tDCS-methodology, application and available results

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Content

> Methodology
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  — Basic
  — Clinical
  — Sleep
the foc.us v2 stimulator

The Worlds Most Advanced Electrical Brain Stimulator.
tDCS, tACS, tPCS and tRNS - all included.
CE certified safe - featuring triple current regulation, voltage control and misuse timers.

foc.us v2 stimulator
Methodology: the (DC-)stimulator

- 1 anode, 1 cathode (standard)
- Triggering possible
- Placebo-controlled
- Double-blind design possible
- tACS possible
- MR-compatible
- Current strength: < 2.0 mA (ECT: < 900 mA)
High-Definition-tDCS

HD tDCS-EEG waveguard cap

> Up to 29 tDCS-Electrodes
> Only for research
tDCS Principle

> Modulation of spontaneous neuronal activity

> **Anodal** stimulation: increase of the membrane’s resting potential $\rightarrow$ depolarisation

    **Increase of the cortical excitability**

> **Cathodal** stimulation: decrease of the membrane’s resting potential $\rightarrow$ hyperpolarisation

    **Decrease of the cortical excitability**

Poreisz et al. (2007) *Brain Res Bull*
Anodal vs. Cathodal polarisation

Methodology

Aftereffects

Monte-Silva et al. (2013) Brain Stim
tDCS application

Guidelines:
Requirements

> Hypothesis
> Electrode location
> Anodal/cathodal stimulation
> Stimulation protocol (duration, sequence)
> Electrode type
> Contact medium
Stimulation model simulation

Nikolin et al. (2015) *NeuroImage*
Reproducibility

Electrode placement / preparation

- International 10-20 system
- Neuro-navigation
- Physiology-based (works only for motor or other primary cortices)

Contact medium:
- Avoid oversaturation (NaCl-liquid)
- Control constant amount (e.g. syringes)
tDCS side-effects

- Occasional side-effects:
  - headache
  - vertigo
  - fatigue
  - nausea
  - tingling/burning sensation under the electrodes

Brunoni et al. (2011) *Int J Neuropsychopharmacol*

Palm et al. (2008) *Brain Stim*
Promising results

Behavioral/Systems/Cognitive

Transcranial Direct Current Stimulation during Sleep Improves Declarative Memory

Lisa Marshall, Matthias Mölle, Manfred Hallschmid, and Jan Born
Institute of Neuroendocrinology H23a, University of Lübeck, 23538 Lübeck, Germany

Boosting slow oscillations during sleep potentiates memory

Lisa Marshall¹, Halla Helgadóttir¹, Matthias Mölle¹ & Jan Born¹
Disillusioning results

No Significant Effect of Prefrontal tDCS on Working Memory Performance in Older Adults

Jonna Nilsson, Alexander V. Lobedev and Martin Lövdén

Aging Research Center, Karolinska Institute and Stockholm University, Stockholm, Sweden

12/6/2016
tDCS-induced inhibition as a boost for focused perception?

Zito et al. (2015) *Front Behav Neurosci*
Results: Basic

tDCS-moderated plasticity

Rroji et al. (2015) PLoSOne
tDCS and memory consolidation

Results: Basic

Javadi & Cheng (2013) *Brain Stim*
Enhancing motor skills in stroke patients

Results: Clinical

Lefebvre et al. (2012) *Front Hum Neurosci*
tDCS in depression

Dependent variable: Montgomery-Asberg Depression Rating Scale (MADRS)

Results: Clinical

Brunoni et al. (2013) *JAMA Psychiatry*
tDCS and cognition in Alzheimer’s disease

Results: Clinical

Khedr et al. (2014) Front Aging Neurosci
tDCS and sleep

Results: Sleep

Frase et al. (2016) *Neuropsychopharmacol*
Own study

- Is it possible to enhance sleep-dependent memory consolidation?
- More refined tDCS protocol
- Target the slow waves (and sleep spindles) with tDCS
- Stimulation location based on functional connectivity data
Results

Functional connectivity of hippocampal area

$p < 0.0001$ (uncorr.)
Experimental procedure

Results: Sleep

- Epworth Sleepiness Scale
  - Women: pregnancy test
- Learning phase
- Baseline retention
  - 20 pairs
  - Self guided
- Episodic memory task:
  - Male faces / occupation
  - 40 pairs
  - 2 learning runs
  - Self guided
- Rest EEG seated
- Rest EEG supine
- Sleep EEG / tDCS or placebo
- Waking up phase
- Delayed retention
  - 20 pairs
  - Self guided

Typical stimulation time-course:

W = Wake
1 = sleep stage 1
2 = sleep stage 2
3 = slow wave sleep

2 min of 2 mA (current density 0.03 mA/cm², electrode size 35 cm²), max. 30 min
Bilateral temporal anodal tDCS increases slow wave amplitudes

Effect of tDCS during S3 on memory consolidation:

Partial Correlation of tDCS-dependent memory performance and real slow wave stimulation:

**tDCS:** $r = 0.89, p < 0.01$
**Sham:** $r = -0.22, p = 0.56$

→ The more slow waves are stimulated, the better the memory consolidation

Effect of tDCS on slow wave amplitude:

- **Mean** = 93.8 ($SD = 5.7$)
- **Mean** = 90.4 ($SD = 6.9$)

$T = 2.2, p < 0.05$
foc.us - reloaded
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- Simon Ruch


Barbieri, M., et al. (2016). "Anodal-tDCS over the human right occipital cortex enhances the perception and memory of both faces and objects." Neuropsychologia 81: 238-244.


