Theme: Cognitive Neuroscience

Optimizing Feedback Calculation and Presentation in a Functional Connectivity-based Neurofeedback Approach using Functional Near-infrared Spectroscopy (fNIRS)

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Abstract:
Recognizing functional dysconnectivity in neuropsychiatric disorders, self-modulation of brain region communication presents a promising therapeutic approach. We aim to replicate a previous connectivity-based neurofeedback (NF) fMRI framework with a cost-efficient, portable alternative: functional near-infrared spectroscopy (fNIRS).
We measured 22 healthy participants (meanage=29.0±6.57) using the NIRSport2 fNIRS system with a 16-source, 15-detector setup targeting the motor network and 8 short-distance detectors (SDD) for extracerebral signals (sampled at 5.08 Hz). A functional localizer with motor action (MA) and imagery (MI) trials identified oxygenated hemoglobin (HbO) channels of interest for 3 NF runs: the most active channels in MI for left and right premotor cortices (PMC), one control channel (inactive during MI), and one SDD channel. Each NF run consisted of 5 'Upregulation' (MI) and 'Downregulation' (rest) 20 sec trials with visual feedback updated every second, calculated using a 7-second sliding window of either (a) Pearson correlation between bilateral PMC, (b) partial correlation with the control channel, or (c) partial correlation with the SDD channel. Feedback values from the last 12 seconds (to account for the hemodynamic delay) were analyzed, with a paired-test, and one-way ANOVA assessing the impact of feedback calculations across conditions.
Only partial correlation-based feedback showed significant differences between conditions ($t=1.81$; $p=0.035$). This was due to the impact on the 'Downregulation' values (meanCorr=0.377±0.541; meanPartial=0.320±0.536, meanPartial_SDD=0.379±0.534, $F(2, 13605)=17.53$, $p<<0.001$) that outweighed the slight decrease in the 'UpRegulation' condition (meanCorr = 0.370 ± 0.535; meanPartial = 0.340 ± 0.527, meanPartial_SDD =0.372±0.522, $F(2, 13173)=5.15$, $p=0.006$), in line with the participant's debriefing. Preliminary results suggest adding a confounding signal could help mitigate spurious connectivity in noisy data such as fNIRS.

Keywords: fNIRS; Neurofeedback; Connectivity-based; Motor Imagery