

**Seminar, December 2, 2016**

# tDCS-methodology, application and available results

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# Content

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- > Methodology
- > Application
- > Results
  - Basic
  - Clinical
  - Sleep

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# Methodology: the (DC-)stimulator

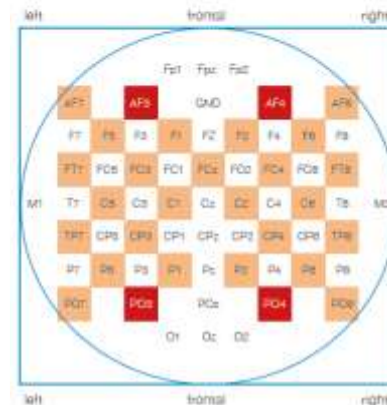
- > 1 anode, 1 cathode (standard)
- > Triggering possible
- > Placebo-controlled
- > Double-blind design possible
- > tACS possible
- > MR-compatible
- > Current strength: < 2.0 mA (ECT: < 900 mA)



# High-Definition-tDCS

## HD tDCS-EEG **wave**guard cap

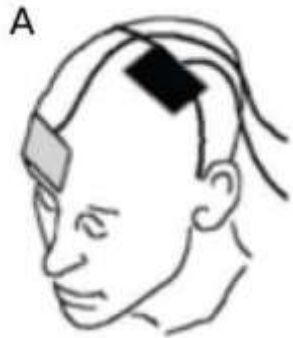
- > Up to 29 tDCS-Electrodes
- > Only for research



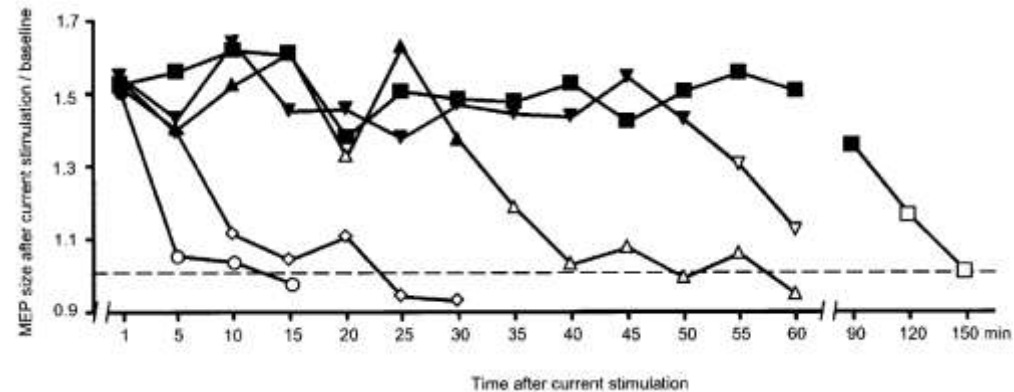
## tDCS Principle

- > Modulation of spontaneous neuronal activity
- > **Anodal** stimulation: increase of the membrane's resting potential → depolarisation  
**Increase of the cortical excitability**
- > **Cathodal** stimulation: decrease of the membrane's resting potential → hyperpolarisation  
**Decrease of the cortical excitability**

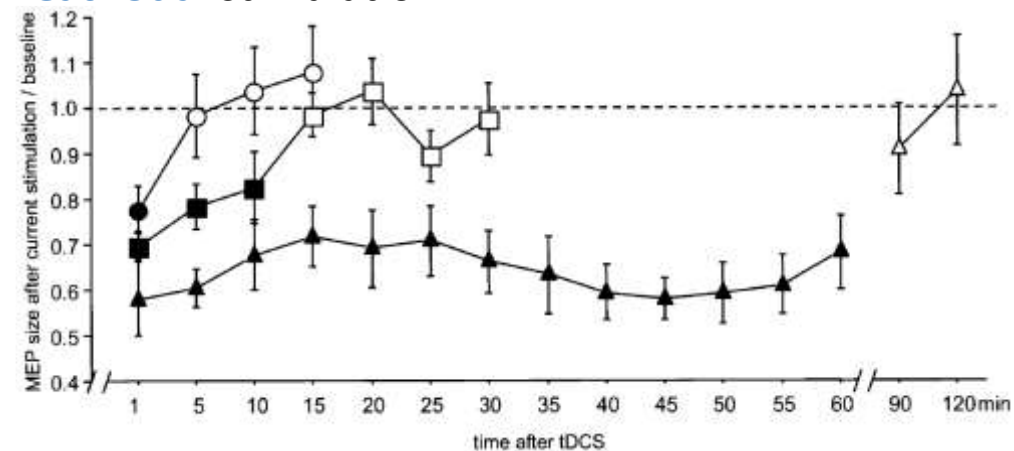
# Anodal vs. Cathodal polarisation



## Anodal stimulation

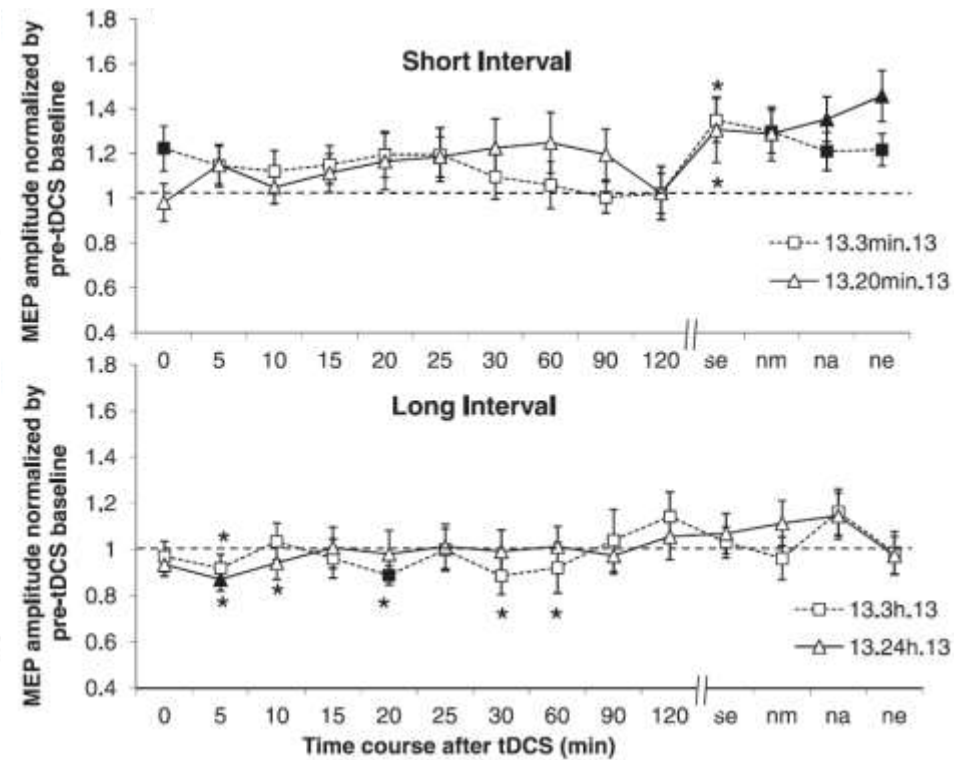
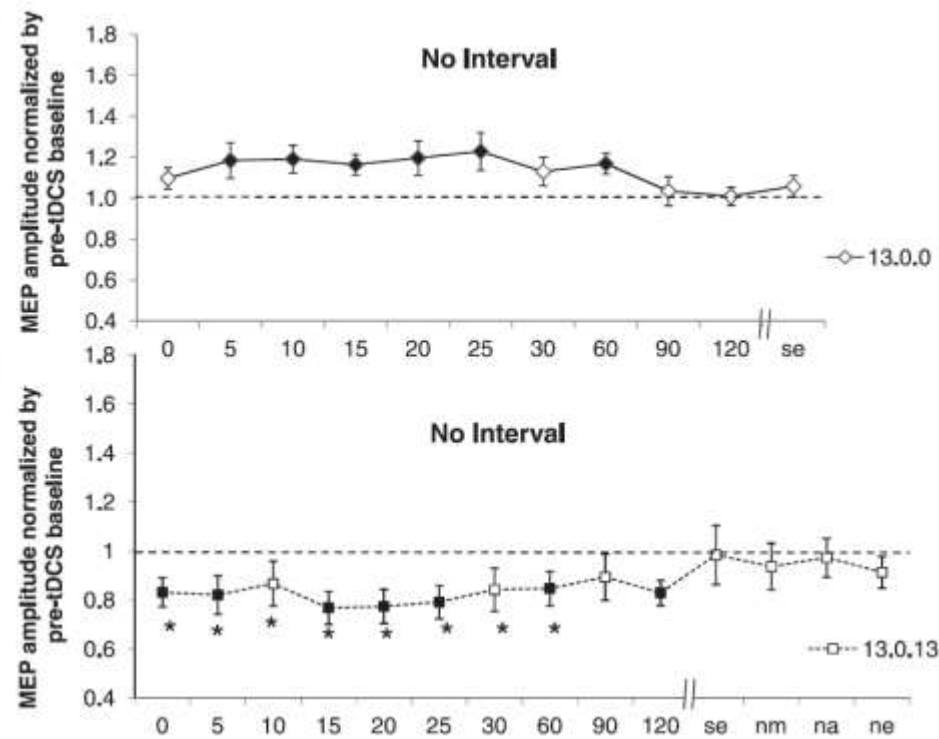


## Cathodal stimulation



Nitsche & Paulus (2001) *Neurology* / Nitsche et al. (2003) *Clin Neurophysiol*

# Aftereffects



Monte-Silva et al. (2013) *Brain Stim*



# tDCS application

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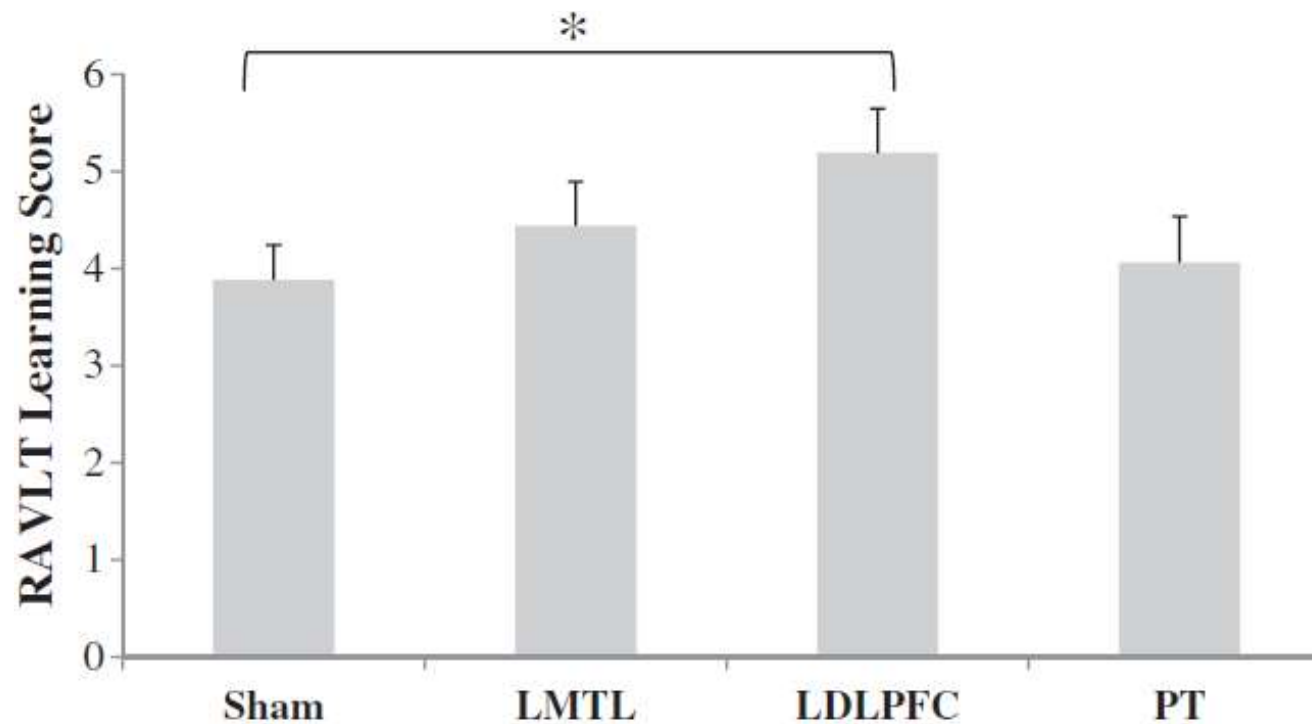
- > Guidelines:
  - Nitsche, Liebetanz, et al. (2003) *Clin Neurophysiol*
  - Poreisz, Boros, Antal, & Paulus (2007) *Brain Res Bull*
  - Woods, Antal, Bikson, et al. (2016) *Clin Neurophysiol*

# Requirements

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

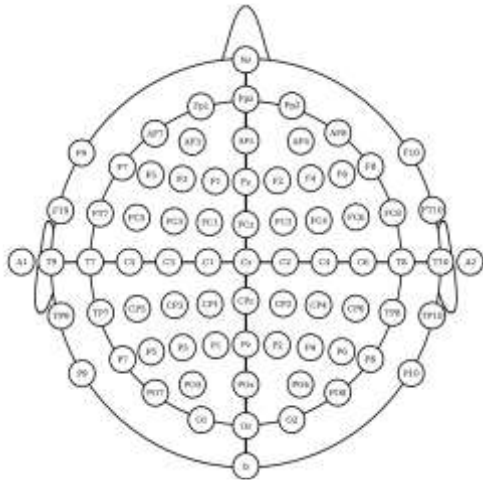
# Stimulation model simulation



# 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



Palm et al. (2008) *Brain Stim*

## Promising results

The Journal of Neuroscience, November 3, 2004 • 24(44):9985–9992 • 9985

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

nature

Vol 444 | 30 November 2006 | doi:10.1038/nature05278

## LETTERS

### Boosting slow oscillations during sleep potentiates memory

Lisa Marshall<sup>1</sup>, Halla Helgadóttir<sup>1</sup>, Matthias Mölle<sup>1</sup> & Jan Born<sup>1</sup>

# Disillusioning results

Brain Stimulation 9 (2015) 730–739



Contents lists available at ScienceDirect

Brain Stimulation

journal homepage: www.brainstimjrnf.com



## Boosting Slow Oscillatory Activity Using tDCS during Early Nocturnal Slow Wave Sleep in Older Adults

Sven Paßmann<sup>a,b,\*</sup>,  
Ulrike Grittner<sup>c,d</sup>, Sfrontiers  
in Aging NeuroscienceORIGINAL RESEARCH  
published: 14 December 2015  
doi: 10.3389/fnagi.2015.00230<sup>a</sup> Department of Neurology, Charité  
<sup>b</sup> NeuroCare Cluster of Excellence,  
<sup>c</sup> Department for Biomechanics and  
<sup>d</sup> Center for Stroke Research, Charité  
<sup>e</sup> Department of Psychology, Free U

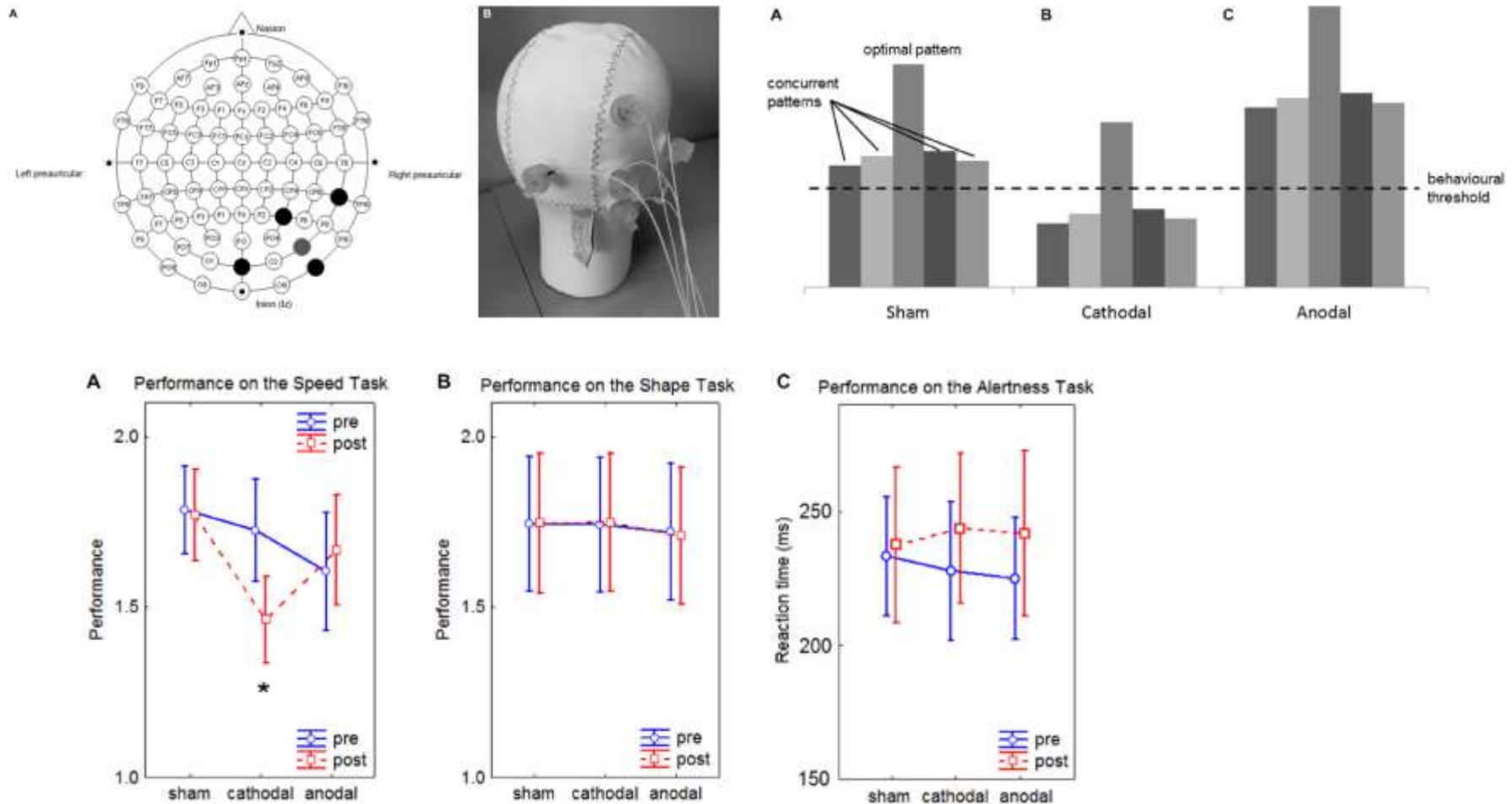
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## No Significant Effect of Prefrontal tDCS on Working Memory Performance in Older Adults

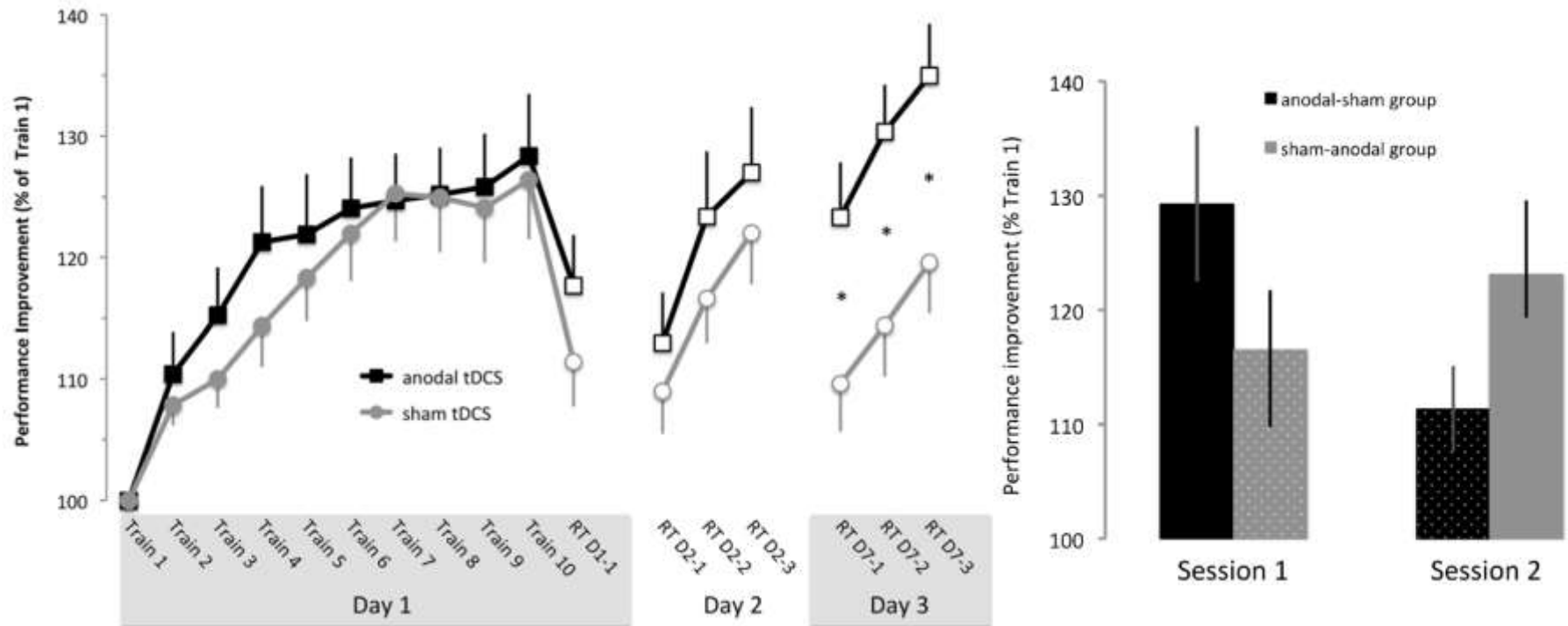
Jonna Nilsson<sup>a,\*</sup>, Alexander V. Lebedev<sup>a</sup> and Martin LövdénAging Research Center, Karolinska Institutet and Stockholm University, Stockholm, Sweden  
CONTROLLED CROSSOVER STUDYGregory L. Sahlem<sup>a,\*</sup>, Bashar W. Badran<sup>a,d</sup>, Jonathan J. Halford<sup>b</sup>, Nolan R. Williams<sup>a,b</sup>, Jeffrey E. Korte<sup>c</sup>,  
Kimberly Leslie<sup>a</sup>, Martha Strachan<sup>a</sup>, Jesse L. Breedlove<sup>d</sup>, Jennifer Runion<sup>a</sup>, David L. Bachman<sup>b</sup>,  
Thomas W. Uhde<sup>a</sup>, Jeffery J. Borckardt<sup>a</sup>, Mark S. George<sup>a,b,d,e</sup><sup>a</sup> Department of Psychiatry, Medical University of South Carolina, 67 President St., 502N, Charleston, SC 29425, USA<sup>b</sup> Department of Neurology, Medical University of South Carolina, 96 Jonathan Lucas St., C5B 301, Charleston, SC 29425, USA<sup>c</sup> Department of Public Health Sciences, Medical University of South Carolina, 135 Cannon Street Suite 303, MSC 835, Charleston, SC 29425-8350 USA<sup>d</sup> Department of Neurosciences, Medical University of South Carolina, 68 President St., BE 101, MSC 501, Charleston, SC 29425, USA<sup>e</sup> Ralph H. Johnson VA Medical Center, 109 Bee Street, Charleston, SC 29401, USAent Stimulation  
Not Improve  
nized Sham

# tDCS-induced inhibition as a boost for focused perception?

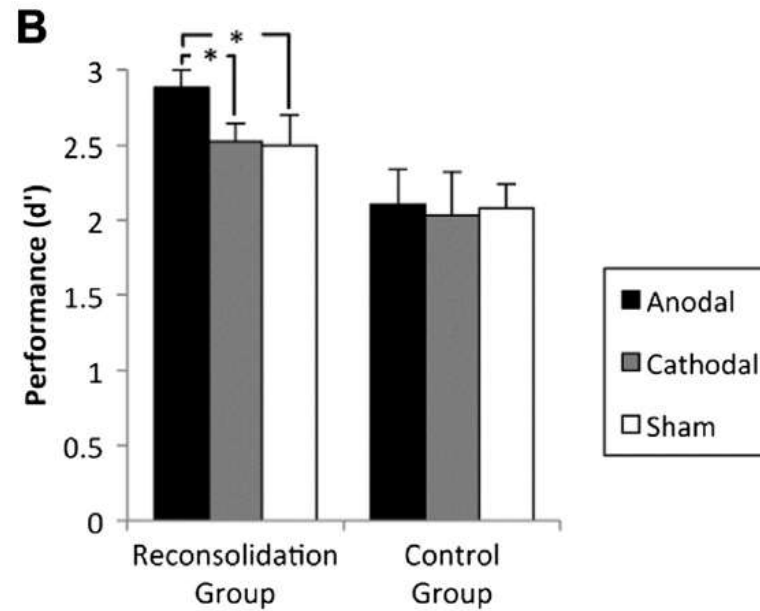




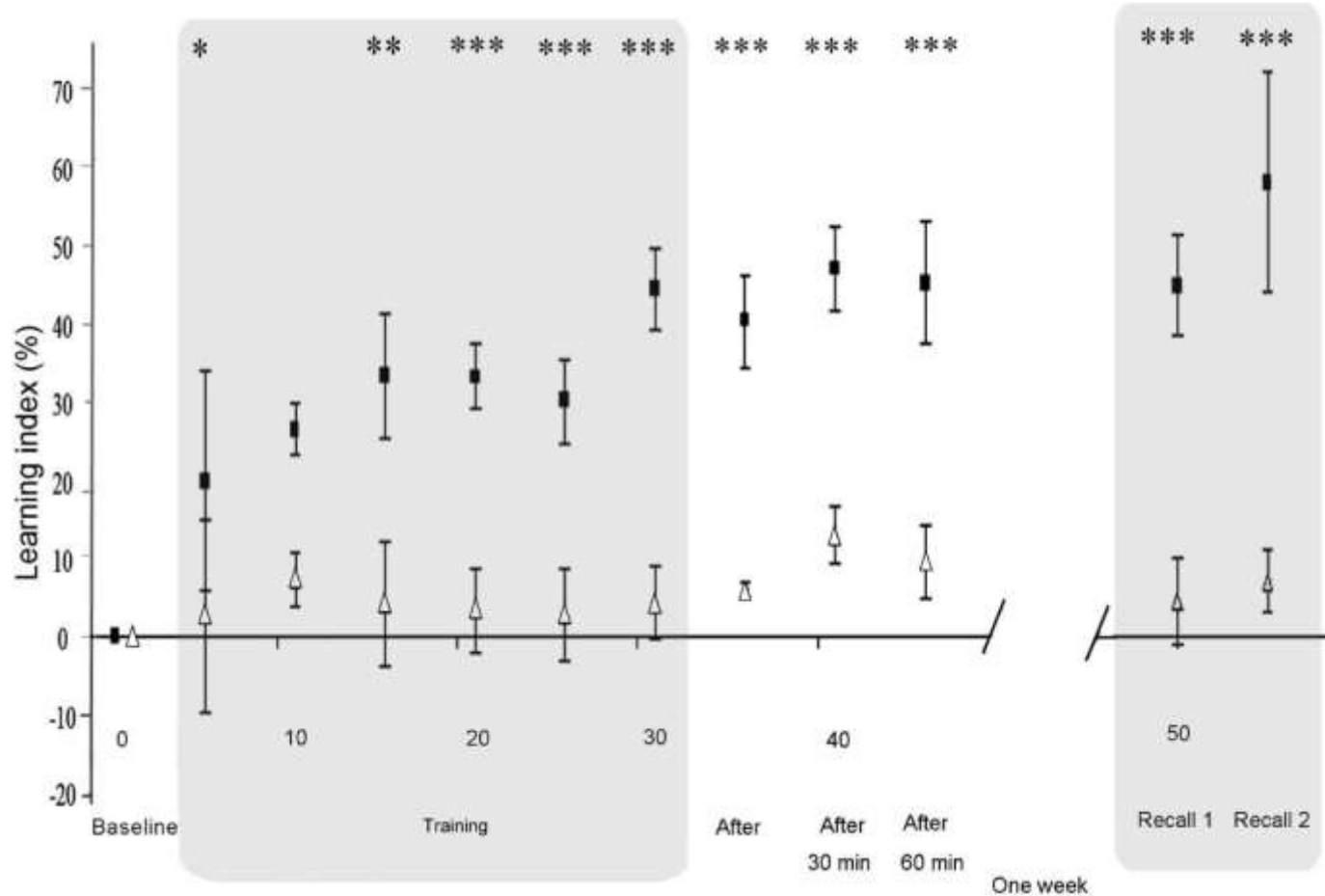
# tDCS-moderated plasticity



# tDCS and memory consolidation

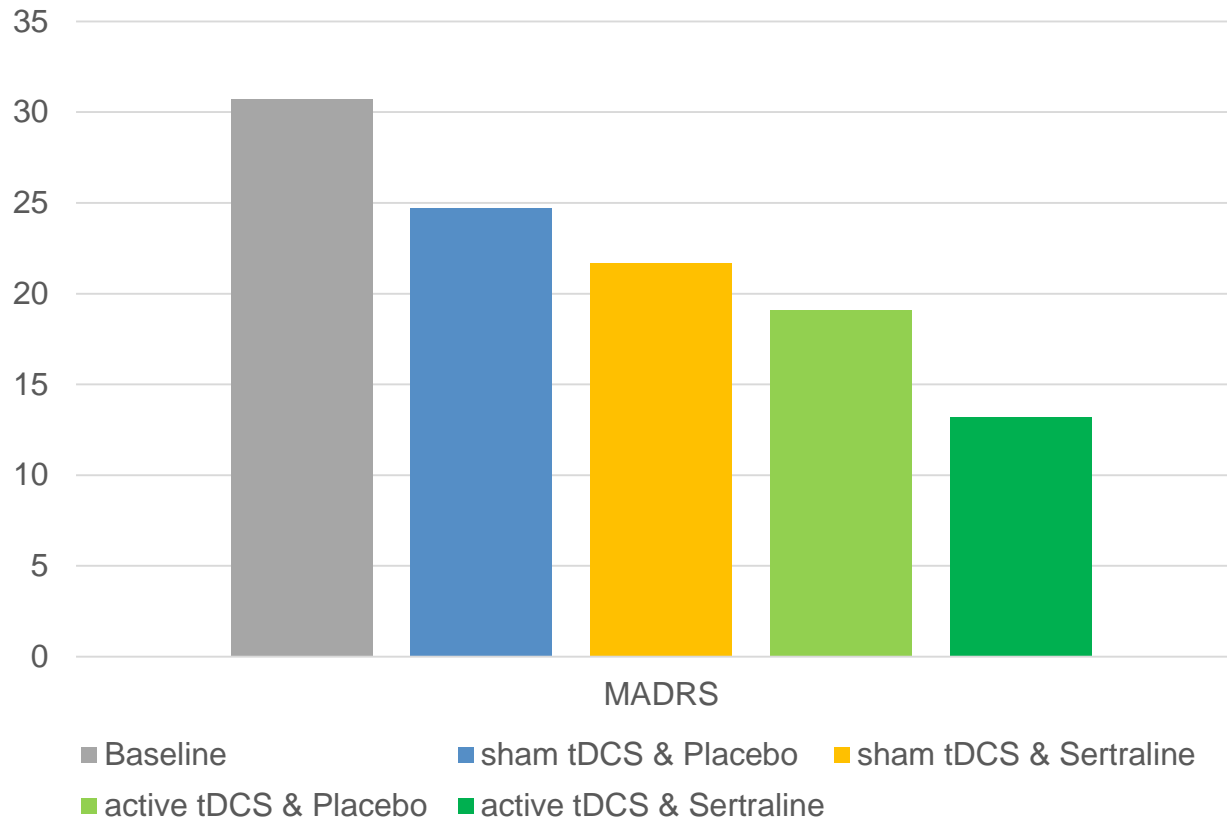


# Enhancing motor skills in stroke patients



## tDCS in depression

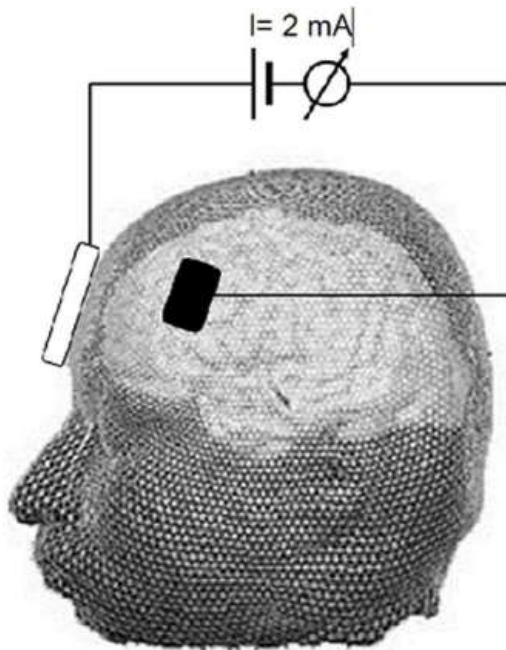
- > Dependent variable: Montgomery-Asberg Depression Rating Scale (MADRS)



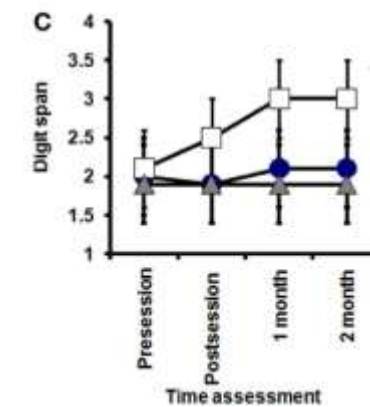
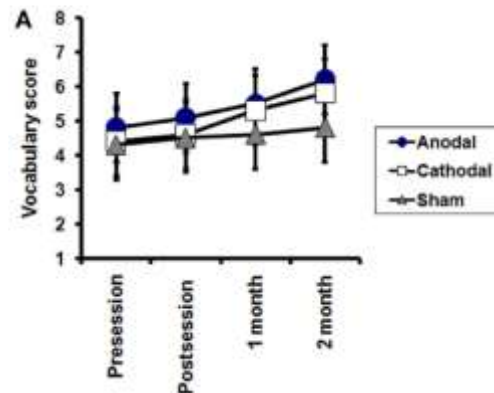
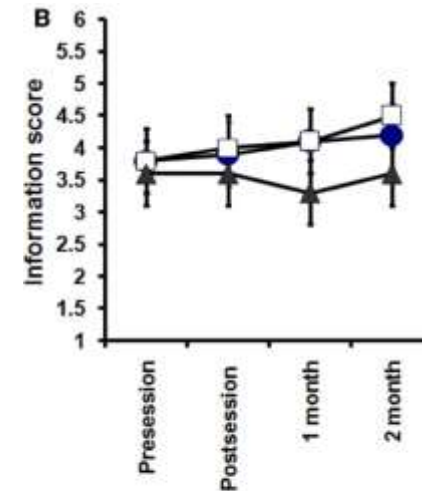
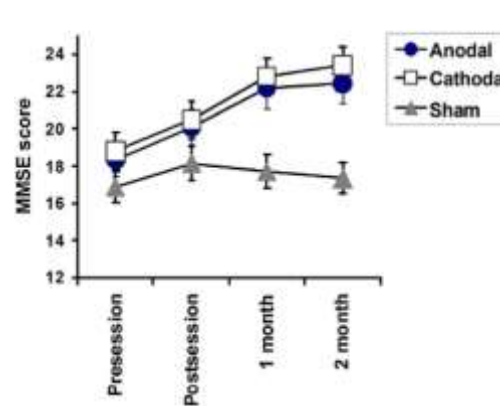
Brunoni et al. (2013) *JAMA Psychiatry*

# tDCS and cognition in Alzheimer's disease

## A tDCS of the DLPFC

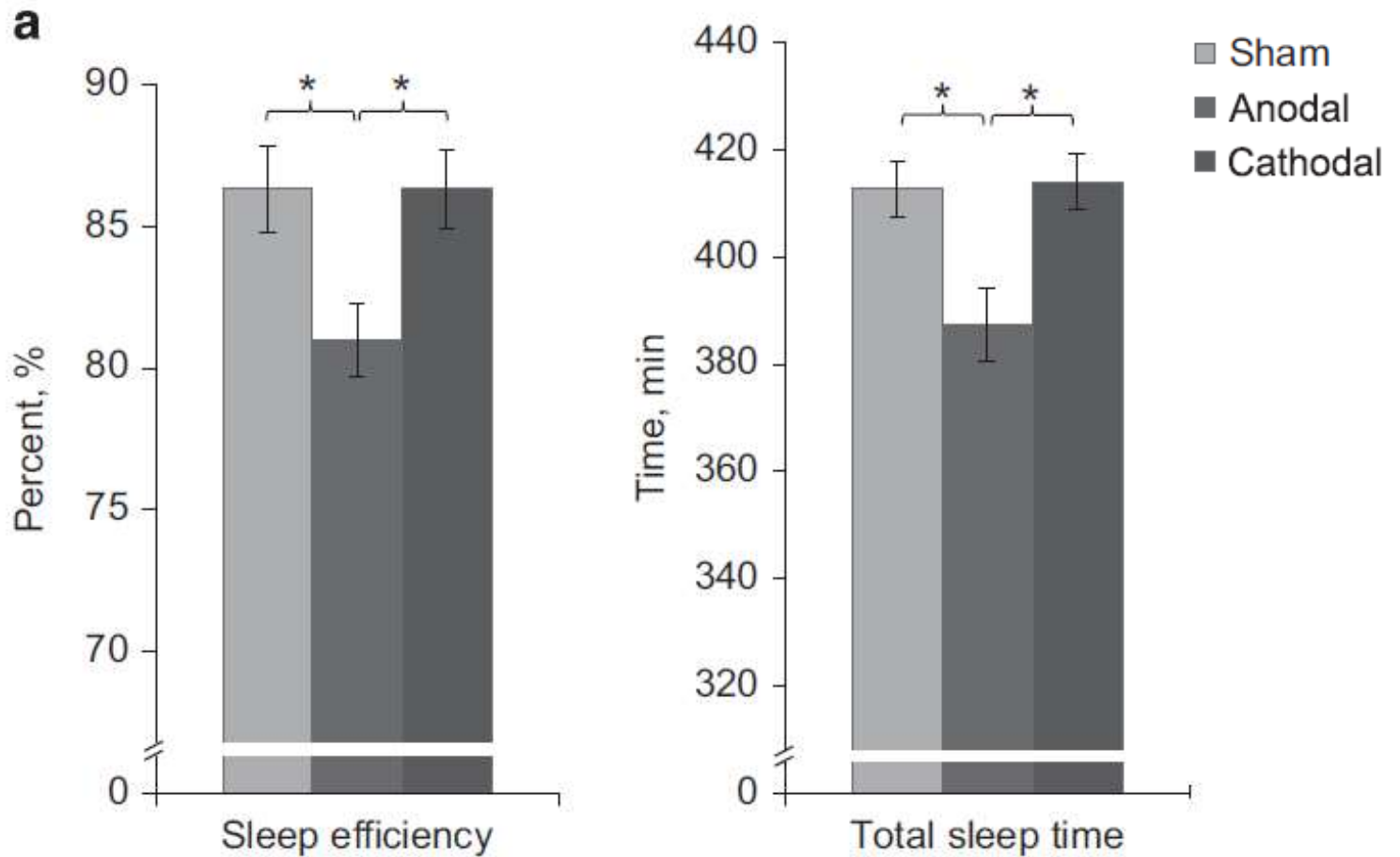


## B Mini Mental State Examination



Time assessment

## tDCS and sleep

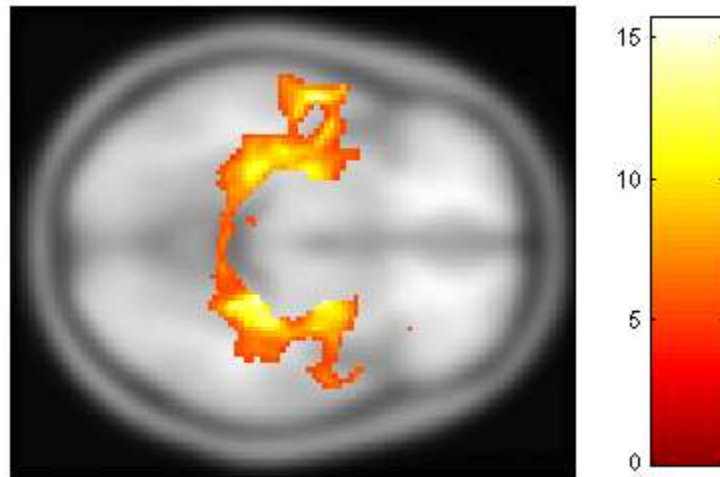


## Own study

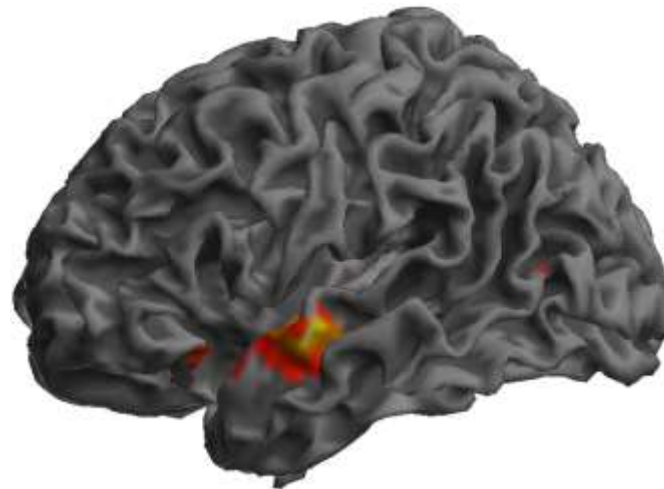
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- > Is it possible to enhance sleep-dependent memory consolidation?
- > More refined tDCS protocol
- > Target the slow waves (and sleep spindles) with tDCS
- > Stimulation location based on functional connectivity data

# Functional connectivity of hippocampal area

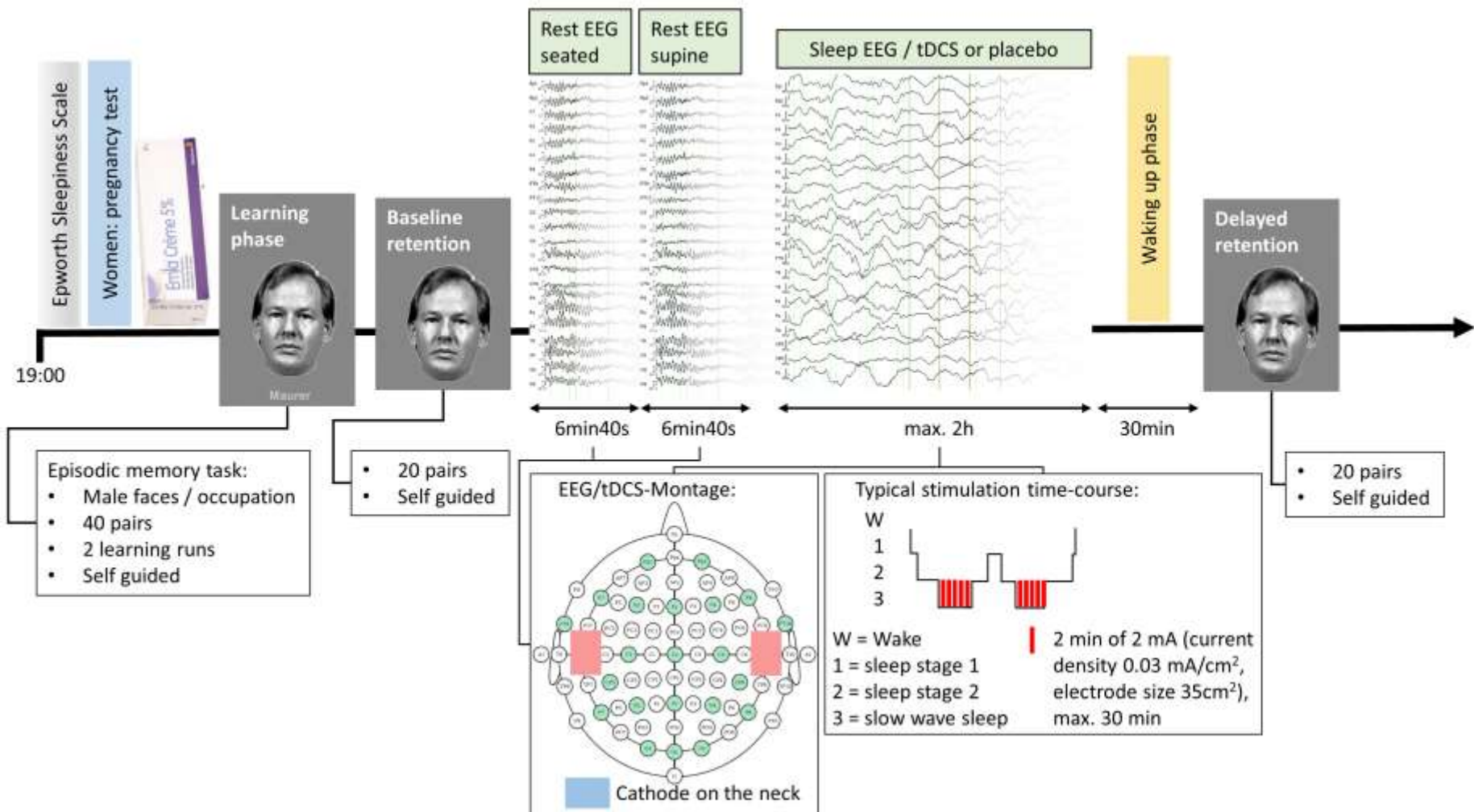


$p < 0.0001$  (uncorr.)





# Experimental procedure



# Bilateral temporal anodal tDCS increases slow wave amplitudes

Effect of tDCS during S3 on memory consolidation:

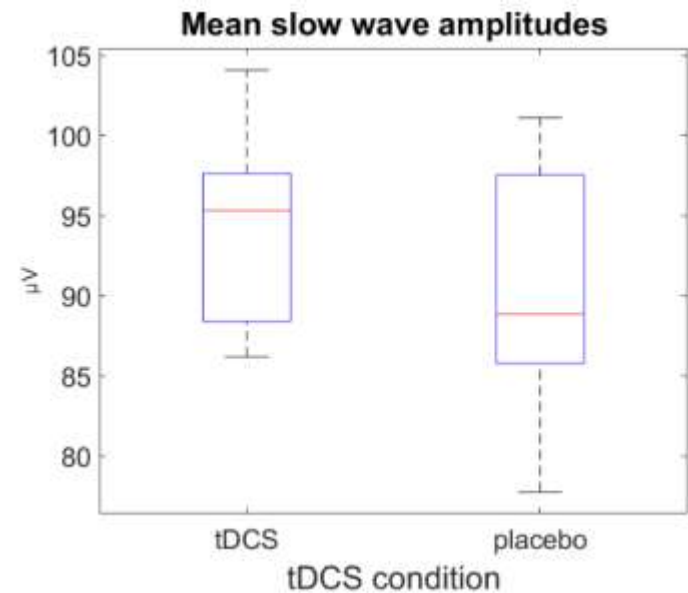
Partial Correlation of tDCS-dependent memory performance and real slow wave stimulation:

**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

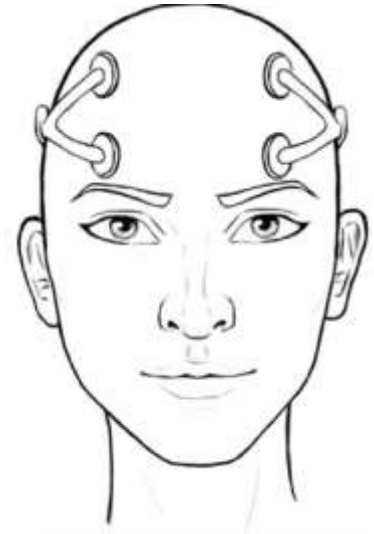
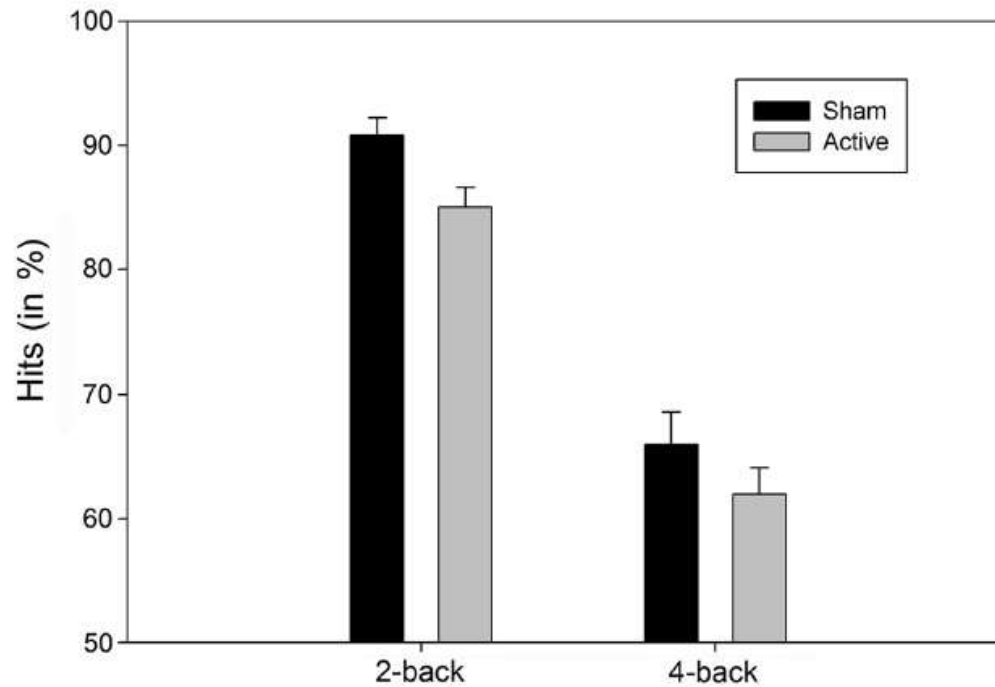
Effect of tDCS on slow wave amplitude:



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

**$T = 2.2, p < 0.05$**

# foc.us - reloaded



# Acknowledgment / Literature

## University Hospital of Psychiatry:

- Thomas Dierks
- Yosuke Morishima
- Sarah Müller
- Stephanie Winkelbeiner

## Department of Psychology:

- Katharina Henke
- Simon Ruch

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