TINNET STSM Final Report:

Modulatory effects of transcranial direct current stimulation (tDCS) on neural activity during and after acoustic stimulation assessed by MEG

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Purpose of the STSM

The present work is, in part, a follow up to a previous STSM mission entitled *'Study of transcranial electrical brain stimulation (tES) methods with MEG in tinnitus'*. In the previous STSM work was carried out investigating the effects of transcranial alternating current stimulation (tACS) on auditory steady state responses with a view of applying this knowledge to those with tinnitus, for whom tACS provides a potential therapy. The present work expands upon this, by investigating the effects of the similar, but distinct form of tES, transcranial direct current stimulation (tDCS). Further, we build upon the previous research by investigating the effects tDCS has on neural oscillations, with particular reference to the frequency bands implicated in the generation of tinnitus. We also sought to investigate the correlations between these neural effects and behavioural measures by employing a simple forward masking paradigm and collecting participant responses.

This work is important to carry out as tDCS is becoming an increasingly used technique in the tinnitus literature and yet its precise neural effects remain poorly understood. In addition, the accuracy of targeting specific areas of the brain e.g. the auditory cortex with tDCS is unclear. It is therefore imperative that work is carried out to confirm that the tDCS is targeting the correct areas of the brain and to further understand what effects it has on tinnitus related neural activity.

Methods of the work carried out

Participants

The mission recruited a total of 11 healthy, normal hearing, participants, with work ongoing to collect more. All work was carried out in the MEG laboratory at the Centre for Mind and Brain Sciences, Mattarello, Trento, Italy under the supervision of Nathan Weisz.

Materials and equipment

All MEG data was acquired using an Elekta Neuroimage 306 channel MEG machine and all tDCS stimulation was administered using a Neuroconn DC Stimulator Plus that was made MEG compatible through various accessories. Electrical stimulation was administered via 2 35cm^2 electrodes encased in saline soaked sponges and placed midway between T3 and T5 (for the anode) and midway between F8 and T4 for the cathode. These electrodes were held in place by a swim cap, helping to maintain their position and their moistness.

Acoustic stimulus was delivered to the participant via an etymotic pneumatic stereo headset controlled using a DataPixx Soundpixx system. Participant responses were collected through a 2 button box attached to a DataPixx ResponsePixx system. All visual stimulus were presented to the participant via a back projected screen linked to DataPixx VPixx projection system.

Protocol

The experimental paradigm is given in figure 1, but consisted of 4 steps:

1. 5 seconds of white noise were presented and on 50% of the trials this was accompanied by anodal tDCS, on the other 50% this was accompanied by a much weaker, sham stimulation.
2. On 50% of the trials, a 50ms, 1Khz pure tone proceeded stimulation. When a tone was presented it occurred at one of four time points: 50ms, 250ms, 450ms or 650ms.
3. This was followed by up to 2.5 seconds of silence

4. The participant was then prompted as to whether they heard a tone and was given 2 seconds to respond either to the positive or the negative.

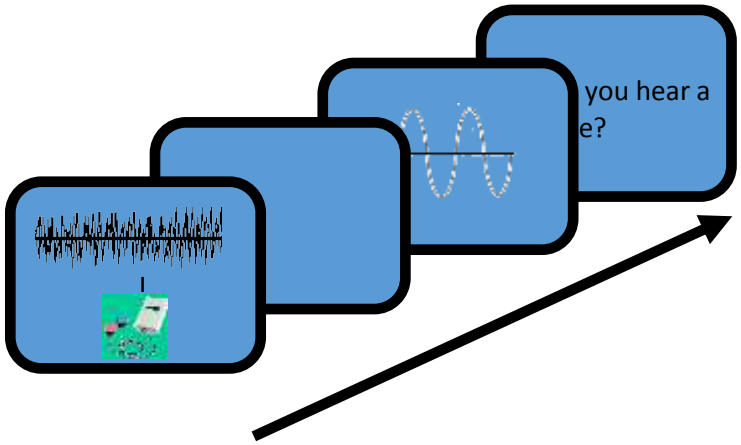

Figure 1: Schematic diagram of the experimental paradigm

Before the main experiment began, all participants were asked to engage a in a simple adaptive staircase to assess their hearing threshold for the white masking noise. This threshold was then increased by 50dB for the main experiment. Further, participants were also required to undergo thresholding for the tDCS, in order to maintain a level of stimulation that was not perceivable by the participant. Following this the main experiment commenced. The experiment took a total of 1 hour to complete and MEG data was acquired throughout (with the exclusion of the threshold finding elements).

Analysis

All MEG data acquired will be analysed in the Fieldtrip toolbox for Matlab and the behavioural data will also be analysed in Matlab.

Results

Analysis of the data is still ongoing and so all results are in a very preliminary stage. Nonetheless, they appear promising. We chose to skip sensor space analysis as the artefact caused by the tDCS was too large. However, going into source space using an LCMV beamformer effectively filtered out the artefact and left us with the evoked response fields shown in figure 2. The figure

shows an interesting increase in activity at the onset and offset of the masker (~1 second and ~6 seconds respectively) in the sham tDCS condition (blue). Analysis will continue to reveal whether this response is consistent across all participants and whether or not this difference is significant. It will also encompass a full analysis of oscillatory effects of both white noise maskers and tDCS and analysis of the behavioural responses.

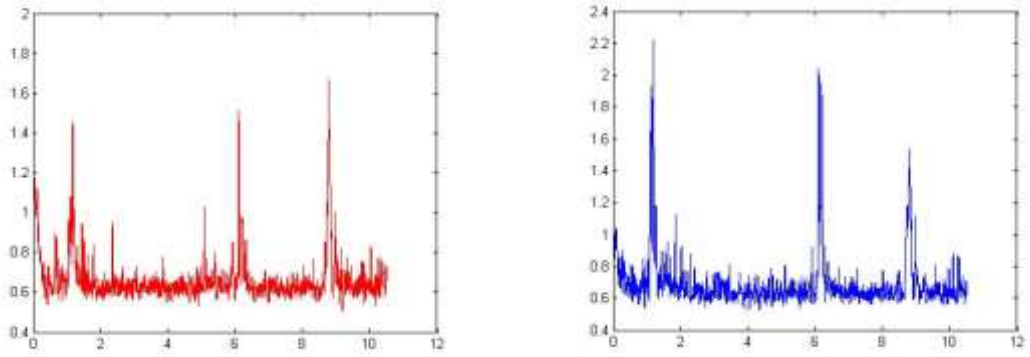

Figure 2: Average Evoked Response Fields for the condition of anodal stimulation and no tone (red) and sham stimulation and no tone (blue) across a full trial period n = 1.

Future collaboration and dissemination of the work

We will continue to collaborate with the host institution until both data collection and data analysis are completed. Following this, we expect to publish an article on this work in a peer reviewed scientific journal as well as present this work at a number of conferences in the near future. The work will also form part of the grantee's doctoral thesis.

Confirmation of successful execution of STSM

Confirmation of the successful execution of this STSM is attached separately.