 DOI: 10.3217/978-3-99161-050-2-053

Decoding Hand Gestures from Gyral and Sulcal Regions of the Sensorimotor Cortex Using High-Resolution fMRI

M. Kromm[1*], M. Raemaekers[1], M.P. Branco[1], N.F. Ramsey[1,2]

[1]*Department of Neurology and Neurosurgery, University Medical Center Utrecht Brain Center, Utrecht University, Utrecht, The Netherlands.* [2]*Donders Institute for Brain, Cognition and Behaviour, Radboud University, Nijmegen, The Netherlands.*

*P.O. Box 85060, Utrecht, The Netherlands. E-mail: m.kromm-2@umcutrecht.nl

Introduction: Implantable brain-computer interfaces (iBCIs) aim to restore communication for individuals with severe motor impairments by establishing a pathway between signals measured from the surface of the brain and a computer. The recording electrodes are commonly placed in or on the sensorimotor gyri, covering parts of the precentral and/or postcentral gyrus. However, much of the human primary motor cortex (M1) is located within the central sulcus [1] and is thereby not easily accessible for electrodes [2]. To establish the potential contribution of sulcal information for decoding, this study compares the classification performance of hand movements in the sulcal and gyral part of the sensorimotor cortex using 7-Tesla functional magnetic resonance imaging (fMRI).

Material, Methods and Results: Ten able-bodied volunteers (age: *mean* = 25.5 years, *range* = 21–42 years, 6 females) participated in the 7-Tesla fMRI study. They performed 20 different gestures with the right hand during fMRI acquisition (*voxel size* = 1.5 mm^3). Results showed that all 20 gestures were classified above chance level (5%) in the primary motor cortex (M1; *mean* = 26%, *SD* = 5%, $p < 0.001$) and the somatosensory cortex (S1; *mean* = 42%, *SD* = 7.4%, $p < 0.001$). The most informative voxels for gesture classification within the combined sensorimotor cortex were located in the hand knob region, covering both the sulcal and gyral areas (Fig. 1B). In M1, classification performance did not significantly differ between the sulcus and the gyrus ($t(9) = -0.5$, $p = 0.6$, *CI* = [-5.5, 3.3]; Fig.1A), while in S1, the classification performance was significantly higher in the gyrus than in the sulcus ($t(9) = 5.3$, $p < 0.001$, *CI* = [7.2, 17.7])).

Conclusion: These findings suggest that choosing intrasulcal recordings for decoding from M1 and S1 may not benefit performance compared to gyral recordings for BCIs. It should be noted that S1 activity during the task might be driven by proprioceptive and tactile feedback of the executed movements. Thus, the observed higher classification performance in the S1 gyrus compared to the sulcus might be absent in paralyzed individuals.

Acknowledgments and Disclosures: Funded by Dutch Research Council OCENW.M.22.142, EU EIC-101070939 and USA NIH NINDS UH3NS114439. There are no disclosures to declare.

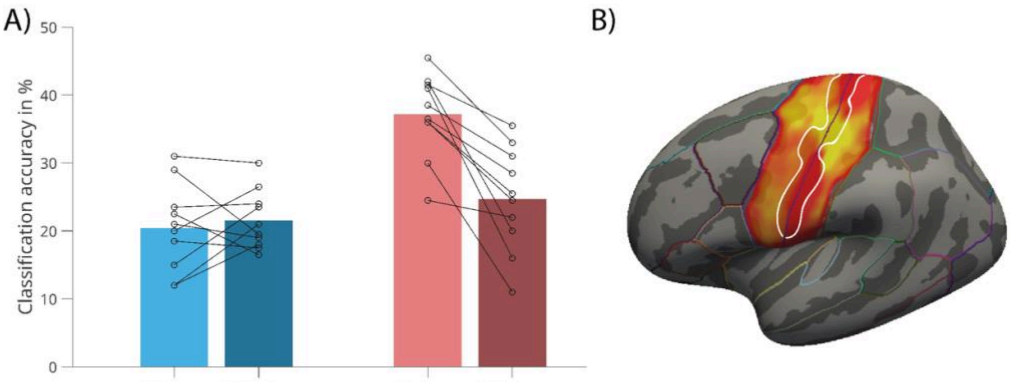

Figure 1: A) *Mean gyral (light) and sulcal (dark) classification accuracy of 20 gestures for M1 (blue) and S1 (red). The circles and connecting black lines show single-subject performance.* B) *Group-averaged SVM-weights show the contribution of sulcal and gyral parts of the sensorimotor cortex to the gesture classification; yellow color indicates higher contribution.*

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Published by Verlag der Technischen Universität Graz