400 word limit (includes Background, Methods, Results, and Conclusions). Underline name of presenting author. Use the same font type/size, margins, etc. that are already included in this template. One figure or table may be included. The entire abstract MUST be within 1 page.

Measurements and models of electric fields in the *in vivo* human brain during TES

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Background: Transcranial electric stimulation (TES) aims to stimulate the brain by applying weak electrical currents at the scalp (Ruffini et al., 2013). However, the magnitude and spatial distribution of electric fields in the human brain are unknown. Despite increasing sophistication in the computational models for TES, none of them have been directly validated to-date. Here we aim to address this with *in vivo* intracranial recordings in humans by directly measuring field intensities produced by TES at the cortical surface and deeper brain areas.

Methods: Electric potentials during TES were recorded intracranially from ten patients undergoing invasive monitoring for epilepsy surgery, with subdural grids, strips, and depth electrodes. These recordings were then compared to various detailed computational models, including differential conductivity between skull spongiosa and compacta, and white matter anisotropy. Models were also calibrated using the recordings to minimize the difference between measurements and model predictions. In doing so, we obtain calibrated models that conclusively answer outstanding questions about stimulation magnitudes, spatial distribution, and modeling choices.

Results: Conductivities reported in the literature used in existing models tend to overestimate the voltages and electric field magnitudes. After calibrating the models using recorded data, we found that the electric field intensities in the brain reach 0.4 V/m when using 2 mA transcranially. This is approximately half as strong as previous predictions using computational models (Datta et al., 2009). Peak intensities are achieved underneath the stimulation electrodes, but also in deep midline structures such as the anterior cingulate and the peri-ventricular white matter for the specific stimulation configurations tested here (Fpz-Oz). We find that individualized models provide predictions of the spatial distribution of currents with an accuracy of r=0.89 for cortical electrodes and r=0.84 for depth electrodes when pooling data across all subjects. These models capture individual anatomy for brain, CSF, skull, air cavities and skin at 1 mm^3 resolution. The best fitted conductivity values vary across individuals, and the median values give significantly better prediction of the electric field distribution compared to models using literature conductivities. Including variables such as anisotropic white matter and inhomogeneous bone compartments does not improve prediction performance. But extending the FOV to include the entire head and neck significantly improves prediction accuracy.

Conclusions: This is the first study to validate and calibrate current-flow models with *in vivo* intracranial recordings in humans, providing a solid foundation to target stimulation and interpret clinical trials.

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Datta, A. (2009), 'Gyri-precise headmodel of transcranial DC stimulation: Improved spatial focality using a ring electrode versusconventional rectangular pad', Brain stimulation, vol. 2, no. 4, pp. 201–207.
Ruffini, G (2013), 'Transcranial current brain stimulation (tCS): models and technologies', IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 21, no. 3, pp. 333–345.

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