Modulation of the Somatosensory and Pain Systems using High Definition Transcranial Direct Current Stimulation

Sebastian Kold* & Thomas Graven-Nielsen
Center for Neuroplasticity and Pain (CNAP), Department of Health Science & Technology, Aalborg University, Fredrik Bajers 7D3, 9220 Aalborg, Denmark

Introduction

- High Definition Transcranial Direct Current Stimulation (**HD-tDCS**) is a non-invasive brain plasticity modulation technique, conducted by applying a low-intensity (<2 mA) electrical current between several small electrodes on the scalp[1].
- tDCS is able to produce a subthreshold shift on the resting membrane potentials of the targeted neurons[2].
- tDCS has been used for research of behavioural studies involving working memory function, attention and learning, with promising results, but still show large variability in somatosensory related research[3-4].
- Anodal tDCS of primary motor cortex (M1) or dorsolateral prefrontal cortex (DLPFC) have shown to provide analgesic effects in chronic pain conditions[5].

Aim

- To investigate the efficacy of high definition tDCS on different cortical targets in modulating the nociceptive system in the healthy subjects.

Methods

- This study has a double-blinded, longitudinal design. Testing took place in three sessions of ~2 hours, following the timeline in Fig 1.
- Repeated sessions of the HD-tDCS protocols were conducted once per day on three consecutive days.
- The effects on the somatosensory system were assessed using a battery of quantitative sensory testing before and after each stimulation session.

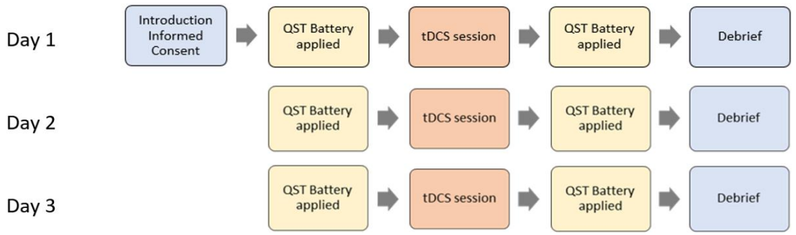

Figure 1: Experimental timeline. Quantitative sensory testing (QST) of pain and sensory profiles was done before and after each high definition transcranial direct current stimulation (HD-tDCS) session on three consecutive days.

Methods (cont.)

The participants were randomly assigned to one of four groups:

Group 1 (N=20) received placebo tDCS (**Sham-tDCS)**.
Age: 26±7 years, Height = 177±9 cm, Weight = 77±12 kg

Group 2 (N=21) received dorsolateral prefrontal cortex tDCS (**DLPFC-tDCS**).
Age: 23±3 years, Height = 172±12 cm, Weight = 69±15 kg

Group 3 (N=20) received primary motor cortex tDCS (**M1-tDCS**).
Age: 25±4 years, Height = 174±9 cm, Weight = 70±10 kg

Group 4 (N=20) received DLPFC + M1 tDCS simultaneously (**DLPFC+M1-tDCS**).
Age: 25±6 years, Height = 174±10 cm, Weight = 72±14 kg

Fig. 2 HD-tDCS equipment, Starstim 32 (Neuroelectrics, Spain)

Somatosensory function was investigated by assessed mechanical pain threshold (**MPT**), pressure pain threshold (**PPT**), heat pain threshold (**HPT**) and cold pain threshold (**CPT)** on the medial flexor muscle (flexor carpi radialis).

- MPT was assessed using a set of weighted pinprick stimulators (MRC Systems, Germany) with a flat contact area of 0.25 mm diameter that exert forces between 8 and 512 mN.
- PPT was assessed using a hand-held pressure algometer (Somedic, Sweden) with a 1-cm^2 probe will be used to record the pressure pain threshold. The pressure is increased gradually at a rate of 30 kPa/s.
- HPT and CPT was assessed using A 3×3 cm (9 cm2) contact thermode (Medoc Advanced Medical Systems, Israel) that applies thermal stimulation and records the temperature when the subject marks their pain threshold.

Fig. 3 Assessments of MPT, PPT, HPT and CPT.

Results

- Unrelated to group increased somatosensory pain thresholds (~5-30%) were observed across all modalities compared to baseline (p<0.05) .
- The active HD-tDCS of DLPFC, M1 or DLPFC+M1 did not induce significant changes on any of the somatosensory thresholds compared to sham-stimulation (p>0.05)

Results (cont.)

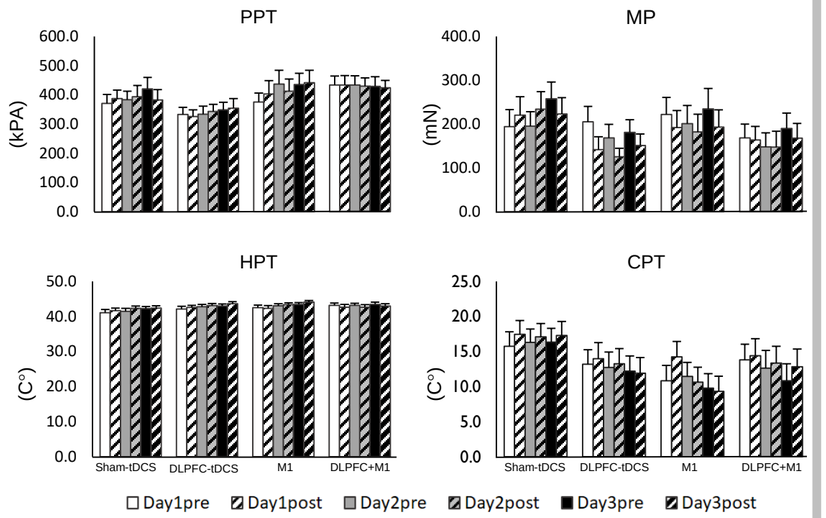

Fig. 4 Thresholds of the somatosensory thresholds (mean±sem) over 3 days before (non-striped) and after (striped) HD-tDCS.

Conclusions

- **HD-tDCS to M1 or DLPFC did not alter the pain thresholds significantly compared to sham-stimulation.**
- **Unrelated to group all pain thresholds increased over the six sessions. This may be due to the habituation effect on the pain assessments, or possibly a placebo-effect.**
- **The results may indicate that HD-tDCS is not able to modulate the somatosensory system in a healthy population[6].**

References

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SKS@HST.AAU.DK

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