

Neural mechanism for neural feedback based on EEG using functional near-infrared spectroscopy (fNIRS)

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Introduction

We aim to compare EEG and fNIRS during a neurofeedback task.^{1,2} and to develop an experimental paradigm, as well as recording and analysis tools, to investigate the neural mechanisms of brain state control.

Methods

Subjects

3 healthy volunteers: 2 males, 1 female; median age: 25

fNIRS/EEG Acquisition

- fNIRS (Shimadzu LABNIRS) and Biosemi EEG system (10-20 EEG electrode placement interleaved with fNIRS optodes)

- Sample rate: 27ms for fNIRS and 1ms for EEG

EEG Neurofeedback

The neurofeedback device (Jedi Force trainer, Unclemilton.com) consists of a dry electrode placed at forehead and a Neurosky chip that provides frequency bands and visualization of the theta band in the form of a “levitating ball”.

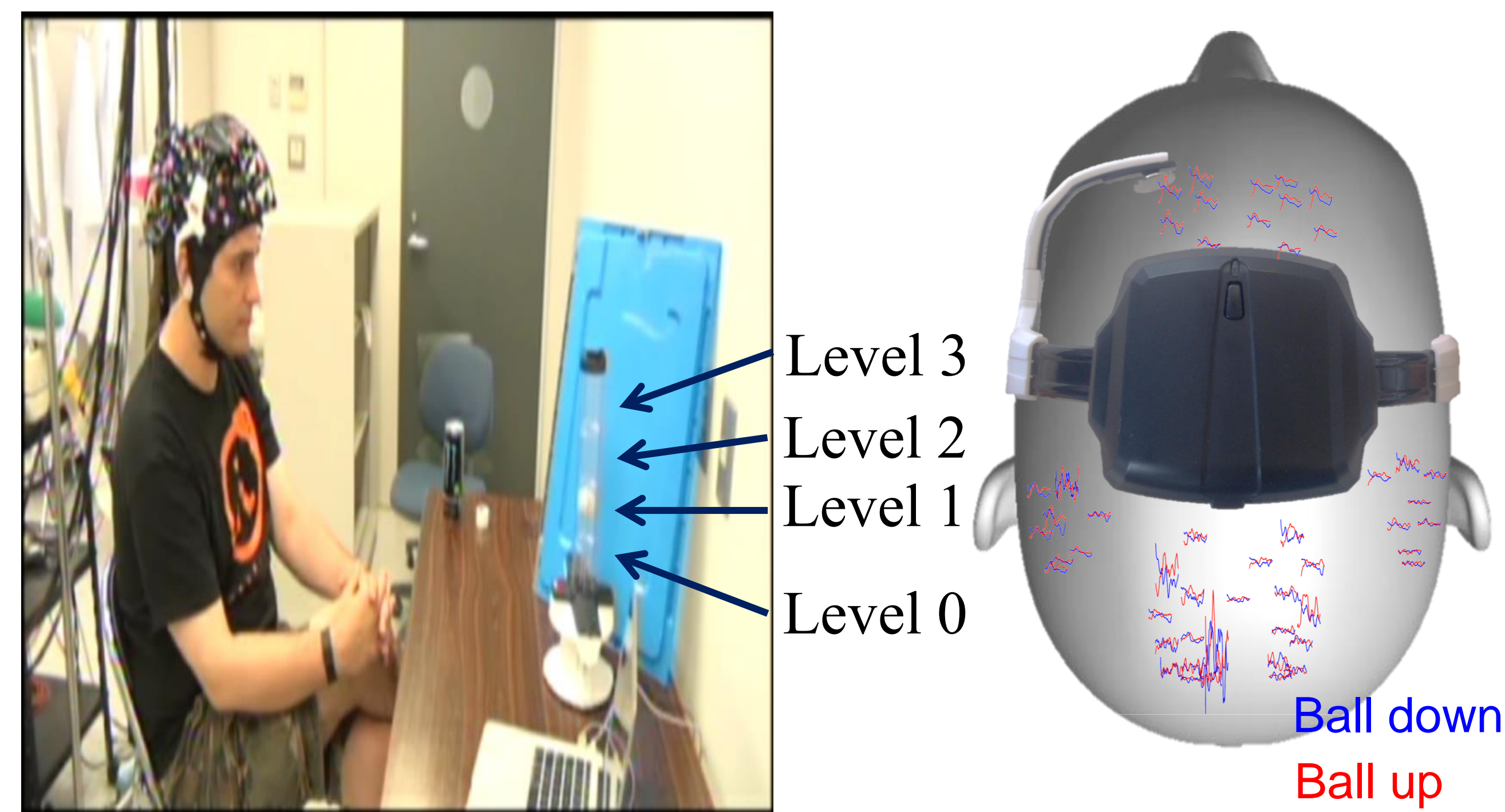


Figure 1. Left: Subject wore an fNIRS/EEG whole-head cap and performed neurofeedback task. Right: Biofeedback device and fNIRS (OxyHb) waveforms for two conditions.

Task

Through volitional shifting of the EEG spectra, subjects can move the ball up and down. Subjects were instructed to maintain the height of the ball at a cued level, including 0 (rest), 1st, 2nd and 3rd levels. The time interval of level change was 20 ± 5 seconds.

Analysis and Results

Event Triggered Average (Volitional effort as regressor)

EEG is decomposed into frequency components and the theta band (4-7 Hz) was analyzed.

Both fNIRS and EEG theta band components were analyzed using Event Triggered Average. The event was based on the cue for increasing the theta wave intensity, “ball up” (eg. from level 1 to 2, or from 2 to 3)

Event Triggered Average

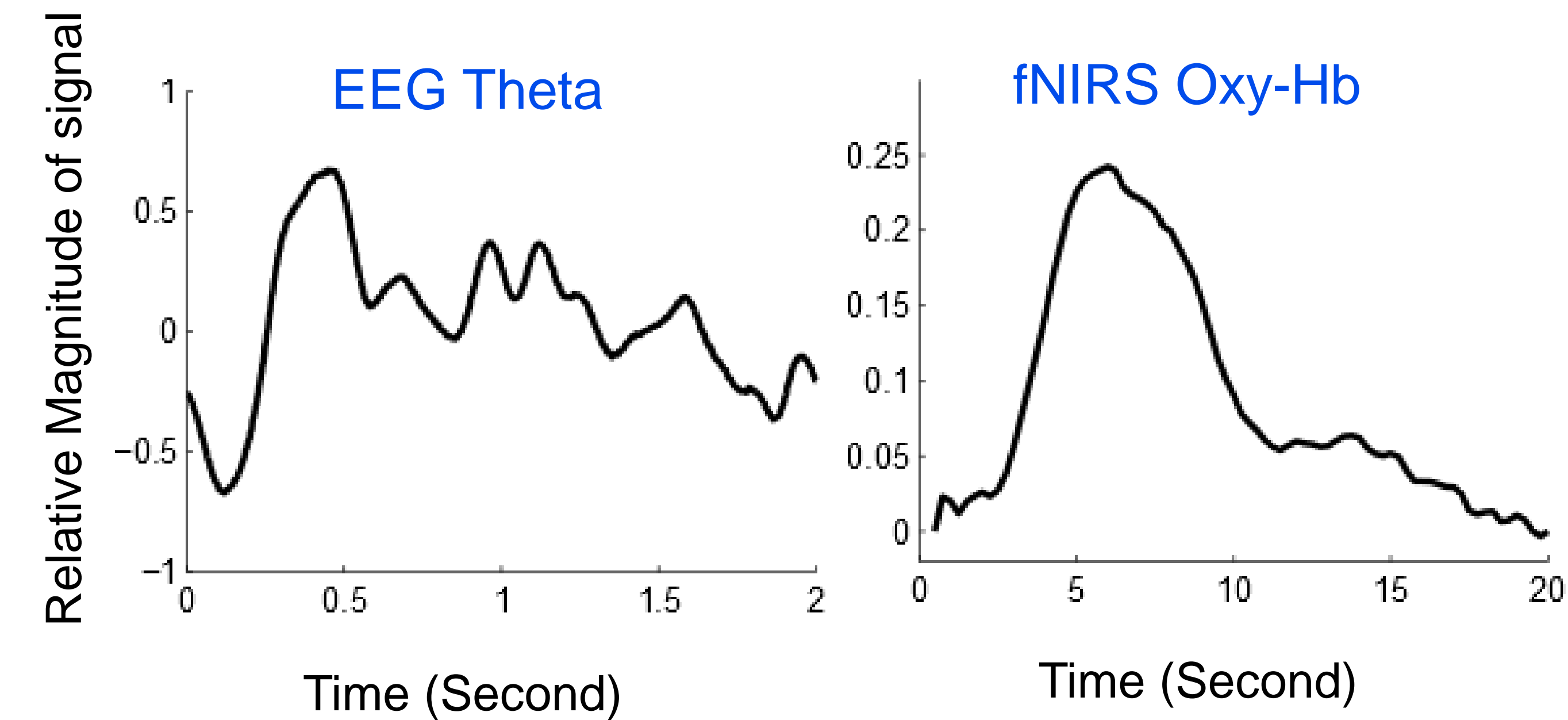


Figure 2. The waveform of EEG theta spectra energy and fNIRS OxyHb signal recorded at Fz.

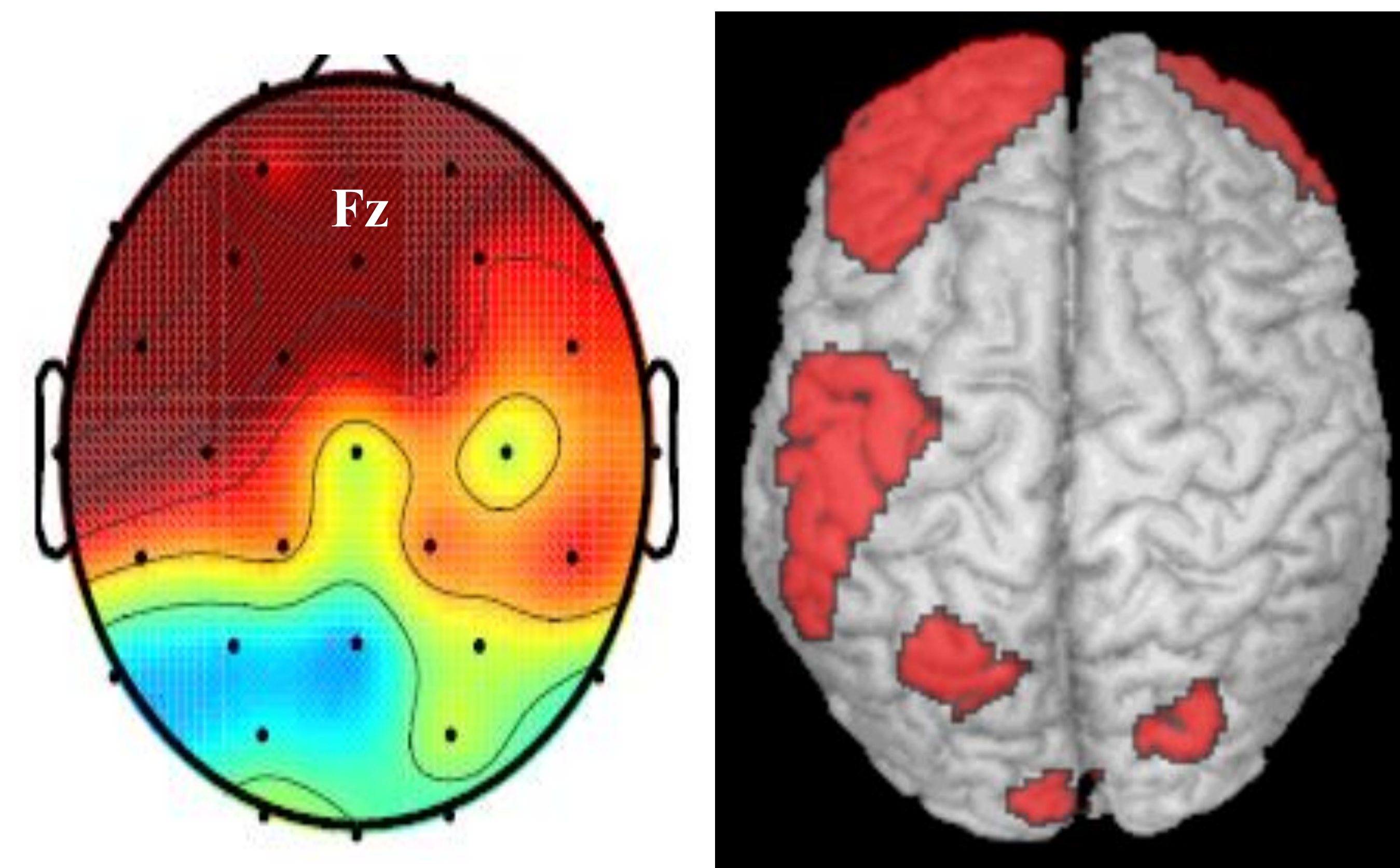
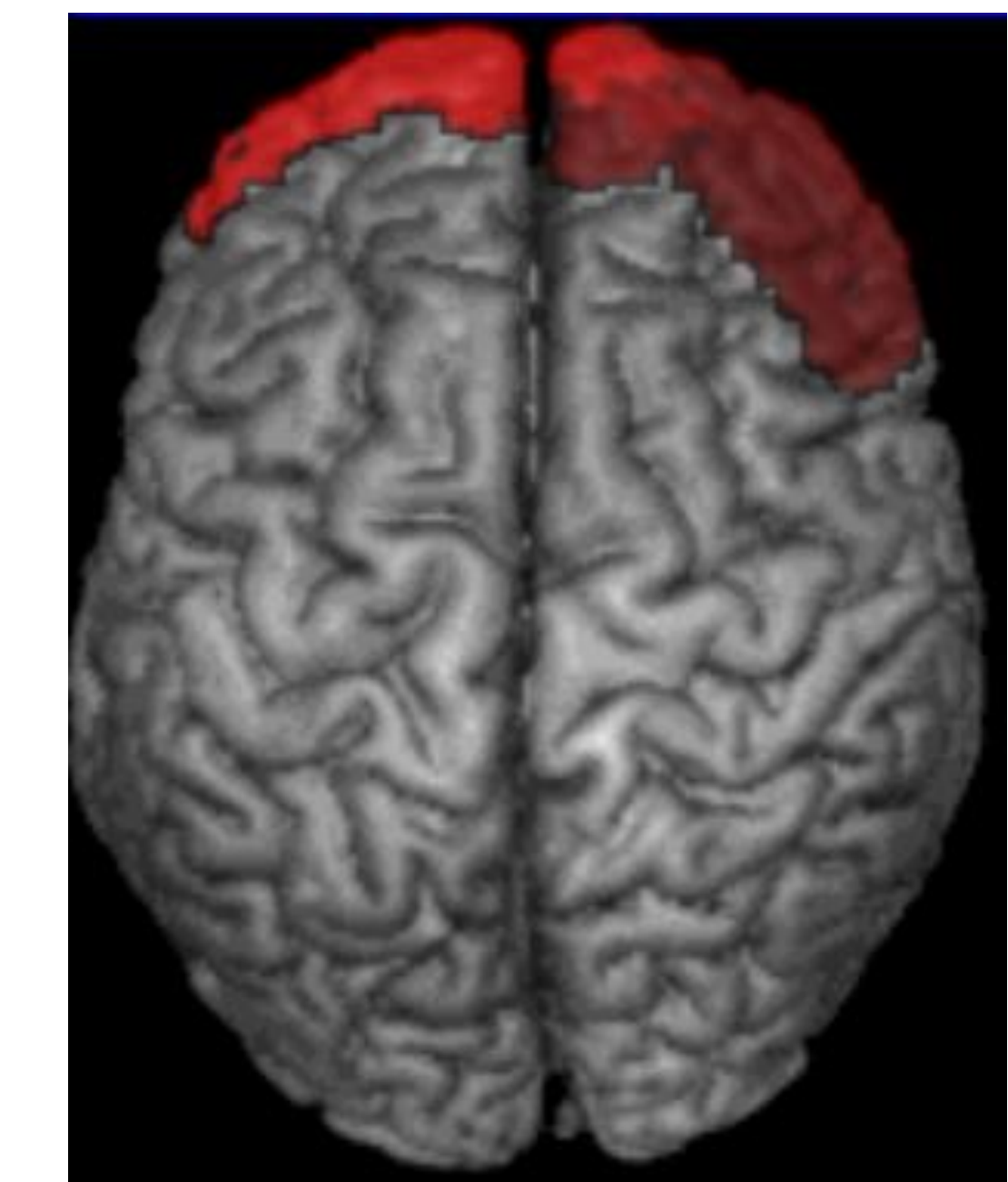


Figure 3. The spatial distribution of the magnitude of EEG (left) and fNIRS OxyHb absorption (right) signals

Impulse function and ball level

A movie of the ball was obtained. The impulse response function reveals neural activity associated with ball motion (See Figure 4).

Impulse function and ball level



Peak location:
MNI -20,64,24
Left Frontal
superior medial
gyrus

Figure 4. The spatial distribution of the magnitude of fNIRS OxyHb signal responding to a delta function of ball level.

Conclusions

Both EEG and fNIRS data suggest that volitional effort in control of brain state engages frontal lobe. The spatial distribution of the BOLD signal is consistent with the EEG source. FNIRS is a promising tool for investigating the neural mechanisms of neurofeedback.

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