Transcranial direct current stimulation in patients with disorders of consciousness

THIBAUT Aurore
PhD Student
Coma Science Group
University of Liège, Belgium
Introduction
## Why direct current?

<table>
<thead>
<tr>
<th>Stimulation</th>
<th>Population</th>
<th>Effects</th>
<th>Authors</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Hemiplegic patients</td>
<td>Dexterity and strength</td>
<td>Hummel et al. Lancet, 2006</td>
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<td></td>
<td>Spastic patients</td>
<td>Spasticity &amp; ADL (activity of daily life)</td>
<td>Wu et al., Arch Phys Med Rehabil 2012</td>
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<tr>
<td><strong>Prefrontal cortex</strong></td>
<td>Healthy subjects</td>
<td>Memory</td>
<td>Marshall et al. J Neurosci, 2004</td>
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<td>Alzheimer’s patients</td>
<td>Memory</td>
<td>Ferrucci et al. Neurology, 2008</td>
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<td></td>
<td>Aphasic patients</td>
<td>Language</td>
<td>Baker et al. Stroke, 2010</td>
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Method
Methods

- Direct current
- 2 mA
- 20 minutes

Randomised double blind sham controlled

Cathodal →

Anodal ←
Methods

Assessing the effect of **tDCS** on cognition in patients with DOC
Methods

**Responder**: CRS-R total post tDCS > pre-tDCS > sham > pre-sham
Results
Group results

- 55 patients (43 18y)
- 25 VS/UWS, 30 MCS
- 25 TBI / 30 non-TBI
- 20 acute / 35 chronic (>3 months)
Group results

- 55 patients (43 18y)
- 25 VS/UWS, 30 MCS
- 25 TBI / 30 non-TBI
- 20 acute / 35 chronic (>3 months)

17 responders
- 2 UWS; acute
- 15 MCS; 7 acute/8 chronic
UWS/UV vs MCS

**Results**

<table>
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<tr>
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<th>MCS (n=30)</th>
<th>VS/UWS (n=25)</th>
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<tr>
<td><strong>tDCS</strong></td>
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<tr>
<td>PRE CRS-R mean scores</td>
<td>11</td>
<td>5</td>
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<tr>
<td>POST CRS-R mean scores</td>
<td>12</td>
<td>5</td>
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* indicates a statistically significant difference.
Discussion
tDCS presumed mode of action

**Short term effects** (Nitsche et al., J Physiol 2000)
Modification of neuronal excitability (action potential)

**Long term effects** (Nitsche et al., Neuroscientist 2010)
Action on opening of ion channels (Na\(^+\), Ca\(^{2+}\))
Increase NMDA receptors excitability
→ improve neuron excitability
Neurophysiology

Prefrontal stimulation

- Increase (anodal) or decrease (cathodal) of α and θ rhythm (EEG)
- Improvement of DMN connectivity (MRI) in healthy subjects

Zaehle et al., BMC Neurosci, 2011
Perspective
tDCS – long term

**Effects last 90 minutes** (Hummel et al., Lancet 2006)
- Short improvement
- Back to initial state

**Daily stimulations** (5days) (Antal et al., J Pain Symptom Manage 2010)
Improvement and extension of benefits

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![Diagram showing tDCS sessions over 5 days for real and placebo sessions.](https://via.placeholder.com/500)

*ndCS = 20minutes*
tDCS - M1

Cognitive effects (+)
Motor effects (?)

Parameters:
2 mA – 20 min
Anode: M1
Cathode: supraorbicular controlateral cortex

1. **TMS**: MEP & motor threshold
2. **Behavioral** assessments:
   CRS-R & Ashworth

Lang et al., 2004

www.comascience.org
tDCS – M1

Cognition and motricity are indissociable for functional rehabilitation
tDCS – neurophysiology

1. Comparison of the results with:
   - cortical lesions (MRI)
   - cerebral metabolism (PET-scan)

   Stimulation of preserved or damaged cortex?

2. EEG before and after tDCS

   Better understanding of neurophysiological effects of tDCS
Conclusion
tDCS improves cognition in both acute and chronic; TBI and non-TBI minimally conscious state patients

Future studies:
1. long term tDCS
2. tDCS on M1
3. neurophysiological effects