High-Density Transcranial Electrical Stimulation

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These slides have been modified for distribution.

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Brain Electrotherapy
The application of electricity to treat neurological and psychiatric disorders

- Diverse applications (neuropsychiatric, rehabilitation, cognitive performance…)
- Individualized therapy
- Targeted brain modulation (space + time)
- Safe (minimal complications + counter-indications)
- Cost
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Transcranial Electrical

Transcranial Magnetic

Invasive Leads
(also Vagus, Spinal..)
FEM analysis of transcranial electrotherapy focality

Conventional Transcranial (large pad)  High-density Transcranial (4x1 Ring)
“Conventional” transcranial electrotherapy
“Conventional” transcranial electrotherapy
High-density transcranial electrotherapy
High-density transcranial electrotherapy
High-density transcranial electrotherapy

**Transcranial Focality**

Application specific configurations

(4x1, 4x4, …)

Targeting of cortical structures

Balance of depth and focality
High-density transcranial electrotherapy hardware
High-density transcranial electrotherapy safety

Skin safety and comfort

The City College of New York (IRB+)
NIH National Institute of Neurological Disorder and Stroke (IRB+)
FDA – assessment of “nonsignificant risk” (NSR). IDE except
High-density transcranial electrotherapy

**Transcranial Focality**
Application specific configurations
(4x1, 4x4....)
Targeting of cortical structures
Balance of depth and focality

**Safe and painless**
Non-invasive, no seizure hazard
Arbitrary waveform
Sub-threshold paradigms
(axonal guidance, neuro-generation....)
Brain Electrotherapy

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<table>
<thead>
<tr>
<th>Disease (Clinical Evaluation/ FDA Status)</th>
<th>Waveform control</th>
<th>Targeting Ability</th>
<th>Invasiveness / Side effects</th>
<th>Application Environment</th>
<th>Selected Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electroconvulsive Therapy (ECT)</td>
<td>Depression, Mania</td>
<td>Poor - Pulse train only</td>
<td>Poor Non-focal</td>
<td>Non-Invasive / Brain Damage, memory loss</td>
<td>Requires trained clinical staff</td>
</tr>
<tr>
<td>Vagus Nerve Stimulation (VNS)</td>
<td>Epilepsy, Depression (debated)</td>
<td>Poor - Pulse train only with indirect modulation</td>
<td>Indirect Unknown</td>
<td>Invasive. Implanted pacemaker and electrodes attached to vagus nerve</td>
<td>Requires trained clinical staff for deployment and optimization</td>
</tr>
<tr>
<td>Deep Brain Stimulation (DBS)</td>
<td>Parkinson, Epilepsy, Depression, Dystonia</td>
<td>Moderate – brief balanced pulses</td>
<td>Excellent</td>
<td>Invasive. Perforation of skull and implanted pacemaker electrodes</td>
<td>Requires trained clinical staff for deployment and optimization</td>
</tr>
<tr>
<td>Transcranial Direct Current Stimulation (tDCS)</td>
<td>Stroke Rehabilitation, Depression, Dystonia, Improvement in: Memory, Learning, amblyopic eye</td>
<td>Poor – DC current</td>
<td>Poor</td>
<td>Non-invasive, DC current between two scalp electrodes / Bi-phasic effects</td>
<td>Robust/simple, potential for home use</td>
</tr>
<tr>
<td>High-Density Transcranial Electrical Stimulation (HD-tES)</td>
<td>Customizable*</td>
<td>Excellent</td>
<td>Good / Excellent</td>
<td>Non-invasive, arbitrary waveform between two+ scalp electrodes</td>
<td>Robust/simple (computer guided). Potential for home use</td>
</tr>
</tbody>
</table>

1= Clinical Trial Phase I  
2= Clinical Trial Phase II  
3= Clinical Trial Phase III  
4= Clinical Trial Phase IV  
A= FDA Approved  
U= Under Clinical Trial
“Rational” electrotherapy
Patient and disease customized electrical therapy.

Pre-stimulation: work-up (MRI)

Pre-stimulation:
Behavioral outcomes

Post-stimulation:
Computational (FEM) models

Treatment (Program) generator

Electrotherapy

Configuration
Configuration accessories

Programming / Configuration