Downloading Personalized Neuromodulation

Marom Bikson


WEARABLE TECH + DIGITAL HEALTH + NEUROTECH, Sept 24, 2018. MIT
Disclosure:

(Patents) The City University of New York on brain stimulation. (Equity and Patents) Soterix Medical Inc. produces tDCS and High-Definition tDCS. (Scientific Advisory Board and Patents) Boston Scientific Inc. produces neuromodulation products.

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Neuromodulation

Application of energy, often electricity, to the body on purpose (to restore or enhance function)
What defines neuromodulation technologies is how energy is delivered to what target.

- **Implants**: Deep Brain Stimulation (DBS), Spinal Cord Stimulation (SCS)
- **In-Hospital**: Transcranial Magnetic Stimulation (TMS), Electroconvulsive Therapy
- **Wearable**: Transcranial Electrical Stimulation (tES), Transcranial Direct Current Stimulation (tDCS)
What defines neuromodulation technologies is how energy is delivered to what target.

- **Implants**: Deep Brain Stimulation (DBS), Spinal Cord Stimulation (SCS)
- **In-Hospital**: Transcranial Magnetic Stimulation (TMS), Electroconvulsive Therapy
- **Wearable**: Transcranial Electrical Stimulation (tES), Transcranial Direct Current Stimulation (tDCS)
tDCS: Transcranial Direct Current Stimulation

- Hand-held device, head gear
- 20 minute session, 2 mA via scalp electrodes
- Modulator of brain excitability and plasticity
- > 400 controlled trials across neurological / psychiatric inductions + performance
- Remote supervised (home)


tDCS

Experimentally-verified
Anatomical MRI derived models of current flow
tDCS

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High Definition tDCS

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High Definition tDCS

Experimentally-verified Anatomical MRI derived models of current flow
Software allows you to steer currents to targeted brain regions
Single programmable device and head-gear
Target optimized solved. Question is what target?
Core transcranial inventions papers

1) **Focal transcranial**: Datta et al. Gyri-precise model of tDCS: Improved spatial focality using ring. Brain Stim 2009

2) **Small (HD) electrodes**: Minhas et al. Electrodes for high-definition DC stimulation. J. Neurosci Methods 2010

3) **Closed-form optimization (deep)**: Dmochowksi et al. Optimized multi-electrodes stimulation increases focality and intensity at target. J Neural Engr 2011

4) **Model validation**: Huang et al. Measurements and models of electric fields in the human brain during transcranial electric stimulation. Elife 2017
Personalized Therapy
Personalized Therapy Iterative

measurement

decision
Personalized Therapy

- Tunable
- Fast Iterations
- Minimal risk
Personalized Therapy

- Tunable
- Fast Iterations
- Minimal risk
Personalized Therapy
• Effective
• Tunable
• Minimal risk

Drugs
Molecular

Implants
In-Hospital

Apps

Wearable
neuromodulation
Software allows you to steer currents to targeted brain regions
Single programmable device and head-gear
Target optimized solved. Question is what target?
EEG automatically and instantly “inverted” to optimal HD-tDCS montage

- Decades old “reciprocity” hypothesis, but with closed head model
- Activity guided targeting, does not require source localization
Phase II (Harvard/Spaulding) Fibromyalgia pain
Daily in-clinic sessions of EEG Guided HD-tDCS
Targeted (Image Guided) tDCS


2) EEG + HD-tDCS Fibromyalgia: Castillo-Saavedra et al. Clinically Effective Treatment of Fibromyalgia With High Definition tDCS. J Pain 2016

3) EEG to HD-tDCS reciprocity: Dmochowski et al. Optimal use of EEG recordings to target active brain areas with transcranial electrical stimulation. Neuroimage 2017
Personalized Neuromodulation Therapy at Home
Personalized Neuromodulation Therapy at Home

Head-gear ($R_x + \text{sensors}$)

App

Medical wearable

decision

Historical data

3x Measure
ElectraRx – Prescription
Adaptive questions optimized to select daily treatment (not diagnose)

How are you?
What is bothering you?
What kind of pain?
How’s work?

Option 1 Rx

Option 2 Rx
Adaptive Questionnaires for Personalized Neuromodulation
Adaptive Questionnaires for Personalized Neuromodulation
Adaptive Questionnaires for Personalized Neuromodulation

Taking everything into consideration, during the past week how satisfied have you been with your.....

......family relationships?

- Very Poor
- Poor
- Fair
- Good
- Very Good
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Adaptive questions optimized to select daily treatment (not diagnose)

How are you?
What is bothering you?
What kind of pain?
How’s work?

Option 1 Rx
Option 2 Rx
Personalized Neuromodulation Therapy at Home

Head-gear ($R_x +$ sensors)

App

Medical wearable

3x Measure

decision

Historical data
Responsive Measures for Personalized Neuromodulation

- Head gear – EEG, EOG, fNIRS, GVS
- HealthDot Sensors - PPG, ECG, Respiration, IMU, EDA, EMG

HealthDot (chronic)
Headgear (during session)

Vital sign
Brain measures

Option 1
Rx

Option 2
Rx
Personalized Neuromodulation Therapy  

**Fast Iterative**

**Tunable targeted**

Head-gear ($R_x +$ sensors)

Medical wearable

App

Measures

Responsive Adaptive Q [Raw Data]

Historical data

Decision

[Diagram with icons and arrows representing the flow of information and decision-making in personalized neuromodulation therapy.]
Personalized Neuromodulation is Personalized

2) **Pediatric Epilepsy:** Meiron et al. HD-tDCS in early onset epileptic encephalopathy. J Brain Inj 2017

2) **Multiple Sclerosis:** Kasschau et al. tDCS Feasible for Remotely Supervised Home Delivery in MS. Neuromod 2016

3) **Dry tDCS:** Khadka et al. Tolerability of a novel multilayer hydrogel composite non-adhesive electrode for transcranial direct current stimulation. Brain Stim. 2018
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Slides and References @MaromBikson