WHEN fNIRS MEETS fMRI TO COMPLEMENT CEREBELLAR EXPLORATION

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Towards an fMRI validation of our previous fNIRS-based explorations of cerebellar activity [1], we introduce here a joint sequential fNIRS/fMRI study based on finger tapping that provides both finer time and space granularities for the assessment of BOLD effect in the cerebellum.

1. INTRODUCTION

The currently blossoming field of cerebellar neuroscience calls for novel, faster, cheaper exploration techniques. Motivated by a recent breakthrough in cerebellar EEGs [2], we showed that fNIRS can also capture the hemodynamics of cerebellar activation in a motor task, with the advantage of higher temporal resolution [1] than fMRI. Now, with the combination of fNIRS and fMRI (aka the gold standard in cerebellar studies), we strive for a finer spatio-temporal assessment of neurovascular response and activity.

2. MATERIAL & METHODS

In our cohort[‡], one right-handed subject was selected to perform a finger tapping task with sequential fNIRS and fMRI recordings, i.e. 3 runs (left/right), summing up to 20 blocks (10s activity + 30~35s rest). Two long (SD=3cm) and two short separation channels were acquired on each cerebellar hemisphere using a customized NIRx Sport2 device. fNIRS data were motion-corrected and analyzed with a GLM subject-wise framework in Homer3. fMRI data were acquired on a 3T Siemens MRI and analyzed on SPM using a single participant GLM for block design ($p < 0.05$ FWE corrected for multiple comparisons at peak level).

3. RESULTS & DISCUSSION

As in [3], fNIRS block averages (Fig.1) display ipsilateral with strong contralateral activations for subdominant hand movement, and somehow weaker contralateral activation for dominant hand. HRF latencies are high (~10s) as in [1]. The fMRI analysis (Fig.2) shows bilateral activations in the Crus I, Lobules VI, VIIIA, VIIB of the cerebellum, matching fNIRS results. Thus, the hemodynamics measured by fNIRS convey similar information to the fMRI. Though, beyond these fNIRS/fMRI similarities, the complementary space/time granularities in BOLD assessment permit finer understanding of the dynamics of neurovascular response and other underlying physiological phenomena. As mentioned in [1], the cerebellum seems to have peculiar hemodynamics, largely unexplored due to the temporal limitations of fMRI.

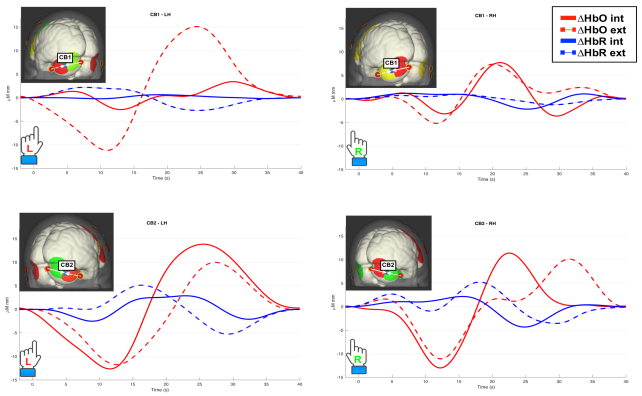

Fig. 1. fNIRS block averages for each channel.

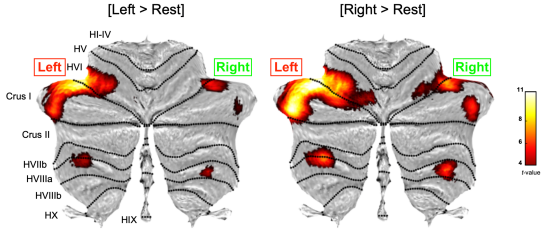

Fig. 2. Cerebellum regions showing significant differences between conditions and represented on a 2-D template.

More detailed vascular imaging should allow the transient features of the HRF to be related to neurovascular dynamics. While establishing fNIRS as a viable tool for cerebellar studies, combining fMRI with fNIRS brings a promising approach to investigate neural activation with finer time/space resolution, allowing for functional studies of the interplay between brain cortex, cerebellar circuitry, and deep-brain structures, e.g. basal ganglia. For this matter, EEG will be the staple [2] for a robust exploration of the timing aspects of neural responses, fully complementing fNIRS/fMRI.

4. REFERENCES

[1] G. Rocco, et al., "A Chiral fNIRS Spotlight on Cerebellar Activation in a Finger Tapping Task," in Proc. IEEE EMBC 2021, Nov 2021. DOI: 10.1109/EMBC46164.2021.9629565.

[2] NPM. Todd, et al. "The human electrocerebellogram (ECeG) recorded non-invasively using scalp electrodes," *Neurosci. Lett.*, vol. 682, pp. 124-131, Aug 2018.

[3] L. Jäncke, et al. "The effect of finger-movement speed of the dominant and the subdominant hand on cerebellar activation: a functional magnetic resonance imaging study," in *Neuroimage,* vol. 9, no. 5, pp. 497-507, May 1999.

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