Software for quantative assessment of the results of navigated TMS mapping

Pavel Novikov*[1], Maria Nazarova*[1], Vadim Nikulin[1,2]

E-mail: novikov-p-a@yandex.ru, mnazarova@hse.ru

*Authors contributed equally to the study
1 Centre for Cognition and Decision Making, National Research University Higher School of Economics, Russian Federation, 2 Department of Neurology Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Introduction

Transcranial magnetic stimulation (TMS) is modern non-invasive approach to study brain organization in humans. In TMS a time-varying magnetic fields generate induced electrical currents in the targeted brain regions with focal location of its maximum. Recently, navigation based on the individual magnetic resonance images (MRI) became available for use during TMS - the technique called navigated TMS (nTMS). Using of MRI navigation systems allows to fully realize the advantages of TMS focality for brain mapping purposes. Due to this development, nowadays motor and speech nTMS mapping is becoming a routinely used procedure in neurosurgery. However, nTMS mapping for dynamic cortical assessment, for example, to study neuroplastic changes after rehabilitation or special training is still limited. An important reason for that is a lack of a standardized methodology for nTMS mapping results assessment. A motivation for a standardized workflow is to enable results comparisons across sessions, subjects and studies and to promote a wider use of nTMS mapping for studying brain dynamical changes.

New software

Here we present TMSmap, the software program for the quantitative analysis of nTMS motor mapping results which addresses the challenges mentioned above. The current version is free and available for download at the website http://tmsmap.ru/. The software is written in C# on the Windows platform; it is standalone and has a graphical interface. The input data includes coordinates of the coil position and response parameters such as motor evoked potential (MEPs) amplitude in each point of stimulation and individual structural MRI. The software makes it possible to consider both standard parameters of the nTMS motor maps, like the size of the cortical muscle representation and the center of gravity location, as well as additional parameters enabling researchers to consider the variability of the MEP amplitude in each stimulation spot such as the volume of the representation, the 3D profile of the muscle cortical representation (Raffin et al., 2015) and the overlap between representations. The 3D profile of the muscle representation is built using two approaches: 1) as a total of Gaussians in each stimulation spot depending on the amplitude of the MEP in the spot; and 2) by finding a smooth surface going through all the stimulation points considering the amplitudes of the MEPs in each point (ABOS method).
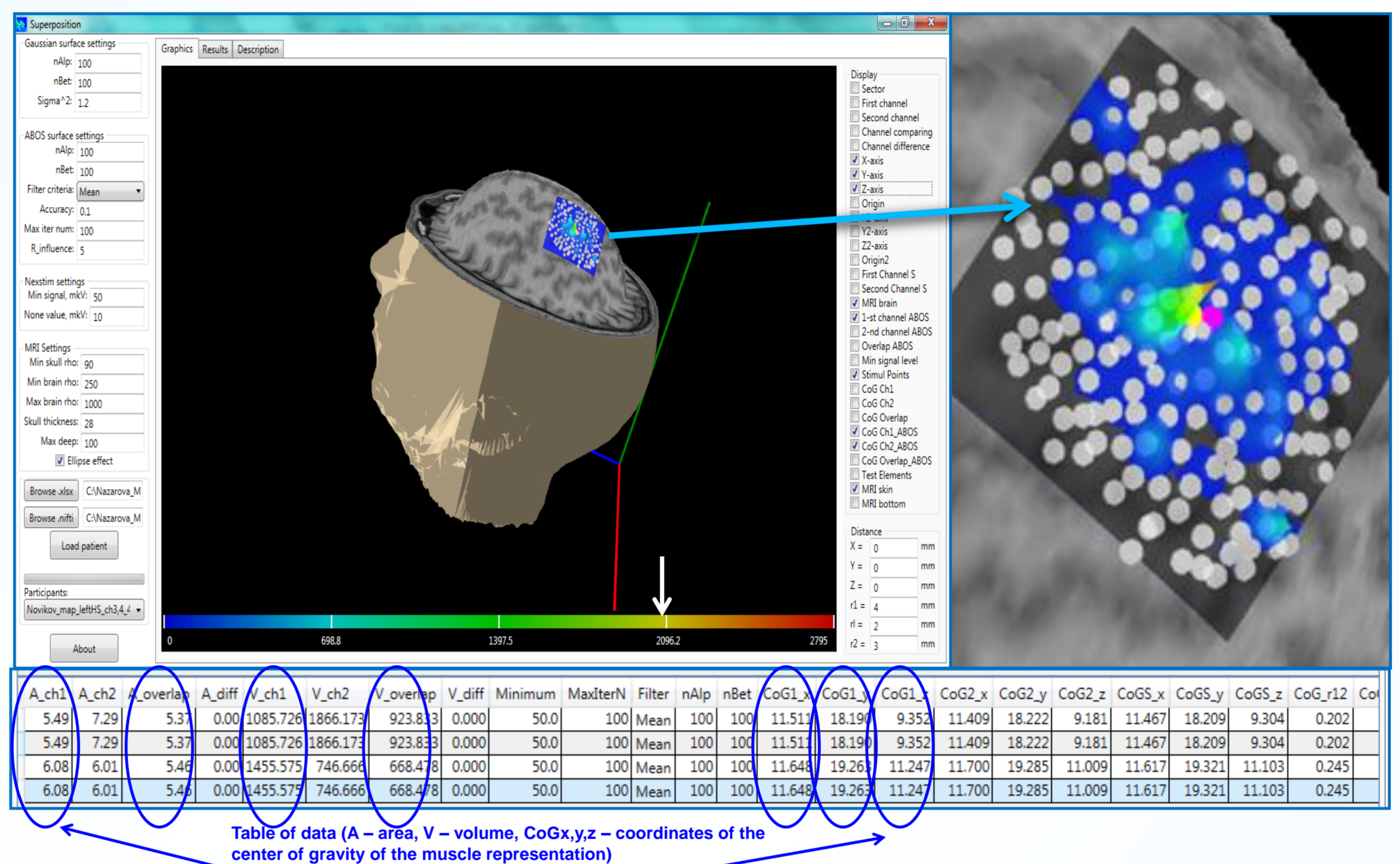
Future perspectives

The results of area calculation were compared with the results got using the method of spline interpolation, which was shown to have a good repeatability in the previous studies (Julkunen 2014).The software was used for the analysis of the nTMS mapping data for several upper extremity muscles in healthy volunteers and stroke patient with hand motor deficit (see example - fig. 2, 3). The future development of the software will include:
• validation of it`s reliability in test-retest session of nTMS mapping;
• it`s adaptation for speech nTMS mapping assessment;
• MNI version of the software which will allow to compare nTMS data of different subjects.

Examples of the use of the software for nTMS motor mapping


Fig. 1 General view of the program window. Light blue arrow is showing the zoomed view of the cortical representation for the studied hand muscle (abductor pollicis brevis, APB). White arrow is showing the scale for MEPs amplitudes. In the bottom – part of the program window with calculated results.

Table of data (A – area, V – volume, CoGx,y,z – coordinates of the center of gravity of the muscle representation)

Fig. 2 The view of the area of cortical representation of the same hand muscle (APB) calculated using two approaches ("Gaussian method" – left, ABOS method – right picture).

	Gaussians method	ABOS method
APB area	5.5	5.5
APB volume	1252.9	1085.7
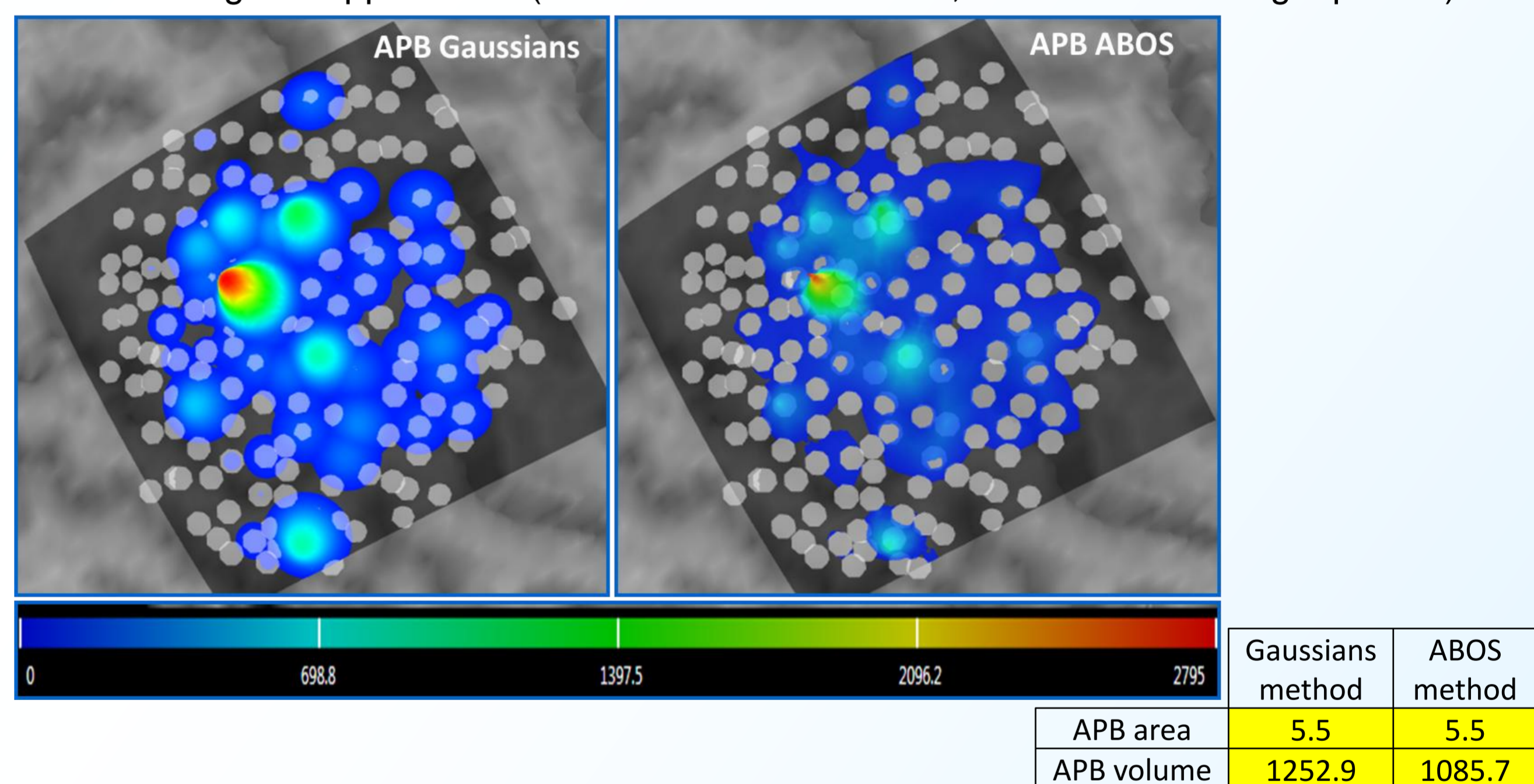
Fig. 3 Cortical representation of the two hand muscles and their overlap: left picture – APB cortical representation, right picture – the representation of the muscle extensor digitorum communis (EDC), in the middle – their overlap
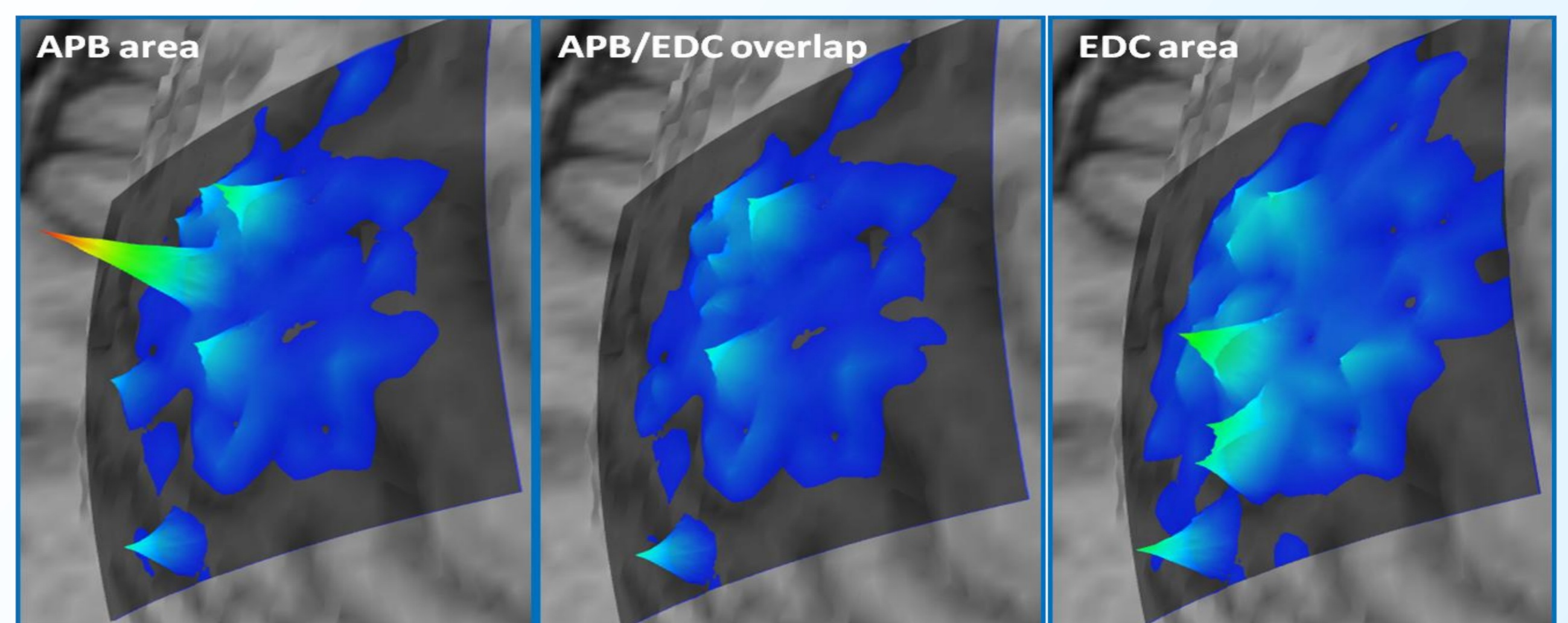
Acknowledgments

Authors are deeply grateful to Dr. A. Ossadtchii and Dr. A. Zhdanov for their consultations during software development and to Dr. Blagoveshchensky for discussions.