Behavioral Intervention Research Using tDCS

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Introduction to Transcranial Direct Current Stimulation in Neuropsychiatric Research

**Plasticity**

- Adaptive
- Maladaptive

**Promoting useful plasticity in motor cortex**

- Patient
- Intervention
- Patient + Intervention

Robotics for assessment of performance kinematics

TMS Demonstration
In order to induce aftereffects, a stimulus duration of at least 3 min at 1 mA or an intensity of 0.6 mA for 5 min.

M. A. Nitsche and W. Paulus

“Only m/cf montage effective”

Corticomotor excitability in stroke

Webster et al (2006)

Kim et al., 2006

Hummel et al., 2005

Khedr et al., 2005

Takeuchi et al., 2005

Boggio et al., 2006

Fregni et al., 2005

Mansur et al., 2005

Takeuchi et al., 2008

Boggio et al., 2007

Fregni et al., 2006

Resting MT

Transcallosal Inhibition

MEP Amplitude

DO NOT COPY
Anodal tDCS favors clinical improvement in stroke... 

Repetitive behavior affects motor cortex?


How does repetitive behavior affect motor cortex?

Rapid formation and selective stabilization of synapses for enduring motor memories

Motor map does not change unless in skill context

Extensive training of elementary finger tapping movements changes the pattern of motor cortex excitability

Simple repetitive finger movements increase excitability

Efficiency Training and Motor Learning

A close relationship between movement kinematics and motor cortex excitability

Reversal of EMG-induced motor switch by training is associated with a reduction in excitability of the antagonist muscle.

Clinical Neurophysiology

How does repetitive behavior affect motor cortex?
How does combined intervention affect motor cortex?

Nitsche et al (2007)

Anodal tDCS prior to excitatory PAS further boosts excitability, while during tDCS reverses effect to reduced excitability.

Is coupling tDCS with training good?

If...

Motor Training = improvement in function ‘X’

and...

tDCS = improvement in function ‘X’

does...

Motor Training + tDCS = improvement in function 2X, X^2, or 0??
Relevance of kinematic measures to clinical function

Movement Speed (peak, mean)
Movement Smoothness
Aim
Deviation

Highest correlation with clinical function

"Kinematic Robot-Based Evaluation Scales and Clinical Counterparts to Measure Upper Limb Motor Performance in Patients With Chronic Stroke" (Boscher et al, 2009)

Movement Training Paradigm

Visual Cue & Feedback

Hand position

20mins, 0.2Hz movement (4mins movt, 1 min rest) x4

Key Findings: Effect of Intervention on Motor Performance

Giacobbe et al., (2013)

<table>
<thead>
<tr>
<th>Training Period</th>
<th>Mean Speed</th>
<th>Smoothness</th>
<th>Aim</th>
<th>Mean Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Alone</td>
<td>p=0.006</td>
<td>p=0.001</td>
<td></td>
<td>p=0.018</td>
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<tr>
<td>Training + tDCS (pre)</td>
<td>p=0.001</td>
<td>* no change</td>
<td></td>
<td>p=0.032</td>
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<tr>
<td>Training + tDCS (during)</td>
<td></td>
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<tr>
<td>Training + tDCS post</td>
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NIH funded study 2012-2017 – tDCS and robotic motor training in stroke

Combined tDCS-Robotic Training Study Design

- 60 patients, Right hemiparesis
- >6mnths post first ischemic stroke
- Robotic protocol alternates S/E-wrist robot across sessions
- tDCS 2mA, 35cm² 0.9% NaCl soaked sponges

Upper limb robotics at Burke-Cornell, New York

Robotics with brain stimulation in patients with motor dysfunction

tDCS and EEG: real-time assessment of patient response

Borutin et al, Clin Neurophys, 2013 (abs)
Physical presence of DC field in human tissue with tDCS (magnitude v time)

Net Biological response to DC field in human tissue with tDCS (MEP amplitude v time)

Note: Theoretical

Cortical
Sub-Cortical

R² = #0.02814#

R² = #0.4145#

R² = #0.80165#

Opposing homeostatic forces
Reverse effects

Webster et al (2006)