Inaccurate segmentation of lesioned brains can significantly affect targeted transcranial electrical stimulation on stroke patients

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Introduction: Transcranial electrical stimulation (TES) has been shown to improve stroke recovery. Computational models of electrical current flow are often used to guide electrode placement on the scalp for targeted stimulation. This process relies on accurate segmentation of the brain, cerebrospinal fluid (CSF), skull and scalp, especially the lesion areas for stroke patients. Current software for brain segmentation usually cannot capture the lesions with high accuracy and manual labor is thus needed to correct segmentation errors from automated tools. However, this is tedious for studies that involve many stroke patients. Here we show that TES models built directly from the automated segmentation generated by the popular software SPM8 without any manual correction give significantly different predictions compared to those with careful manual clean-up.

Methods: T1-weighted magnetic resonance images (MRI) were obtained on 17 stroke patients with lesions in the left-hemisphere. Individualized computational models were built following previously published method (Huang et al. 2013). Briefly, each head was segmented first by SPM8 and then manually corrected for segmentation errors, especially for the lesion area. Electrodes following EEG 10-10 convention were placed on the scalp. Finite element model (FEM) was made based on the segmented tissue mask and solved for each bipolar electrode configuration with electrode Iz as ground. To study how manual segmentation affects the modeling results, another version of models was also built for each subject directly from SPM8-generated segmentation. Targeted stimulation were performed (Dmochowski et al., 2011) for each subject on the 2 versions of models. This was done for over 10,000 randomly picked and co-registered cortical points on each subject. For each cortical point, t-test was performed to compare if manually-corrected models give different predictions on achieved electric field at the target compared to models without manual correction.

Results: About 66% of the 10,000 locations on the cortex achieved significantly higher electric field intensity at the target if manual correction was performed when building the models (average $p=0.01$, $t(16) = 3.01$).

Conclusion: Purely automated segmentation of lesioned brains will significantly divert model predictions on current flow. This motivates us to develop new segmentation algorithms for lesioned brains to help reduce the manual workload in targeted TES for stroke patients.