# Densifying Optodes Montage to Enhance Cerebellar fNIRS

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**Abstract:** In this preliminary study, we introduce the use of personalized high-density optodes montage for cerebellar fNIRS acquisitions. One subject performed left or right finger tapping tasks consecutively with fNIRS and fMRI. Conclusive ipsilateral cerebellar activations were observed in the fNIRS HRF and supported by strong clusters in the fMRI.

**Introduction:** The recent blossoming of cerebellar neuroscience calls for novel and flexible techniques for further investigations. In a previous study, we proved the feasibility, through simple montage, of measuring cerebellar hemodynamics with fNIRS[1], and further validated it with fMRI[2]. To better tackle the physiological challenge of accessing the cerebellum with NIRS, we assess here the advantage of using personalized high-density layouts of optodes, optimized in terms of sensitivity, and their impact on the HRF estimation.

**Methods:** One healthy right-handed male subject (27y) was recruited. A Monte-Carlo based method, implemented on NIRSTORM, was used to derive a personalized dense optodes positioning[3], sensitivity-optimized using the subject's anatomical MRI (T1-weighted). The subject participated consecutively in one CW-fNIRS and one fMRI session, by performing an auditory cued finger tapping task with alternating hands (20 trials: 10s activity + 30 to 38s random rest). Guided by a neuronavigation system, the optodes (incl. one SS per hemisphere) were glued on the subject's head. fMRI was acquired using GRE-EPI sequences (3.7 mm3, TR = 2 s, TE = 25 ms, 41 slices). Both fNIRS and fMRI signals were processed following standard pipelines and a GLM block-design framework for single participant.

**Results:** A high sensitivity montage was achieved with 3 sources and 5 detectors for each cerebellar hemisphere (Fig 1A). Ipsilateral cerebellar activations were clearly observed (Fig 1B, for readability only S7D7, S7D9 are displayed for the left hemisphere, and S2D3, S3D1 for the right one). Accordingly, strong ipsilateral clusters were found in the fMRI ($p < 0.001$ FWE corrected at peak level) (Fig 1C). Precisely, [Left] (resp. [Right]) condition elicited activations in Crus-1 and lobule 8 cerebellar regions. Critically, Crus-1 activations were bilateral, though stronger in the ipsilateral cluster for each condition, matching well with the hemodynamics as measured by fNIRS.

**Conclusion:** This study demonstrates the feasibility and interest of personalized high-density fNIRS cerebellar montage to improve the quality of the acquired hemodynamic signals. This approach provides the potential to perform cerebellar 3D source reconstruction and also coherent spatio-temporal filtering to better separate the bona fide neuronal activity from physiological confounding components. At the more practical level, more participants are currently being recruited to fully assess the inter-subject variability.

**References:**
1. Rocco *et al.*, IEEE EMBC, (2021).
2. Rocco *et al.*, IEEE ISBI, (2022).
3. Machado *et al.*, J. Neurosci. Methods 309(1), (2018).

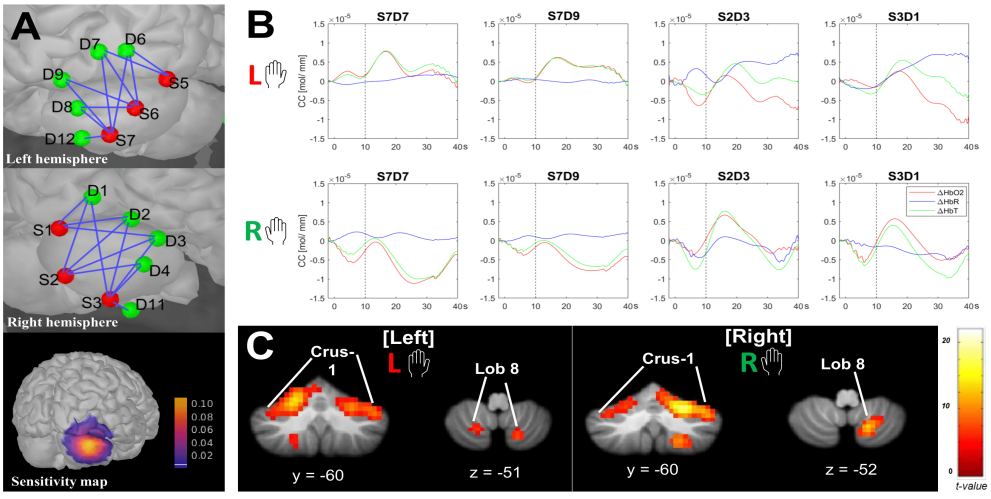


**Figure 1.** A: personalized fNIRS montage. B: fNIRS HRF results. C: fMRI activated clusters


*International Conference of the Society for functional Near Infrared Spectroscopy (SfNIRS), October 9–12, 2022, Boston, USA.*