Individual targeting and optimization of multi-channel transcranial electric stimulation of the human primary somatosensory cortex

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***Abstract*— Individually targeted multi-channel transcranial Electric Stimulation (tES) has been suggested as a promising approach for manipulation of brain networks. Our somatosensory study investigates the effect of individualizing (1) the targeting using combined Electro- and Magneto- EncephaloGraphy (EMEG) source analysis and (2) the stimulation montages using optimized multi-electrode tES. We focus on the P20/N20 component of combined somatosensory evoked potential (SEP) and field (SEF) data and use calibrated realistic finite element method (FEM) head volume conductor models for targeting and optimization. Individual source analysis results, differing especially in the source orientation components and the resulting differences in optimized tES montages are presented.**

I. INTRODUCTION

Individually targeted multi-channel tES has been suggested as a promising new approach for manipulation of brain networks [1 – 5]. Our study aims at evaluating the contribution of this novel technique. We focus on the human somatosensory system, a well-controlled network that has been deeply investigated over the past decades. For individual targeting, we analyzed the P20/N20 component using EMEG. We then investigated how the individually determined targets affect the optimization of electrode montages for performing multi-channel tES of the somatosensory cortex.

II. METHODS

SEP/SEF were elicited by (a) Electric-Wrist (EW) stimulation of the median nerve, (b) Braille- (BT) and (c) Pneumato- tactile (PT) stimulation of the index finger during EMEG (275 gradiometers - OMEGA2005, VSM MedTech Ltd., Canada and 80 electrodes – EASYCAP GmbH, Herrsching, Germany). Each run had a duration of 10 min (1200 Hz sampling rate and online low pass filtering at 300 Hz). Supine position was used to reduce head movements and to avoid cerebrospinal fluid (CSF) effects due to brain shifts when registering EMEG and magnetic resonance images (MRI) [6, 7]. The preprocessing of SEP/SEF was applied similarly to [6] for all the types of stimulation.

T1w- and T2w- MRI (MAGNETOM Prisma 3.0 T, Release D13, Siemens Medical Solutions, Erlangen, Germany) were used for the construction of a six compartment (skin, skull compacta, skull spongiosa, CSF, gray and white matter) head model using MATLAB and SPM12 – FieldTrip [8]. A geometry adapted hexahedral mesh was constructed including white matter anisotropy [6]. FEM simulations using Venant source modeling (SimBio†) and EMEG source reconstruction was performed based on dipole scanning for each stimulation condition.

A multi-electrode array of 39 possible positions was used for the tES optimization of 8 electrodes (Starstim tES system, Neuroelectrics, Barcelona, Spain). The optimized stimulation protocols were estimated using a maximum intensity optimization algorithm [2] with an additional L2 regularization constraint over the injected currents for better current distribution and an overall anodic current limited at 2mA.

III. RESULTS

Figure 1 presents the targets, tES optimization results and the quantification of the optimized current density for all three stimulation conditions.

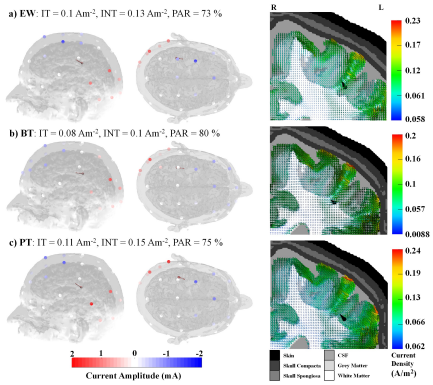

Figure 1. Optimized currents for **a)** EW, **b)** BT and **c)** PT. Each target is presented by a black point for its localization and a black line for its orientation. The intensity of the current density in the target area (IT), the averaged intensity of the current density in non-target regions (INT), and the percentage of current that is oriented parallel to the target vector (PAR as DIR/IT, where DIR is the inner product of current density and target vector) is displayed for every target.

IV. DISCUSSION & CONCLUSION

The P20/N20 sources for the three stimulation conditions (EW, BT and PT) are reconstructed in different subareas of Brodman area 3b, i.e., different location and especially different orientation of the involved patches of synchronized pyramidal cells. Therefore, the resulting optimized electrode montages also clearly differ and the montage differences might be seen as a simple indicator for a possible contribution of individually targeted multi-channel tES over standard montages. We are currently running a somatosensory experiment for evaluating the impact of targeted optimized versus standard tES.

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†https://www.mrt.uni-jena.de/simbio/index.php/Main_Page