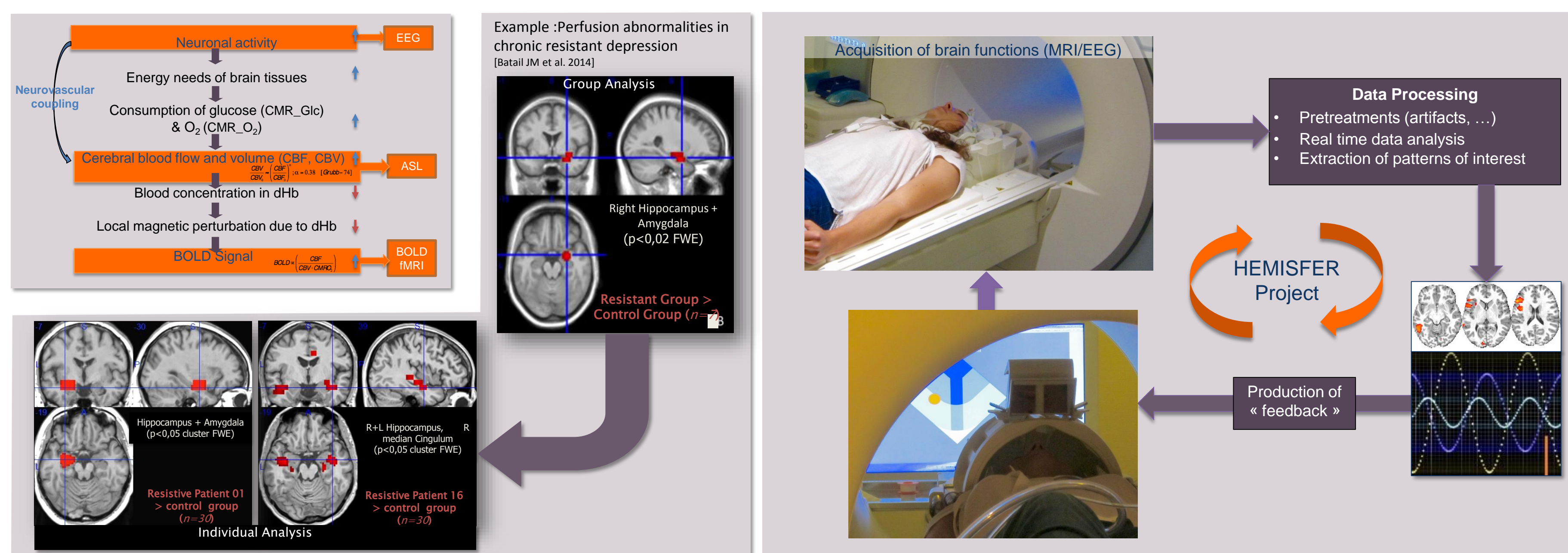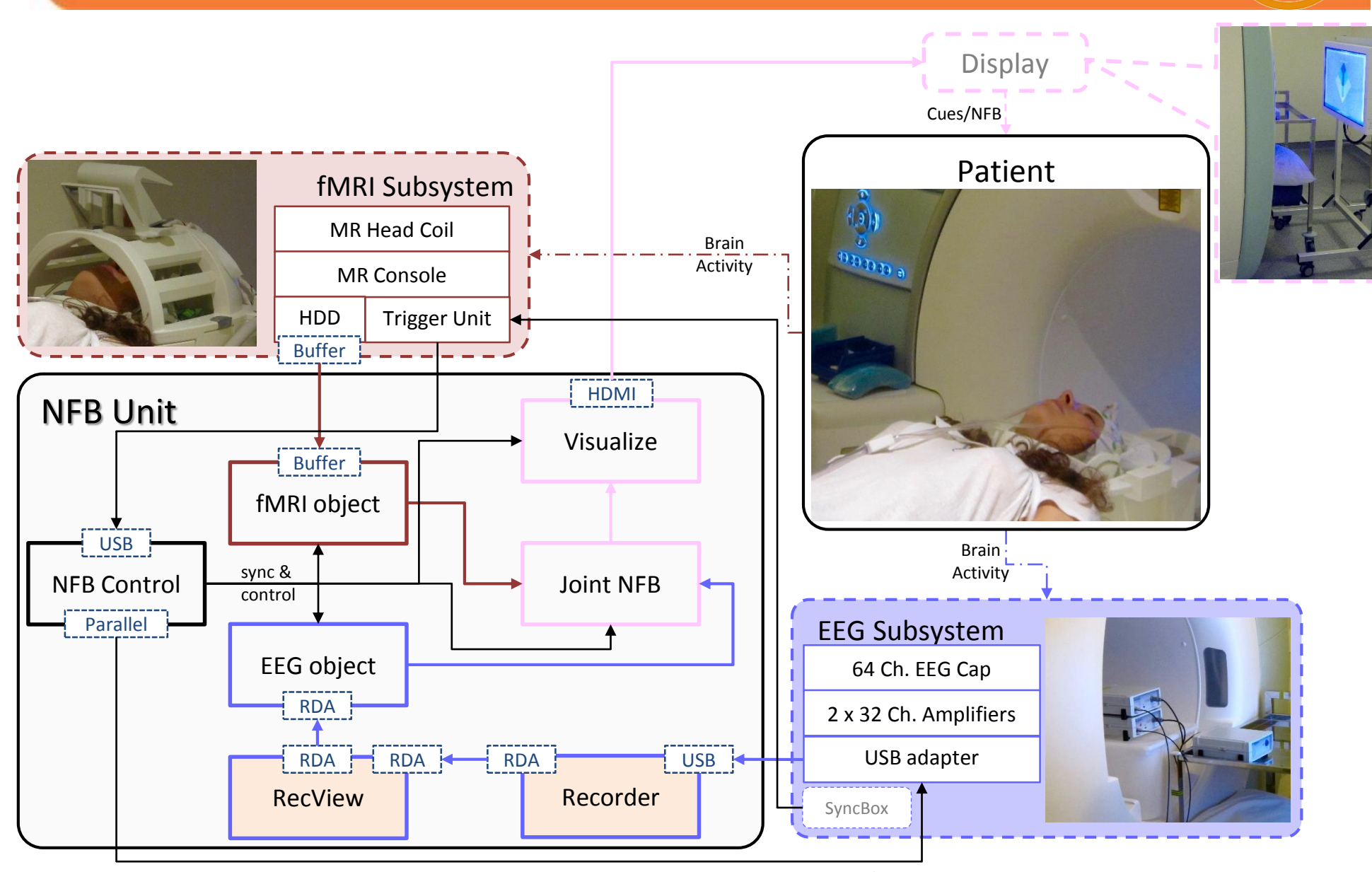

Major Challenges

- Develop new NF paradigms able to profit from simultaneous EEG/fMRI/fASL recordings
  - We expect these novel paradigms to be able to concentrate the brain metabolism on specific regions of the brain
- Learn models at the signal level able to explain the coupling of EEG and fMRI signals under simple and more advanced brain stimuli (e.g. BOLD fMRI, fASL, basal ASL)
  - Learn both the domain in which brain activity is sparse (e.g., dictionary learning), and adjust parametric models of the acquisition processes
  - Achieve super-resolution in the spatial and frequency domain by expressing the problem as a linear inverse problems regularized with the learned coupled model
  - Use brain connectivity models as prior information (later stage)
- Use the learned coupling models in order to "enhance" the EEG signal while performing the same stimuli and NF tasks outside MRI
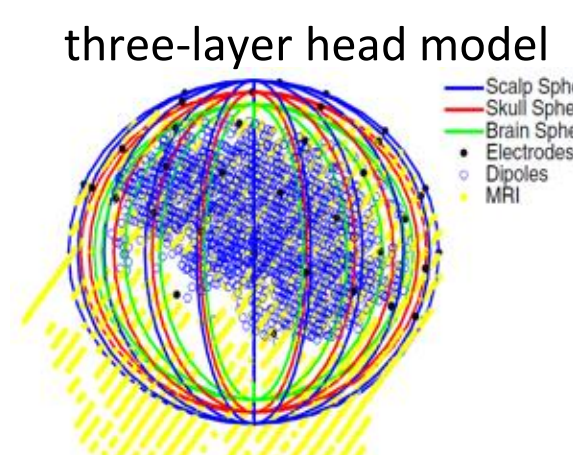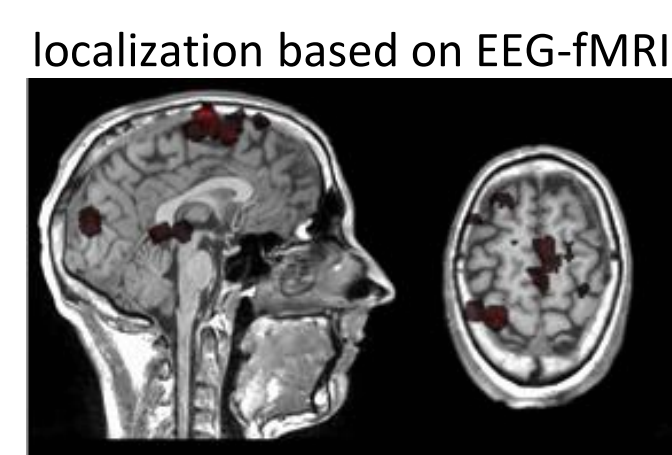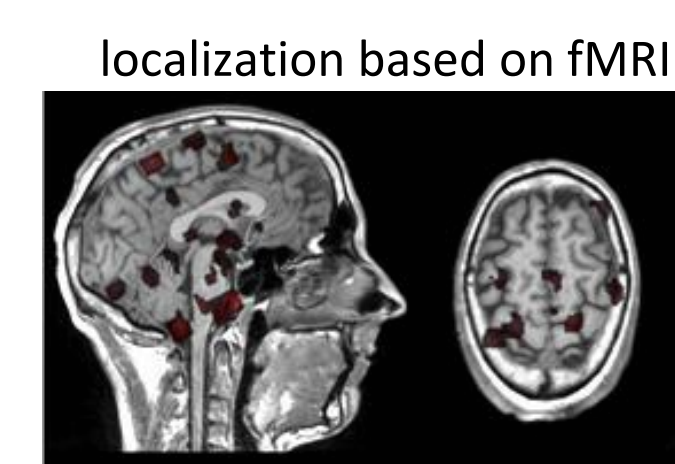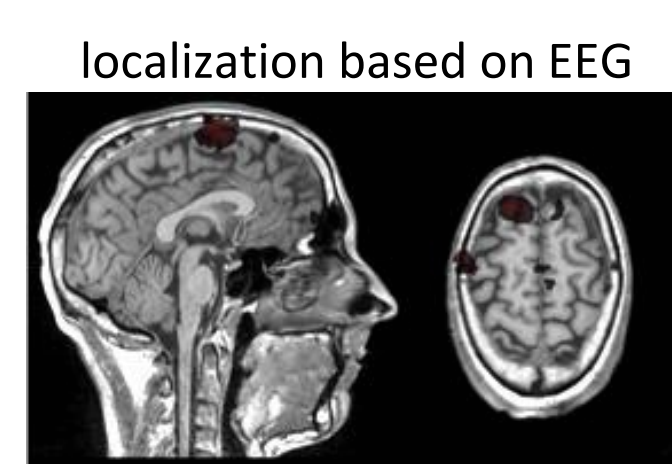
Paradigm

Experimental Platform Neurinfo

*Recorder and RecView are commercial software, the rest of the NFB UNIT modules are build in-house (Matlab/C++)

Current Status:
- fMRI with Siemens MR 3T scanner
- EEG with Brain Products 64-channel system
- Real-time EEG and fMRI data acquisition, processing, NF calculation and visualization in full synchronization.

Future Challenges:
- Online NF with joint modeling approaches
- Improve performance with GPU based real-time parallel processing

Coupling Model

Introduction of a new linear EEG/BOLD coupling model using sparsity-based regularization term:

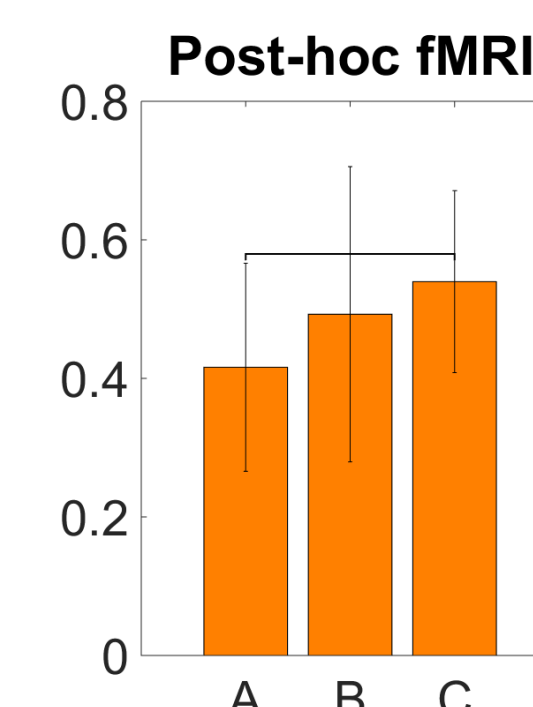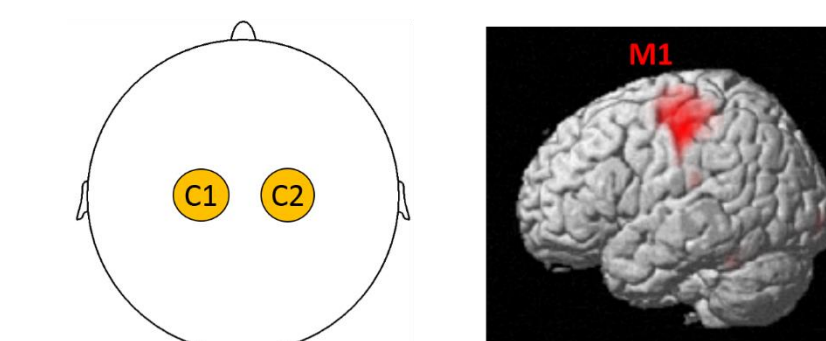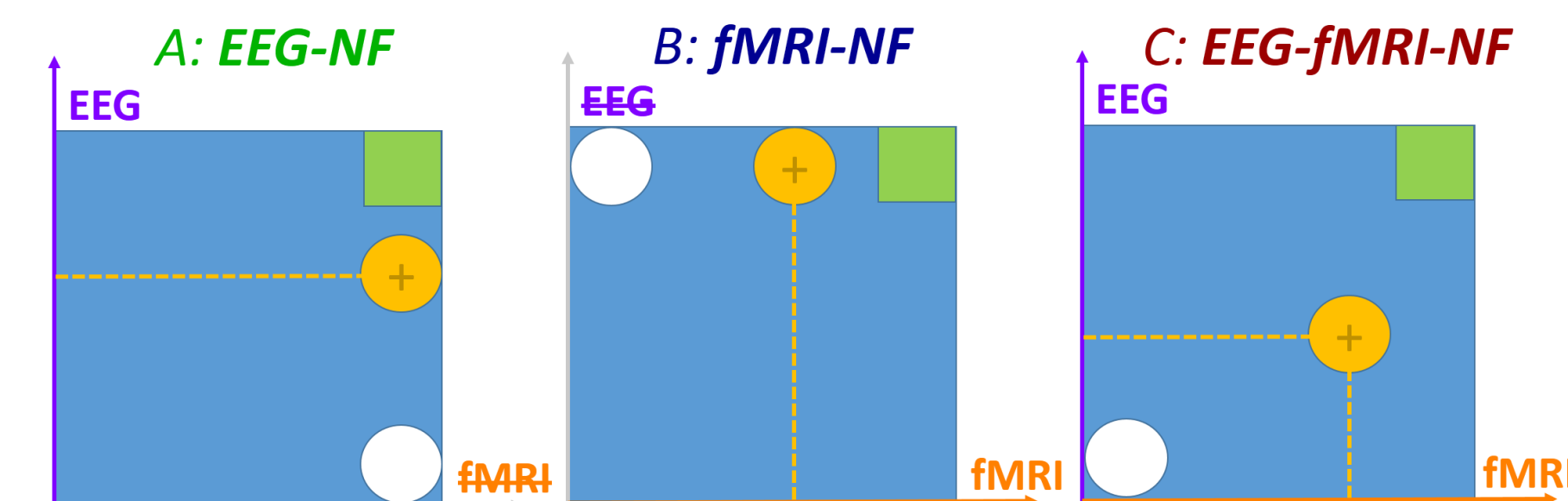$$X^* = \arg\min \left(\frac{\alpha}{2} \| E - GX \|_F^2 + \frac{1-\alpha}{2} \| F - XH \|_F^2 + \lambda\phi(X) \right)$$

localization based on EEG

localization based on fMRI

localization based on EEG-fMRI

three-layer head model

Results

In the first study:
- We compared EEG-NF, fMRI-NF and EEG-fMRI-NF on a motor imagery task with 10 subjects
- We propose an integrated feedback metaphor for EEG-fMRI-NF

A: EEG-NF B: fMRI-NF C: EEG-fMRI-NF

- Motor imagery-related fMRI activations were stronger during EEG-fMRI-NF than EEG-NF
- During EEG-fMRI-NF participants regulated more the modality that was harder to control

In the second study, we compared 1D EEG-fMRI-NF and 2D EEG-fMRI-NF

Post-hoc fMRI