Enhancing Cerebellar fNIRS/fMRI via Tailored Pipelines

G. Rocco[1], É. Delaire[2], S. Ramanoël[1], O. Meste[1], M.N. Magnié-Mauro[3], C. Grova[2], J. Lebrun[4]

[1]Université Côte d'Azur, Nice, France; [2]Concordia University, Montreal, Canada; [3]CHU, Nice, France; [4]CNRS, Sophia Antipolis, France
Presenting Author email address: giuliarocco209@gmail.com

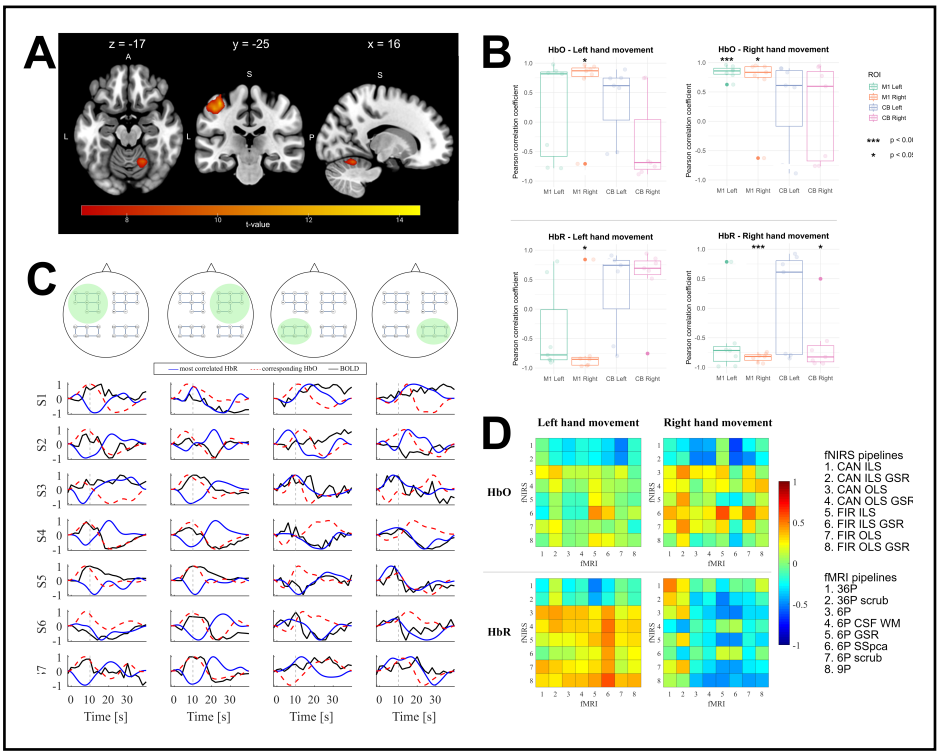
Abstract: fNIRS and fMRI sequences were simultaneously recorded from the cerebellum and motor cortex during a motor task. Spatial and temporal concordance between modalities and various data processing pipelines were assessed. The results confirm high spatial and temporal correlation and highlight the necessity of using an ad-hoc pipeline for the cerebellar region of interest.

Introduction: In prior work[1], we demonstrated the feasibility of high-density cerebellar fNIRS with concordant fMRI results. However, sequential acquisitions and subject-specific optimized optode montages introduced potential intra-subject variability. This study addresses this concern by implementing simultaneous fNIRS/fMRI with a standardized grid montage based on predefined fiducial landmarks.

Methods: Ten healthy subjects (1 left-handed) underwent concurrent CW-fNIRS and fMRI scans during an auditory-cued finger-to-thumb opposition task (20 trials: 10s activity + 30-38s rest). The fMRI were acquired using GRE-EPI sequences (3.7 mm3, TR = 2 s, TE = 25 ms, 41 slices) and complemented with 20 fNIRS channels on the motor cortex and 14 on the cerebellum (SDD = 3 cm). Both modalities were analyzed using a single-subject GLM block-design framework with varying nuisance regressors. Temporal correlation between the upsampled BOLD averages and the GLM-estimated HRFs was obtained per subject and ROI. Spatial correlations between group-averaged fNIRS and fMRI β maps (GLM-derived) were computed using tailored pipelines inspired by various sources[2-3], by changing the HRF model (canonical/FIR), solver (ordinary/AR-ILS LS), or adding motion, physiology, or bi-directional regressors.

Results: After preprocessing, 7 subjects were fully retained. fMRI activations are displayed in Fig. A. Temporal correlation analysis (Fig. B) revealed higher variability within the cerebellum, with coefficients showing a bimodal distribution (all >|0.5|). To investigate BOLD-fNIRS coupling, a remarkable compliance was achieved by overlaying the average BOLD signals from each ROI and subject with the corresponding fNIRS channel exhibiting the highest temporal correlation (Fig. C). The spatial correlation patterns (Fig. D) exhibited high variability in terms of polarity. One-way non-parametric ANOVA revealed significant pipeline differences ($p < 0.001$) within fMRI data and HbR results.

Conclusion: This study investigated concurrent cerebellar fNIRS/fMRI recordings during a motor task and found high spatial and temporal correlations between the two modalities, even with generic high-density montage. The statistically significant differences in the cerebellum analysis suggest the importance of pipelines to achieve meaningful correlation values, and thus β.



References:

1. Rocco, G., et al., fNIRS, (2022). doi.org/10.5281/zenodo.7009822
2. Lydon-Staley, D. M., et al., Netw. neurosci., 3(2), (2019). doi.org/10.1162/netn_a_00071
3. Huppert, T. J., Neurophotonics, 3(1), (2016). doi.org/10.1117/1.nph.3.1.010401

International Conference of the Society for functional Near Infrared Spectroscopy (SfNIRS), Sep.11-15, 2024, Birmingham, UK.