Asymmetries in Cerebellar Activation during Finger Movements: A Functional Near-Infrared Spectroscopy Study

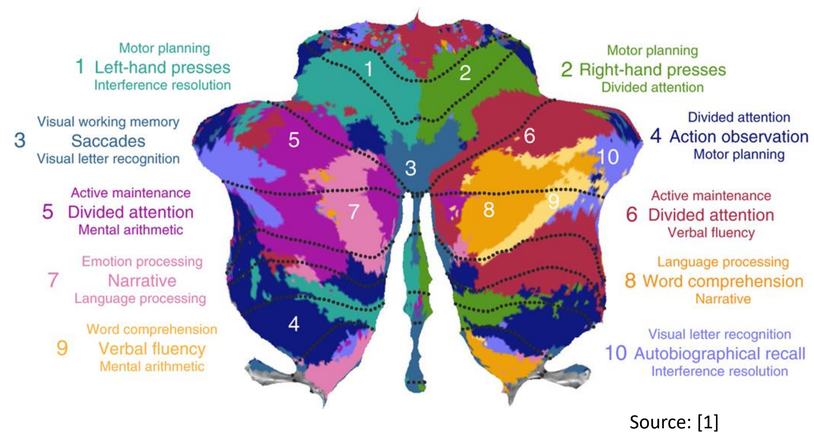
G. ROCCO [1], J. LEBRUN [1], O. MESTE [1], M.N. MAGNIÉ-MAURO [2,3]

[1] I3S Laboratory, [2] BCL Laboratory, [3] Centre Hospitalier Universitaire - Université Côte d'Azur, Nice, France

INTRODUCTION

- Growing interest in unravelling cerebellar functions in the last decades
- Heterogeneous findings about cerebellar involvement in sensorimotor control
- Need for further analysis and new methods to investigate cerebellum with a focus on hemisphere specificity

⇨ investigation of which **cerebellar hemisphere** displays **activation** during finger movement of the dominant and sub-dominant hand using **functional Near-Infrared Spectroscopy** (fNIRS).

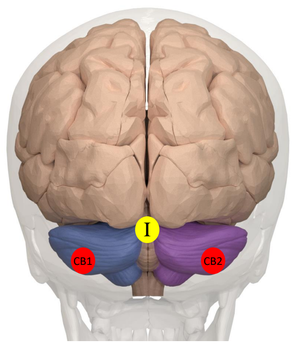


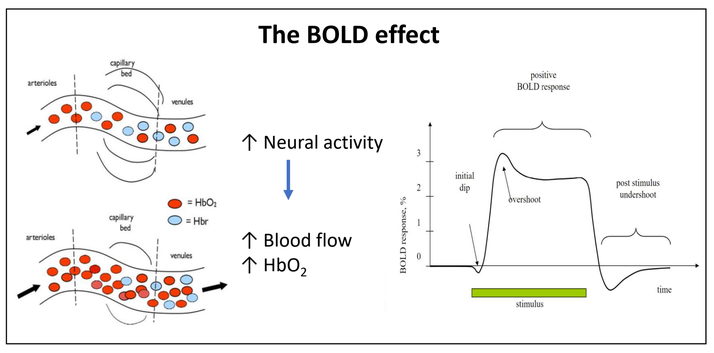
Source: [1]

METHOD

- fNIRS is an **optical technique** that allows to measure the changes in concentration of oxygenated (ΔHbO_2) and deoxygenated (ΔHbR) hemoglobin supposedly caused by neuronal activation.

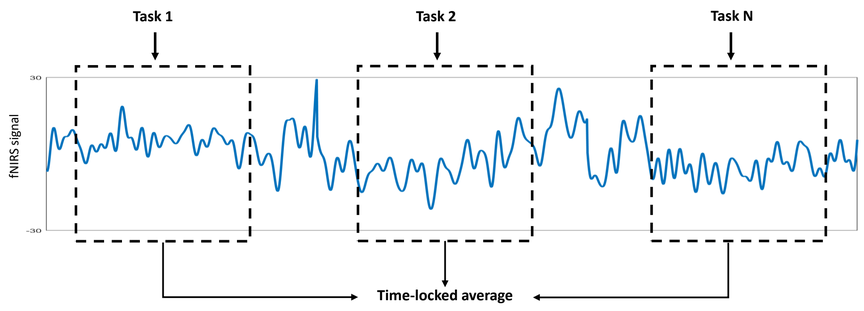
- Two channels (source and detector) acquired, respectively on the left (CB1) and right (CB2) cerebellar hemisphere with source-detector distance at 3.5 cm to ensure an adequate depth to access the real cerebellar signal and to elude muscle and extracerebral activity.



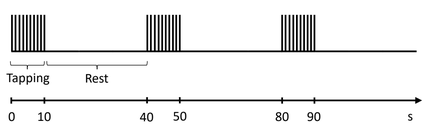


- Recording of the blood oxygenation level dependent (**BOLD**) effect: neural activation is associated with an increase in local arterial vasodilation, which leads in turn to a regional increase in cerebral blood flow and volume and thus oxygenation.

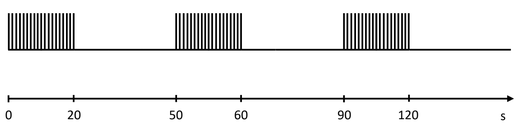
- One healthy subject performed a **finger tapping** task: 6 repetitive blocks (task + rest) respectively for the left and right hand.



- The task was repeated twice for each hand changing the activity periods:

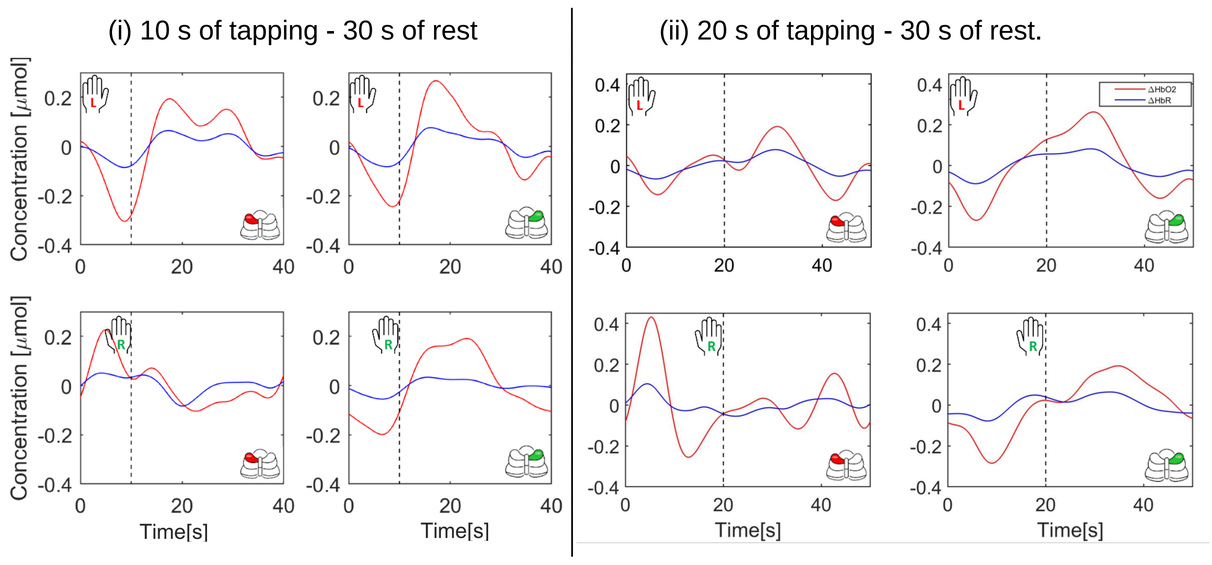


(i) 10 s of tapping - 30 s of rest



(ii) 20 s of tapping - 30 s of rest.

RESULTS



- Similar hemodynamic response observed ipsilaterally and contralaterally for both protocols (10 s vs 20 s activity).

- Involvement of the dominant hemisphere (right-handed subject) even during the sub-dominant hand movement (validated with a left-handed subject) [2].

- A finer analysis shows higher synchronization of the right hemisphere for left hand movement in according with previous fMRI studies [3]:

  - Ipsilateral activation with the dominant hand movement

  - With movements of the subdominant hand BOLD signal increases ipsilaterally and also contralaterally. This raised the hypothesis of a dual layer processing

Source: [3]

CONCLUSIONS

- fNIRS proved to be a bona fide alternative technique to capture cerebellar hemodynamics in a non-clinical setting.

- The observed asymmetries in cerebellar activation agree with previous fMRI studies [3].

- They suggest the existence of different layer of controls from the cerebellum in the two hemispheres: one for precise movements and the other for repetitive ones.

- Extended experiments are planned in the future to study motor and cognitive functions in a multimodal setting with EEG recordings.

- This work paves the ground towards the implementation of a new diagnostic tool to interpret patterns of cerebellar activation.

REFERENCES

[1] King, M., Hernandez-Castillo, C. R., Poldrack, R. A., Ivry, R. B., & Diedrichsen, J. (2019). Functional boundaries in the human cerebellum revealed by a multi-domain task battery. *Nature neuroscience*, *22*(8), 1371-1378.

[2] Rocco G., Lebrun J., Meste O., & Magnié-Mauro M. N. (2021). A Chiral fNIRS Spotlight on Cerebellar Activation in a Finger Tapping Task. *43rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC).*

[3] Jäncke, L., Specht, K., Mirzazade, S., & Peters, M. (1999). The effect of finger-movement speed of the dominant and the subdominant hand on cerebellar activation: a functional magnetic resonance imaging study. *Neuroimage*, 9(5), 497-507.

CONTACT:

giulia.rocco@i3s.unice.fr

i3S sophia antipolis — Laboratoire d'Informatique de Signaux & Systèmes de Sophia Antipolis
Centre Hospitalier Universitaire de Nice — Université Côte d'Azur
BoostUrCAreer
Région Sud Provence Alpes Côte d'Azur — Investissements d'Avenir Initiative d'Excellence — UCA J.E.D.I. Université Côte d'Azur — Co-Funded by the European Union
Société de Physiologie