 DOI: 10.3217/978-3-85125-962-9-161

Assessing the Potential of VASO-fMRI to Determine which Cortical Layer Offers the Best Motor Decodability for ECoG BCI

M. Kromm[1*], M.A.H.L.L. Raemaekers[1], N.F. Ramsey[1]

[1]*UMC Utrecht Brain Center, Department of Neurology and Neurosurgery, University Medical Center, Utrecht, the Netherlands*

* E-mail: m.kromm-2@umcutecht.nl

Introduction: Functional Magnetic Resonance Imaging (fMRI) is frequently used to establish the feasibility and optimal location for a Brain-Computer Interface (BCI) [1]. While standard fMRI provides information for the placement of BCI implants, it does not distinguish between cortical layers. Knowing which layer provides optimal decoding information affects the optimal electrode size [2]. However, the blood oxygenation level-dependent (BOLD) signal, generally used for fMRI measures, includes a strong contribution from draining veins making it less spatially bound to the locus of neuronal activity. Vascular-Space-Occupancy (VASO) fMRI is specifically sensitive to changes in blood volume, which are spatially more tightly linked to the electrophysiological sources [3]. In this study, we establish the potential of using VASO to determine the optimal cortical depth for decoding movement for implantable BCIs, thus aiming to optimise the electrodes' location and their optimal size.

Material, Methods and Results: High-resolution VASO/BOLD data (0.85x0.85x1.5 mm) were acquired in three subjects on a 7-Tesla scanner using a 32-channel surface coil over the left sensorimotor cortex. Subjects performed two gestures from the American Sign Language with their left and right hand in a slow event-related design. Data were preprocessed using SPM12, custom MATLAB scripts and LayNii tools [4]. Support vector machines (SVMs) were trained to distinguish gestures based on either ipsilateral or contralateral activity. Decoding results indicated that while VASO could distinguish between gestures of the contralateral hand (μ=64%), classification based on ipsilateral activity was close to chance (μ=56%). Classification accuracy was reduced relative to BOLD classification, with BOLD being able to classify based on contralateral (μ=87%) and ipsilateral activity (μ=78%). First results for the layer-specific activity profiles confirm that VASO is spatially more linked to the neuronal sources, while the BOLD signal is amplified in the superficial layers (Fig. 1).

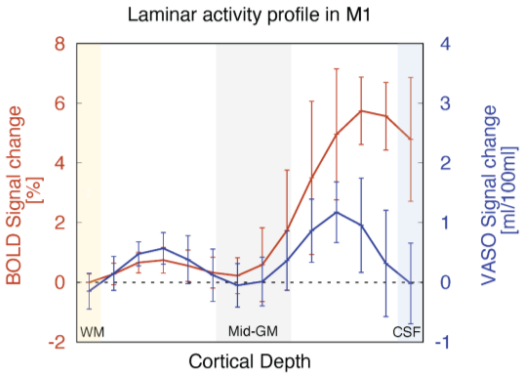

***Figure 1**. Signal changes (mean and standard deviation) across cortical depth during contralateral hand movement (n=1). The cortical depth is approximated; measurement points do not correspond to biological layers.*

Discussion and Significance: Our results show that VASO has the potential to be used for assessing the feasibility of BCI designs, thereby providing a means to locate the necessary differential neuronal sources more precisely. As the signal-to-noise ratios of VASO are reduced relative to BOLD, it would benefit from more trials and, thus, longer measurement periods to train SVMs adequately. Future research will include the assessment of layer-specific classification, which can help to assess the nature of the neuronal sources driving a BCI more precisely.

References:

[1] Hermes, D., Vansteensel, M. J., Albers, A. M., Bleichner, M. G., Benedictus, M. R., Orellana, C. M., … & Ramsey, N. F. (2011). Functional MRI-based identification of brain areas involved in motor imagery for implantable brain-computer interfaces. *Journal of neural engineering, 8*(2), 025007.

[2] Vermaas, M., Piastra, M. C., Oostendorp, T. F., Ramsey, N. F., & Tiesinga, P. H. E. (2020). When to include ECoG electrode properties in volume conduction models. *Journal of neural engineering, 17*(5), 056031.

[3] Huber, L., Finn, E. S., Handwerker, D. A., Bönstrup, M., Glen, D. R., Kashyap, S., Ivanov, D., Petridou, N., Marrett, S., Goense, J., Poser, B. A., & Bandettini, P. A. (2020). Sub-millimeter fMRI reveals multiple topographical digit representations that form action maps in human motor cortex. *NeuroImage, 208*, 116463.

[4] Huber, L. R., Poser, B. A., Bandettini, P. A., Arora, K. Wagstyl, K., Cho, S., … & Gulban, O. F. (2021). LayNii: A software suite for layer-fMRI. *NeuroImage, 237*, 118091.