Transcranial direct current stimulation in chronic spinal cord injury: quantitative EEG study

Mar Cortes[1,2], Laura Dubreuil Vall[3], Giulio Ruffini[3], Douglas Labar[1,2] ,Dylan Edwards[1,2]

[1] Non-invasive Brain Stimulation and Human Motor Control Laboratory, Burke Medical Research Institute, White Plains, NY, USA

[2] Neurology Department, Cornell University, NY, USA [3] Starlab Barcelona SL, Barcelona, Spain

INTRODUCTION

Existing strategies to enhance motor function following spinal cord injury (SCI) are suboptimal leaving patients with considerable disability. Available evidence suggests that Transcranial Direct Current Stimulation (tDCS) is a promising non-invasive neuromodulation method that can improve motor behavior. How tDCS affects resting brain activity monitored by EEG is little explored.

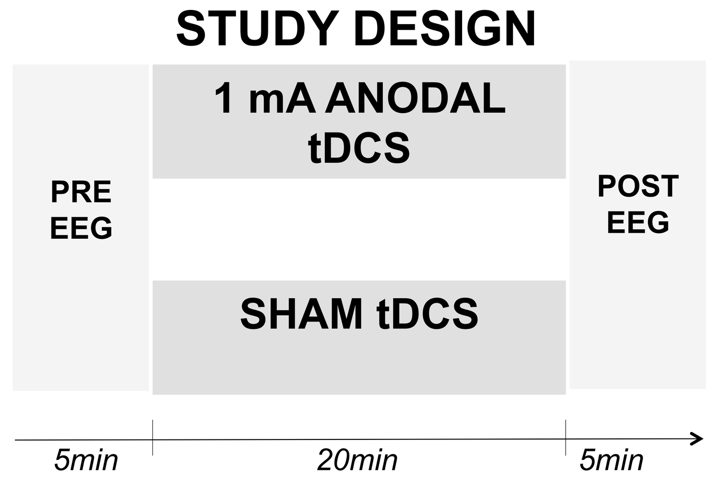
Using Neuroelectric's Starstim novel multichannel wireless device, which allows for simultaneous electroencephalograpy (EEG) and tDCS, we aim to determine the effects of anodal tDCS on EEG to assess changes in brain system activity after stimulation, and understand further the mechanisms of this technique in modulating cortex plasticity and its potential in protocols for motor rehabilitation.

METHODS

We conducted a randomized, single-blind, sham-controlled, cross-over study in seven chronic SCI subjects with cervical lesions, investigating the effects of 20-minute anodal tDCS applied over the primary motor cortex (M1) on electroencephalography (EEG) power spectrum density, coherence and frequency band power (theta (4-8Hz), alpha (8-10Hz), beta1 (16-25Hz), beta2 (25-35Hz). Subjects were randomized to receive either 1mA or sham stimulation.

The EEG data consisted of 5-minute takes of 24 bit, 500 S/s 8-channel EEG collected with StarStim Ag/AgCl EEG electrodes (positions at C3, AF8, F3, F4, Cz, C4, P3 and P4; and Pi Ag/AgCl electrodes at C3 and AF8) acquired at two time points for each subject (pre and post stimulation). C3 was used for anodal stimulation and AF8 as a return electrode (Figure 1).

STUDY DESIGN



NEUROELECTRIC'S STARSTIM tDCS DEVICE

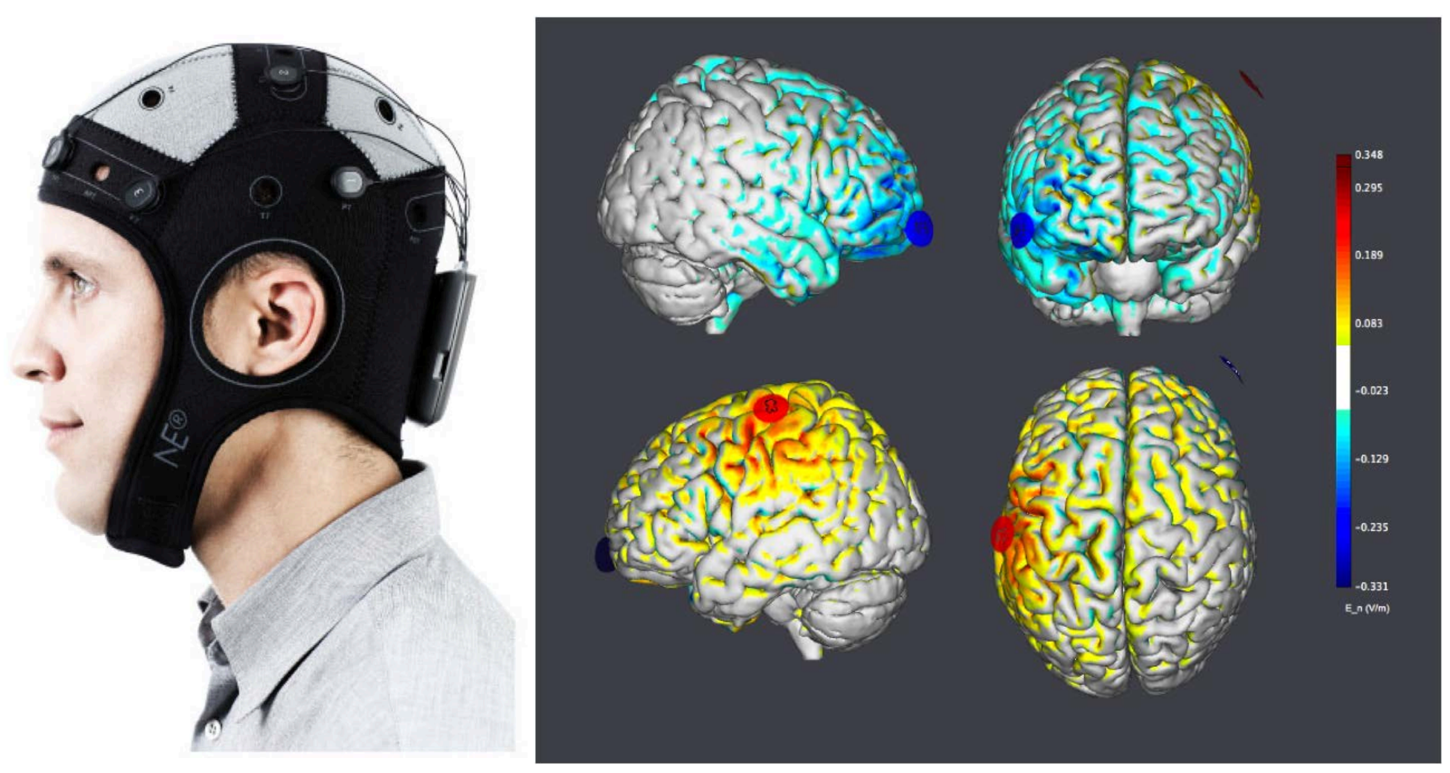


Figure 1. Starstim wireless tDCS device. Electric field induced by montage (+ 1mA C3 anodal – 1mA AF8 cathodal) using small, Ag/AgCl "pi" gelled electrodes with a surface area contact to 3 cm2

RESULTS

Our results showed that, in comparison to sham stimulation, 20-minutes of active 1mA tDCS induced a pattern of faster activity around the anodal stimulating electrode, and slowing activity near the return electrode in the **mean frequency** (full band) and **mean power** domain (gamma band, Figure 2). In addition, tDCS increased coherence in the fastest bands (gamma, beta 2) and decreased coherence in slower frequency bands (theta, SMR), with no relation with brain topography or the stimulation electrode polarity (Table 1).

Table 1. EEG statistical significant changes (post/pre, $p<0.005$)

Feature	Frequency band	Type of change and location
MEAN POWER	Gamma	Increase **C3**
MEAN COHERENCE	Theta	Decrease P4, P3
	SMR	Decrease C3
	Beta2	Increase F3, Cz
	Gamma	Increase C3, AF8,Cz, C4
	Fullband	Increase Cz
MEAN FREQUENCY	Apha1	Decrease P4
	Beta2	Increase F3,F4
	Fullband	Increase **C3**,C4

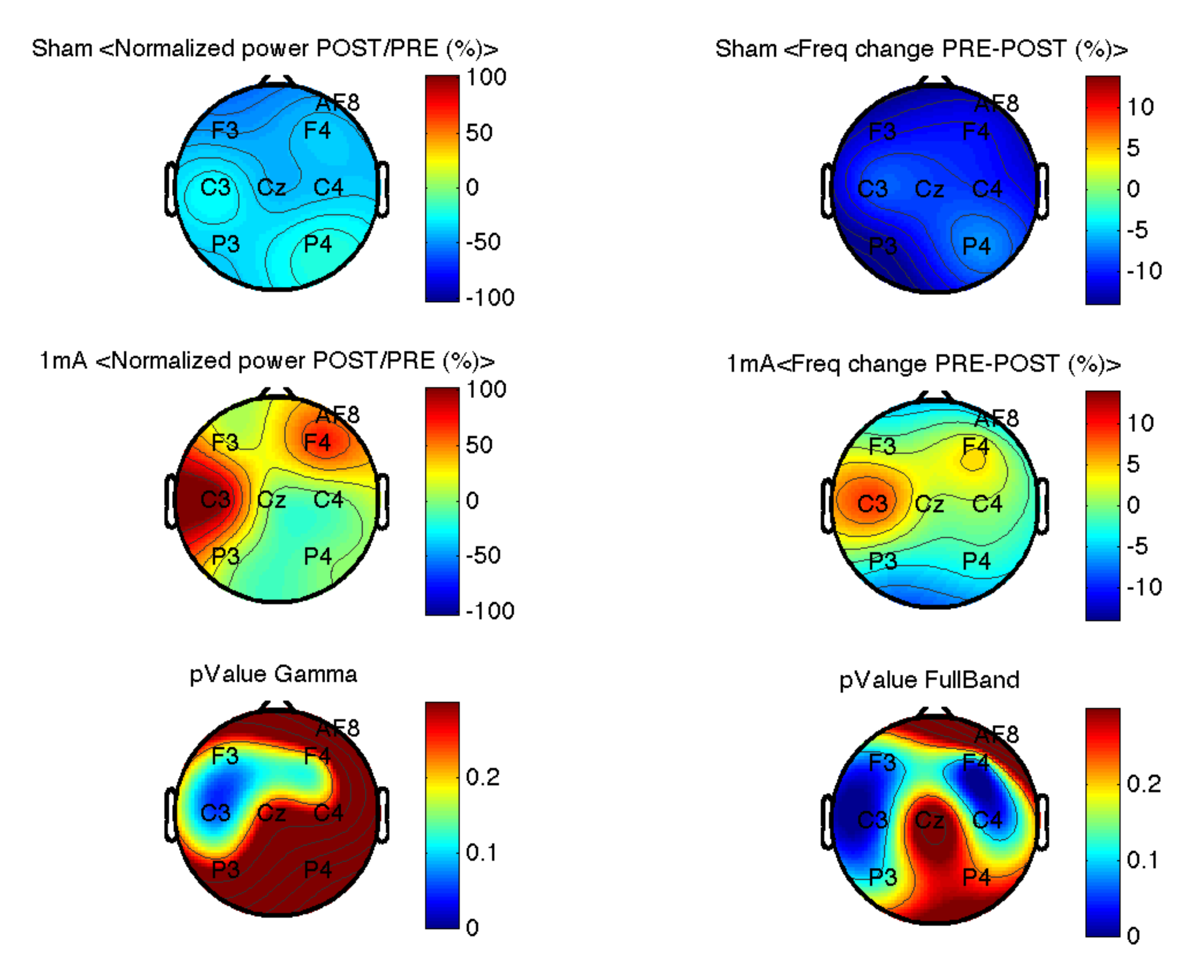


Figure 2. Gamma Power and Full band Frequency results for the normalized Pre-Post Power changes of 1mA vs sham. The bottom map provides the p-value (Wilkox) of Sham vs. active stimulation.

CONCLUSION

These findings show that tDCS is capable of inducing modulation of ongoing oscillatory brain rhythms captured by EEG, in spinal cord injury patients. The combined use of EEG and tDCS sets the stage for optimizing tDCS protocols targeting motor cortex and may have application in treatment of motor dysfunction and chronic pain.

Email: mac2083@med.cornell.edu