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## Hybrid EEG and fMRI platform for multi-modal neurofeedback

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The *NFB Control* is responsible for the full synchronization of both modalities. Furthermore, it contains the experiment protocol (i.e. types of tasks, durations, repetitions), it starts/stops the experiment, controls all the other objects' behavior throughout the experiments, and stores the data at the end of each session.

## NFB experiments and real-time performance

Our platform has been successfully used to conduct several uni-modal and bi-modal NFB studies. The goal of the studied NFB protocols has been to maximize the brain activity measured by EEG and fMRI while performing motor imagery related mental tasks. All experiments were preceded by a preparation phase needed to install the EEG cap and prepare the subjects for the NFB experiments (Figure 4a, b & c). Next, a calibration session (without NFB) was recorded and the data was processed offline to extract initialization information and define the NFB targets. After calibration, the subjects conducted several NFB sessions, where they showed to be able to modify their brain activity by performing the tasks and controlling the feedback presented on the screen (Figure 5).

Our platform has shown very good real-time performance with various pre-processing, filtering, NFB calculation and visualization methods. The entire fMRI process from acquisition to NFB calculation takes around 150ms, well below the TR of regular EPI sequences (1000ms or 2000ms). The NFB visualization is very fast (1-2ms) and it is done within one screen refresh (i.e. 16,7ms for a screen with 60Hz refresh rate).

## Conclusion

The platform introduced here offers a reliable environment for bi-modal EEG-fMRI NFB experiments. Its modular architecture is generic enough to be adapted to other similar neurosignals acquisition subsystems, and also easily adaptable to different experimental environments and/or NFB protocols. The parallel real-time processing pipelines have shown to be an optimal solution for real-time NFB applications.

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## References

1. Weiskopf N, Scharnowski F, Veit R, et al. Self-regulation of local brain activity using real-time fMRI. *Journal of Physiology-Paris*. 2004;98(4):357-373.
2. Zich C, Debener S, Kranczioch C, et al. Real-time EEG feedback during simultaneous EEG-fMRI identifies the cortical signature of motor imagery. *NeuroImage*. 2015;114:438-447.
3. Zotev V, Phillips R, Yuan H, et al. Self-regulation of human brain activity using simultaneous real-time fMRI and EEG neurofeedback. *NeuroImage*. 2014;85:985-995.
4. Sulzer J, Haller S, Scharnowski F, et al. Real-time fMRI neurofeedback: progress and challenges. *Neuroimage*. 2013;76:386-399.
5. Birbaumer N, Ruiz S and Sitar R. Learned regulation of brain. *Trends in cognitive sciences*. 2013;17(6):295-302.
6. Stoeckel L E, Garrison K A, Ghosh S S, et al. Optimizing real time fMRI neurofeedback for therapeutic discovery and development. *NeuroImage: Clinical* 2014;5:245-255.
7. Allen P J, Josephs O and Turner R. A method for removing imaging artifact from continuous EEG recorded during functional MRI. *Neuroimage* 2000;12(2):230-239.
8. Debener S, Mullinger K J, Niazy R K and Bowtell R W. Properties of the ballistocardiogram artefact as revealed by EEG recordings at 1.5, 3 and 7 T static magnetic field strength. *Int. Journal of Psychophysiology* 2008;67(3):189-199

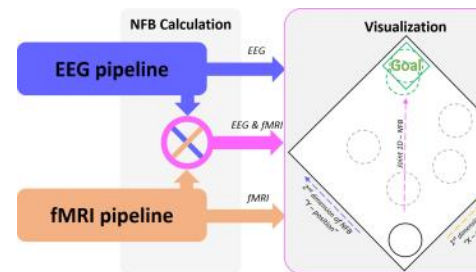


Figure 3. The hybrid platform is able to provide both uni-modal and bi-modal NFB and the visualization is flexible following the results of the calculation. In this visualization example, the NFB goal is to put the disk inside the small 'green' square. The disk position inside the big square is determined by the normalized NFB values coming from the brain activity measured with EEG and fMRI.

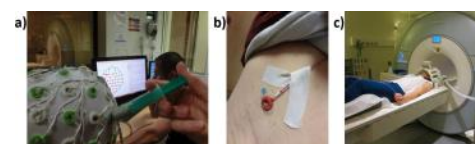


Figure 4. Different phases of the system preparation: a) Installation and preparation of EEG subsystem, b) ECG electrode mounting, c) Re-testing the EEG acquisition after fMRI coil installation and before the acquisition sessions start.



Figure 5. Snapshot of a subject during an experiment. The subject is trying to move the orange disk toward the darkest blue colored area using its brain activity generated by performing motor imagery tasks and measured in real time using EEG and fMRI.