34

tDCS TRAINING IMPROVES EXPERT TENNIS PLAYER SERVING PERFORMANCE

William F. Stubbeman [*], *Victoria Raglan*, *Raya Khairkhah*, *Kathryn Vanderlaan*, *Jerry Eyeler*. *William F. Stubbeman, MD; Los Angeles, CA, USA*

* Corresponding author.

Introduction: Visual attention and motor performance skills improve following transcranial direct current stimulation (tDCS) training in novice practitioners. However, the effects of tDCS on expert athletic performance have not been studied.
Methods: A former professional tennis player's first serve percentages were evaluated before and after task and imagery paired tDCS. A 2 mA current was applied over F10 (anode), a brain area linked to visual attention, and Fp1 (cathode). For task paired tDCS, the player served 50 tennis balls before, during, and after tDCS for 3 consecutive days and the results were evaluated immediately and 5 days later. For imagery paired tDCS, the player served 50 tennis balls into a service court with a 3′ × 3 target before and after 15 minutes of motor imagery paired tDCS on a single day. High speed video cameras recorded all data
Results: The percentage of serves landing in the service court after task paired tDCS increased in the short term by 13.1% ($p = 0.042$, $z = -2.033$). Five days following tDCS, the first serve percentage improved by 22.9% ($p = 0.045$, $z = -2.003$) above baseline. The percentage of serves landing in a 3′ × 3′ target zone increased within a single day by 88.7% ($p = 0.017$, $z = -2.379$) after imagery paired tDCS.
Discussion: TDCS paired with motor activity and imagery significantly improves short and long term expert tennis serving performance. These exploratory results are the first to demonstrate elite athletic performance gains following tDCS training and warrant further study in larger controlled trials.

35

TENNIS FIRST SERVE PERCENTAGE FOLLOWING TASK AND IMAGERY PAIRED tDCS

William F. Stubbeman, *Victoria Ragland* [*], *Raya Khairkhah*, *Kathryn Vanderlaan*. *William F. Stubbeman, MD, Los Angeles, CA, USA*

* Corresponding author.

Introduction: Transcranial direct current stimulation (tDCS) improves task performance following motor cortical stimulation and visual perceptual sensitivity following right inferior frontal cortical stimulation. However, the effects of tDCS on real world athletic performance in sports requiring extensive visual tracking skills have not been evaluated.
Methods: The short and long term first serve percentages of an amateur tennis player were evaluated before and after task or imagery paired 2 mA tDCS at F10 (anode), a brain area linked to visual attention, and Fp1 (cathode). For task paired tDCS, the player served 100 tennis balls before, during, and after tDCS for 3 consecutive days and the results were evaluated both immediately and 5 days later. For imagery paired tDCS, the player served 100 tennis balls before and after executing an eyes closed, first person visualization exercise for 15 minutes. High speed video cameras recorded ball trajectories.
Results: For task-paired tDCS, the percentage of serves landing in the service court increased in the short term by 20% ($p = 0.0006$, $z = -3.432$). Five days later, the first serve percentage remained elevated ($p = 0.039$, $z = -2.066$) above the initial level without interim practice. After 15 minutes of imagery-paired tDCS, the first serve percentage increased by 30% ($p = 0.029$, $z = 2.102$).
Discussion: Task and imagery paired TDCS significantly impacts both short and long term first serve percentage. These results are the first to demonstrate the potential for tDCS technology to enhance athletic performance.

36

ELECTROSLEEP METHODS IN A COMPUTATIONAL VIEW

Berkan Guleyupoglu, *Marom Bikson*. *Department of Biomedical Engineering, The City College of New York, New York, New York, USA*

Electrosleep is a method of transcranial Electrical Stimulation (tES) that has been used since the early 1900s. The montages for Electrosleep that were originally used were called as such due to a perceived effect of narcosis once stimulation was turned on. The state of narcosis was also claimed to continue until it was turned off. Over the course of electrosleep's history, it was determined the it does not actually cause the effect of sleep. The dosages that were used during the early years of Electrosleep however, were not very well regulated or reported and the effect may have been there when it originally began. A finite element method model was used to determine the current flow through the brain and surrounding large cranial nerves using historically relevant electrode montages and two new montages were modelled to reduce adverse side effects that were a source of major contention as well as the main reason for moving away from the original electrode montage that was used by early researchers. The newer methods presented here demonstrate an improvement on the old Electrosleep montage while preserving the areas of the brain that were stimulated by the method.

37

EVALUATING THE EFFECTS OF MODEL-BASED OPTIMAL BIPOLAR tDCS CONFIGURATIONS ON CORTICAL EXCITABILITY

Sumientra Rampersad [a,b,*], *Vincent Jansen* [b], *Edwin van Asseldonk* [c], *Dick Stegeman* [b,d]. [a] *Department of Electrical and Computer Engineering, Northeastern University, Boston, USA*; [b] *Department of Neurology; Donders Institute for Brain, Cognition and Behaviour; Radboud University Nijmegen Medical Centre; Nijmegen; the Netherlands*; [c] *Department of Biomechanical Engineering, MIRA-Institute for Biomedical Technology and Technical Medicine, University of Twente, Enschede, the Netherlands*; [d] *Faculty of Human Movement Sciences, Research Institute MOVE, VU University, Amsterdam, the Netherlands*

* Correponding author.

Many positive effects of tDCS have been demonstrated, but these effects can be small or short-lived. Volume conduction modeling results have suggested that the effects of tDCS may improve by using different electrode placements. Some novel configurations have been put forward, but experimental validation is scarce. In a recent modeling study, optimal configurations were found for maximizing either the electric field strength or the electric field strength in the presumably most effective direction in a cortical target area. Configurations with two large electrodes were optimized as this is still the most widely available setup and this approach allows for a comparison with the conventional setup solely based on placement. In the current study, these optimal configurations were compared with the conventional configuration for motor cortex stimulation for their effects on neuronal excitability. Three tDCS configurations were compared in a randomized crossover design with twenty healthy subjects. Corticospinal excitability was evaluated from electromyography of the right first dorsal interosseus muscle using single-pulse transcranial magnetic stimulation. Excitability was measured before and until 25 minutes after 15 minutes of 2 mA tDCS. The configuration that was optimized for field strength in the most effective direction produced significantly larger effects on a group level than the configuration optimized for absolute field strength, and slightly larger effects than the conventional configuration. However, individual differences were large and should be taken into account.

38
MODULATING LANGUAGE COMPREHENSION USING HD-tDCS

Amy Price [a,*], *Michael Bonner* [a], *Roy Hamilton* [a], *Jonathan Peelle* [b], *Murray Grossman* [a]. [a] *Center for Cognitive Neuroscience, University of Pennsylvania, Philadelphia, PA, USA*; [b] *Department of Otolaryngology, Washington University in St. Louis, St. Louis, MO, USA*

* Corresponding author.

Language comprehension relies on the ability to integrate the meaning of individual words into coherent combinations (e.g., integrating “plaid” and “jacket” into a coherent understanding of “plaid jacket”). In a previous fMRI and patient study we found that the angular gyrus was important for the process of successfully integrating conceptual information. Here we demonstrate that high-definition transcranial direct current stimulation (HD-tDCS) to the left angular gyrus modulates the process of integrating word meaning with no effect on control tasks. In this study, participants viewed an adjective-noun word pair on a screen and indicated by button press whether or not the word pair was a coherent combination (e.g., coherent combinations were word pairs like “tiny radish” and low coherent combinations were word pairs like “fast blueberry”). We hypothesized that anodal stimulation to the left angular gyrus would enhance the processing of coherent relative to low coherent word combinations. In a within-subjects design, participants ($N = 18$) received anodal left angular gyrus stimulation, an active sham, and anodal right angular gyrus stimulation on separate days. We found that left angular gyrus stimulation resulted in reduced reaction time for the coherent relative to low coherent word pairs compared to the sham and to the right angular gyrus condition ($p < 0.05$). There were no effects on the visual discrimination and attention tasks. These findings are consistent with the hypothesis that the angular gyrus supports the integration of semantic information, and that this mechanism can be altered by tDCS.

Acknowledgments: We thank the Wyncote Foundation for their support. We also thank Dr. Adam Woods for helpful advising.

39
APPROXIMATION OF FULLY OPTIMIZED HD-tDCS STIMULUS PATTERNS WITH FEWER CURRENT SOURCES USING BRANCH AND BOUND ALGORITHM

Seyhmus Guler [a,b,*], *Moritz Dannhauer* [b,c], *Burak Erem* [d], *Rob Macleod* [b,c], *Don Tucker* [e], *Sergei Turovets* [e], *Phan Luu* [e], *Deniz Erdogmus* [a], *Dana H. Brooks* [a,b]. [a] *Department of Electrical and Computer Engineering, Northeastern University, Boston, MA, USA*; [b] *Center for Integrative Biomedical Computing, University of Utah, Salt Lake, UT, USA*; [c] *Scientific Computing and Imaging Institute, University of Utah, Salt Lake, UT, USA*; [d] *Computational Radiology Laboratory, Boston Children's Hospital, Boston, MA, USA*; [e] *Electrical Geodesics Inc. (EGI), Eugene, OR, USA*

* Corresponding author.

High-Density transcranial Direct Current Stimulation (HD-tDCS) uses arrays containing up to 512 electrodes to modulate brain function non-invasively. HD-tDCS offers the possibility to more precisely target current delivery to target regions while imposing side constraints by optimizing current patterns across the array. However full optimization with N electrodes requires N-1 independent current sources, which can be costly and impractical. One approach is to approximate fully optimized HD-tDCS using an exhaustive search algorithm. However, if multiple current sources are desired, the feasible set of solutions grows exponentially with the number of sources and exhaustive search rapidly becomes intractable. Instead, we have developed a branch and bound (BAB) algorithm to approximate the optimal solution with fewer than N-1 current sources. We first assign currents in the optimal solution below a chosen threshold to 0, then the BAB enumeration tree is constructed on the remaining set. We ‘prune’ configurations that can't improve the objective function. We compared BAB to exhaustive search using a subject specific, high definition finite element head model. Preliminary results suggest we can achieve 2-5 order of magnitude speedup using BAB, even with a naïve BAB implementation, and we expect significant further computational improvement will be achieved by, e.g., making use of electrode weights in the linear objective function and/or the optimal stimulus patterns. Our ultimate goal is to define the tradeoff between number of current sources and the ability to target complex distributed regions.

40
BRAINSTIMULATOR: A FLEXIBLE EXTENSIBLE SOFTWARE TOOL FOR MODELING AND OPTIMIZING TRANSCRANIAL BRAIN STIMULATION

Moritz Dannhauer [a], *Ayla Khan* [a], *Daniel White* [a], *Seyhmus Guler* [b,*], *Spencer Frisby* [a], *Rob S. MacLeod* [a], *Dana H. Brooks* [b]. [a] *Scientific Computing and Imaging (SCI) Institute, University of Utah, Salt Lake City, UT, USA*; [b] *B-SPIRAL Group, Electrical and Computer Engineering, Northeastern University, Boston, MA, USA*

* Corresponding author.

Computational modeling and optimization of transcranial brain stimulation (both tDCS/tACS and TMS) is increasingly important as stimulation systems become more complex and applications become more diverse. However the field lacks sophisticated, flexible, useable, and extensible software tools for modeling and optimization of stimulation. To fill this gap, the Center for Integrative Biomedical Computing, CIBC, has developed BrainStimulator, a tailored set of software modules, module networks, datasets, and documentation, based on the C++ dataflow simulation package SCIRun, for tDCS and TMS (with tACS support planned in the near future). BrainStimulator inherits SCIRun's computational and graphical infrastructure and software engineering and support behind its neuromodulation-specific presentation. The basic modeling engine is a fast, accurate finite element (FE) solution to the governing equations, with sophisticated electrode boundary conditions (“complete model”) for tDCS. The FE tools efficiently compute a transfer (“lead field”) matrix directly relating sources to volume potentials. We include models of patch and high-density electrode arrays and a standard TMS coil, and tools to mesh and position electrodes and coils. We provide realistic geometric models of the head at various resolutions and an optimization routine (requires Matlab) for tDCS that computes current patterns to maximize current along desired directional fields in selected regions of interest (ROIs), while constraining non-ROI current amplitude and imposing flexibly defined safety constraints. BrainStimulator is supported by CIBC's team of researchers and software developers