Psychiatria Danubina, 2022; Vol. 34, Suppl. 3, pp 10-57

MODELLING NON-INVASIVE BRAIN STIMULATION OF DEEP BRAIN STRUCTURES FOR PSYCHIATRIC APPLICATIONS

Emilė Radytė[1], Karen Wendt[2,3], Majid Memarian Sorkhabi[2], Jacinta O'Shea[1] & Timothy Denison[2,3]

[1]Wellcome Centre for Integrative Neuroimaging (WIN), Oxford Centre for Human Brain Activity (OHBA), University of Oxford, Department of Psychiatry, Warneford Hospital, Oxford, UK
[2]MRC Brain Network Dynamics Unit, University of Oxford, Oxford, UK
[3]Department of Engineering Science, University of Oxford, Oxford, UK

Introduction: Recent neuropathological and neuroimaging work has identified the lateral habenula as a critical deep brain structure that likely contributes to the neuro-pathophysiology of prevalent psychiatric illnesses. The ability to modulate deep psychiatric targets will become critical to the development of novel treatment protocols and modalities. This is a computational modelling study to explore two common (transcranial alternating current stimulation (tACS) and transcranial magnetic stimulation (TMS)) and one novel (temporally interfering electric fields (TI EFs)) non-invasive brain stimulation (NIBS) methods in their ability to reach and modulate deep brain targets, and anticipate relevant local effects.

Methods: Firstly, the relative strengths of electric fields on- and off-target, a novel target of the lateral habenula in humans, are modelled and compared using simulations based on human neuroimaging data with SimNIBS. Secondly, local effects of these field strengths are modelled on single-compartment neuronal models. Finally, potential side effects such as conduction blocks are investigated using simple single-compartment neuronal models to assess the diverse potential impact of field strength on neuronal activity on- and off-target in the brain.

Results: Across the studied NIBS modalities, the ratio of maximum electric field strength off-target to that at the target remains high, especially for figure-8 coil TMS. Investigation of local effects suggests that the field strengths of all the studied NIBS modalities engage off-target regions of the brain while barely modulating activity at the target when constrained to safe currents for tACS and TI EFs in particular. Finally, it is suggested that electric fields off-target could generate conduction blocks, which can lead to a lack of neuronal response to additional inputs.

Discussion: This exploratory study demonstrates some of the challenges –such as off-target conduction blocks – to be considered if NIBS methods were applied for deep brain structure targeting when treating neuropsychiatric conditions in the future.

* * * * *

UNDERSTANDING CIRCUIT MECHANISMS OF ELECTROCONVULSIVE THERAPY USING MULTIMODAL MRI

Joan A. Camprodon[1], Tracy Barbour[1], Benjamin Ward[2], Carles Soriano-Mas[3] & Marta Cano[4]

[1]*Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA*
[2]*University of California, Los Angeles, CA, USA*
[3]*Bellvitge Biomedical Research Institute-IDIBELL, Barcelona, Spain*
[4]*Univestitat Autonoma de Barcelona, Barcelona, Spain*

Electroconvulsive therapy (ECT) remains the most effective treatment in psychiatry, and among the most effective in medicine. While our clinical understanding of ECT is significant, it contrasts with how little we know about its neurobiological mechanisms of action. Given how diffuse the induced electric fields are and the fact that ECT leads to a generalized seizure, ECT has been traditionally considered a non-specific neuromodulation treatment. However, neuroimaging research is challenging this notion and suggesting ECT is more focal than previously considered. In this symposium, we will present data from groups working in the Global ECT-MRI Research Collaboration (GEMRIC) using structural and functional MRI to understand predictors and mechanisms of action of ECT at the circuit level.

Dr. Wade will discuss results using functional connectivity MRI to compare the mechanisms of action of ECT to other rapidly acting treatments (serial ketamine infusion and total sleep deprivation), identifying modality-specific mechanisms and treatment-response biomarkers.

Dr. Soriano-Mas will present data from GEMRIC aiming to understand the anatomical antidepressant mechanisms of action of ECT using structural covariance. Changes in structural covariance of the hippocampus and the anterior insula are associated with antidepressant efficacy, highlighting the importance of a circuit-based approach to understanding pathophysiology and the and mechanisms of treatment response.

Dr. Cano will present data from GEMRIC analyzing 148 patients with treatment resistant depression, assessing structural changes (volume, area and thickness) associated with the antisuicidal properties on ECT, and highlighting the role of the anterior cingulate.

Dr. Camprodon will discuss results assessing patterns of functional connectivity that both predict and explain the antisuicidal efficacy of ECT at the circuit level. This study illustrates the use ECT as a systems neuroscience translational tool to identify treatment targets and inform subsequent treatment development research for suicide, using other neuromodulation interventions such as TMS.

* * * * *

POTENTIAL OF ELECTRIC FIELD SIMULATIONS IN CLINICAL PRACTICE

Chris Baeken[1], Martin Tik[2], Oula Puonti[3], Debby Klooster[1], Alex Opitz[4] & Maria Vasileiadi[5]

[1]*Ghent Experimental Psychiatry (GHEP) Lab, Ghent, Belgium*
[2]*Brain Stimulation Lab, Psychiatry and Behavioral Sciences, Stanford, CA, USA*
[3]*Danish Research Centre for Magnetic Resonance, Copenhagen University Hospital Amager and Hvidovre, Copenhagen, Denmark*
[4]*University of Minnesota, Minneapolis, MN, USA*
[5]*Medical University of Vienna, Vienna, Austria*

Brain stimulation induced electric field simulations can identify how brain regions are affected depending on the individual's gyral folding pattern. The information about the distribution and strength of the electric fields can be used to derive personalized stimulation parameters or be considered retrospectively in statistical analyses. In this symposium,

First, Oula Puonti (Danish Research Center for Magnetic Resonance) will give an introduction on electric field simulations in practice. Furthermore, he will talk about the link between field modeling and personalized stimulation protocols and present results on the validation of the simulations using invasive and non-invasive approaches identifying crucial aspects for accurate electric field estimates.

Debby Klooster (Ghent University) will demonstrate how electric field simulations could be used in clinical practice to derive the optimal coil position. Current clinical routines assume highest stimulation effects under the center of the coil. This model falls short in explaining the real induced currents. Using data from the HCP, she shows the added value of electric field simulations over simple projection methods.