A three-layer MRI-based head phantom for experimental validation of tES simulations

Abstract
Autism spectrum disorder (ASD) is a neurodevelopmental disorder with a prevalence of around 1.5%. Many individuals with ASD have significant executive function impairments, revealing difficulties in working memory, planning, and performance monitoring. Research has made progress in discovering endophenotypes in ASD but is still far from achieving a comprehensive knowledge of the altered brain mechanisms. Consequently, it is still unclear what mechanism should be targeted during therapeutics. It has been proposed that brain-computer interface (BCI) approaches based on specific electroencephalographic (EEG) frequency bands may stimulate specific neural targets ultimately leading to behavioural adjustments.
Here, we investigated theta band activity as a marker of executive function during an EEG-based BCI task performed by 10 healthy and 10 ASD individuals. Midfrontal theta has been linked to neural processes implicated in executive function and seems to signal general cognitive resource allocation. We developed a BCI task for executive function stimulation and monitoring that requires learning and inverting pseudowords in working memory and analysed which factors contribute to theta power modulation. Midfrontal theta modulation was evaluated during response preparation and execution in both groups. We followed the hypothesis that theta modulation during response preparation would reflect distinct neuronal cognitive resource allocation between groups.
Results revealed augmented theta oscillations in ASD, suggesting that ASD individuals may need increased active cognitive control and attentional mechanisms to obtain similar performance as the control group. Such results suggest midfrontal theta as an important target for neuromodulation in ASD and that our task might be an interesting approach to stimulating the neural mechanisms underlying executive function. Moreover, our study contributes to clarifying the role of theta activity in executive function, as well as its alterations in ASD individuals.
Research Category and Technology and Methods
Translational Research: 14. Brain-computer Interface
Keywords: Autism spectrum disorder (ASD), EEG-based BCI, Executive function, Theta band modulation

http://dx.doi.org/10.1016/j.brs.2023.01.440

Abstract key: PL- Plenary talks; S- Regular symposia oral; FS- Fast-Track symposia oral; OS- On-demand symposia oral; P- Posters

P1.140

SHORT- AND LONG-TERM OUTCOMES OF CHRONIC PALLIDAL DEEP BRAIN STIMULATION IN THE DYSTONIC DTSZ HAMSTER

Denise Franz [1], Marco Heerdegen [1], Nadja Engel [1], Fabiana Santana Kragelund [1], Anika Lüttig [2], Stefanie Perl [2], Angelika Richter [2], Rüdiger Köhling [1]. [1] *University Medical Center Rostock, Oscar Langendorff Institute of Physiology, Germany;* [2] *Institute of Pharmacology, Pharmacy and Toxicology, VMF, University of Leipzig, Germany*

Abstract
Deep brain stimulation (DBS) of the globus pallidus internus has become an effective treatment for generalised dystonia. Despite the rising data sets from clinical trials, however, it remains hard to predict the outcome of DBS for individual dystonic patients due to a lack of knowledge about the pathophysiology of dystonia and the mechanisms of the DBS. As part of the DFG-funded Collaborative Research Center “Electrically Active Implants”, we investigate the short-term (3 h) and long-term (11 d) effects of pallidal DBS with a continuous current pulse (130 Hz, 60 μs, 50 μA) in the dtsz hamster, an animal model of generalised dystonia. Due to the delayed effects of DBS treatment, we are highly interested in alterations of the synaptic plasticity within specific parts of the basal ganglia. We recently verified an improvement in the severity of dystonia in the dtsz hamster with pallidal DBS.
In patch clamp recordings with acute parahorizontal brain slices directly prepared after the DBS was turned off or after the appropriate period for the sham group, we examined the synaptic communication in the striatum and ventrolateral thalamus. We indicated a reduction of excitatory synaptic input on striatal medium spiny neurons after short-term and long-term DBS. In the ventrolateral thalamic nucleus neurons, the inhibitory synaptic tone was reduced in the long-term DBS-treated dtsz hamsters. With the quantitative RT-PCR, we investigated the effects of short- and long-term DBS on the gene expression of dopaminergic, muscarinic, glutamatergic, and adenosine receptors, which differ in the cortex, striatum, and pallidum.
All in all, our studies point to the alteration of synaptic plasticity after short- and long-term pallidal DBS at the molecular and electrophysiological levels and provide indications for possible biomarkers.
This study is supported by the German Research Foundation (DFG) within the Collaborative Research Centre (SFB 1270/1 ELAINE 299150580).
Research Category and Technology and Methods
Translational Research: 1. Deep Brain Stimulation (DBS)
Keywords: Dystonia, Pallidal deep brain stimulation, Synaptic communication, Basal ganglia

http://dx.doi.org/10.1016/j.brs.2023.01.441

Abstract key: PL- Plenary talks; S- Regular symposia oral; FS- Fast-Track symposia oral; OS- On-demand symposia oral; P- Posters

P1.141

A THREE-LAYER MRI-BASED HEAD PHANTOM FOR EXPERIMENTAL VALIDATION OF TES SIMULATIONS

Steven Beumer [1], Maarten Paulides [2,3], Evelien Carrette [4,2], Raymond van Ee [5,2], Albert Colon [6], Debby Klooster [4,2], Paul Boon [4,2], Rob Mestrom [2]. [1] *University of Technology Eindhoven, Department of Electrical Engineering, Eindhoven, The Netherlands;* [2] *University of Technology Eindhoven, Department of Electrical Engineering, The Netherlands;* [3] *Erasmus Medical Center Cancer Institute, Department of Radiation Oncology, The Netherlands;* [4] *Ghent University Hospital, Department of Neurology, Belgium;* [5] *Philips research Eindhoven, The Netherlands;* [6] *Academic center for epileptology Kempenhaeghe/MUMC+, Department of epilepsy surgery, The Netherlands*

Abstract
Transcranial electric stimulation (tES) is being investigated for the relief of seizures in medically refractory epilepsy patients. In a quest to optimize the electrode placement and current for improvement of the outcome, we are investigating the exploitation of the pre-stimulation planning using finite element simulations based on individual anatomy from MRI [RM1] scans. A crucial step is validating the stimulation modeling accuracy, but commercial setups for validation do not exist.
Hereto, we developed a three-layer head phantom, consisting of skin, skull, and brain tissue, that captures the crucial anatomical features and provides a convenient way of verifying the induced electric fields. It also enables systematic characterization of the uncertainties and variations in conductivity and anatomy. Experiments on the three-layer phantom bridge the gap between simulations and clinical practice since they also allow for using clinical hardware and electrodes.
The developed phantom consists of an agar and salt brain layer, a graphite-doped polyurethane skull, and a skin layer made from agar gel with a different conductivity. In this way the solid skull separates the two gel layers, preventing possible ion drift over the layers. The anatomy is based on the ICBM 152 linear model, an average of 152 MRI scans, which enables us to intuitively link measurements and simulations. To perform the systematic characterization experiments, hardware and software were designed in-house. This allows for stimulations and measurements on the phantom in a cheap and modular way. The designed hardware consists of a PID-controlled tES stimulator, which can deliver 4 mA with a frequency up to 100 Hz, and a four-channel differential sensing board based on the OpenBCI Ganglion board.
A realistic and modular phantom expands the possibilities of preclinical tES research by providing a tool to validate electric field simulations as well as experiment with clinical hardware and anatomical variations.
Research Category and Technology and Methods
Translational Research: 19. Modeling and computational methods
Keywords: Transcranial electric stimulation, Phantom, Treatment Personalization

http://dx.doi.org/10.1016/j.brs.2023.01.442

Abstract key: PL- Plenary talks; S- Regular symposia oral; FS- Fast-Track symposia oral; OS- On-demand symposia oral; P- Posters