Medical Devices 08 – Transcranial Direct Current Stimulation (tDCS)

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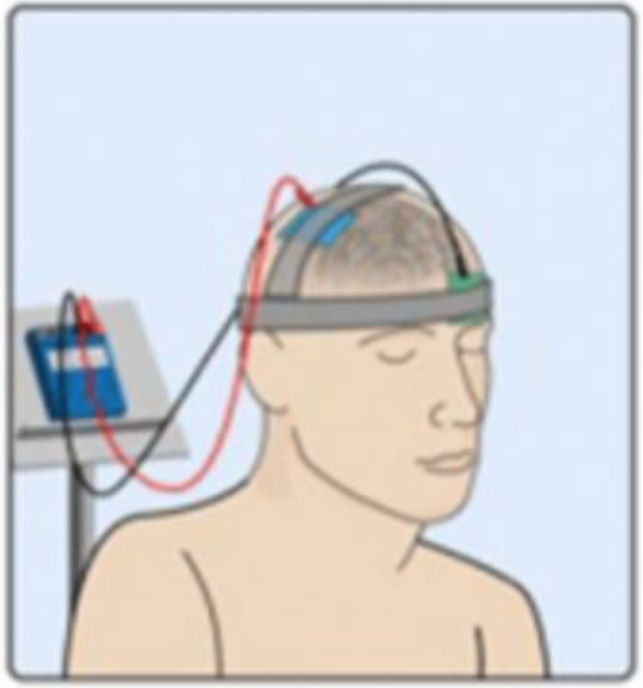
TMS vs. tDCS

TMS



tDCS

TMS – *Transcranial Magnetic Stimulation*

- Magnetic stimulation on outside of brain
- Magnetic pulses produce changes in neuron activity

tDCS – *Transcranial Direct Current Stimulation*

- Direct Current stimulation on outside of brain
- Low level current between anode & cathode to produce changes in neuron activity

TMS vs tDCS

	tDCS	TMS
Mechanism	Change of the resting membrane potential	Induces action potential
Sounds during stimulation	Silent	Click
Dermal sensation	Tingling	Weak pain
Headache	12%	23%
Epilepsy	No reports	Report by stimulation with high frequency
Price of the machine	One million yen	Ten million yen
Size	Small	Large
Time resolution	Several minutes	Milliseconds
Spatial resolution	Several centimeters	1 cm

Neurophysiological Mechanisms of tDCS

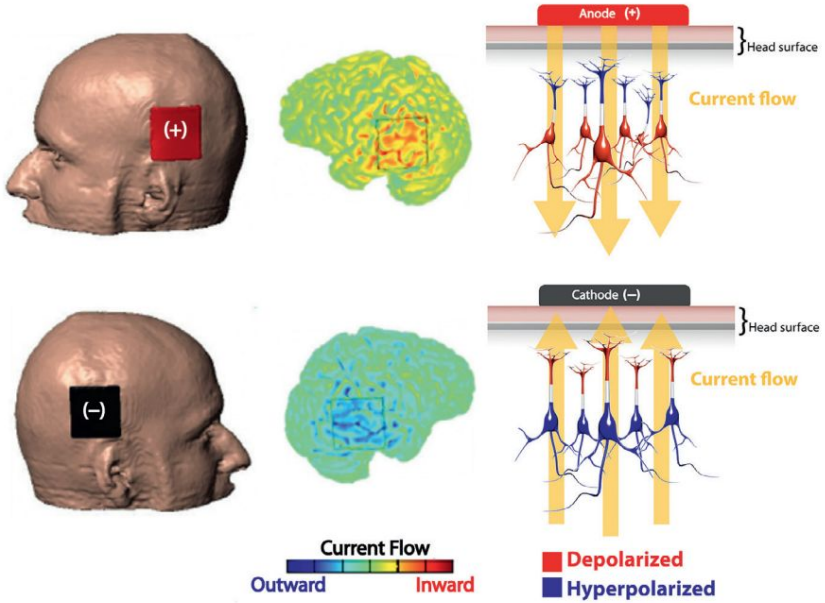


FIGURE 2.5 With tDCS, electrode polarity determines current direction of flow in the brain. The polarity also influences the cortical and sub cortical regions that are activated by the stimulation. *Upper right*: Direction of current flow through the anode (+) in tDCS. The current passes through structures, including the scalp and bone, before reaching cortical and subcortical regions. In the pyramidal cortical neurons under the anode, apical dendritic regions of the neuron become hyperpolarized (blue) whereas the somatic regions become depolarized (red). *Lower right*: Direction of current flow through the cathode (–) in tDCS. The current passes through cortical and subcortical structures, then through the bone and scalp, before reaching the cathode. In the pyramidal cortical neurons under the cathode, apical dendritic regions of the neuron become depolarized (red) whereas the somatic regions become hyperpolarized (blue).

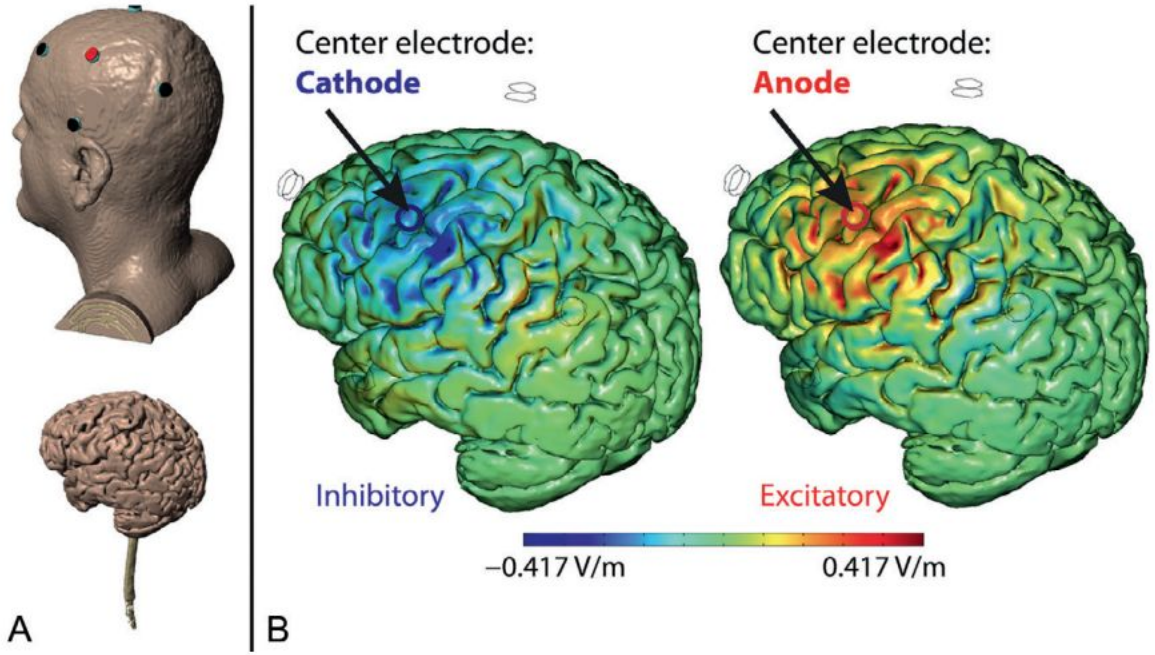


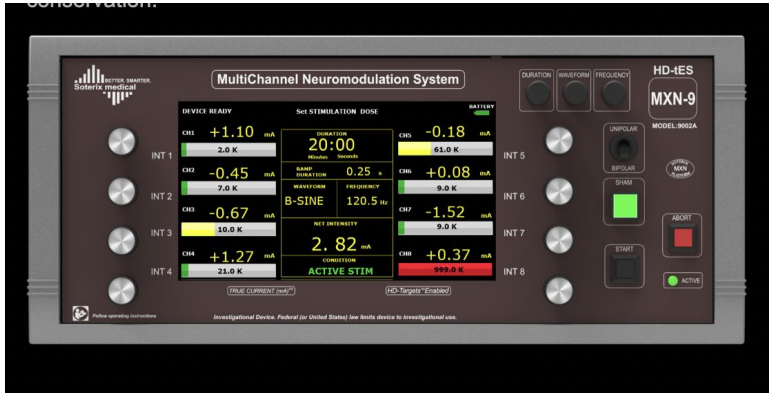
FIGURE 2.6 HD-tDCS setup and current penetration. (A) One center electrode (red) is placed over the area of stimulation and four return electrodes (black) are placed around it. The radius of the ring around the center electrode determines the modulation of the area of interest. (B) An inhibitory effect is achieved with the center electrode as a cathode, whereas an excitatory effect is achieved with the center electrode as an anode.

https://neuralengr.org/wp-content/uploads/2015/02/moreno-duarte2014.pdf

HD-tDCS (MRI-compatible cap)

when I got zapped!!

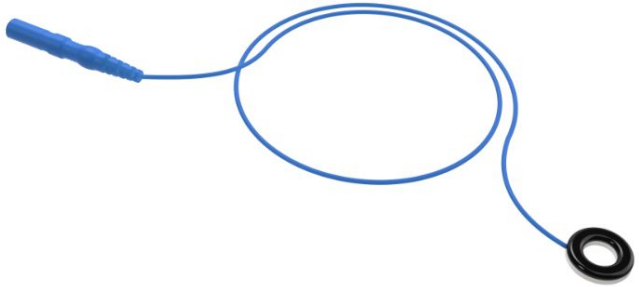
HD-tDCS supplier



MR compatible holder

https://soterixmedical.com/research/hd-tdcs/accessories/hdtes-holder

electrode (this one not MR compatible!)



https://soterixmedical.com/research/hd-tdcs/accessories/hd-electrode

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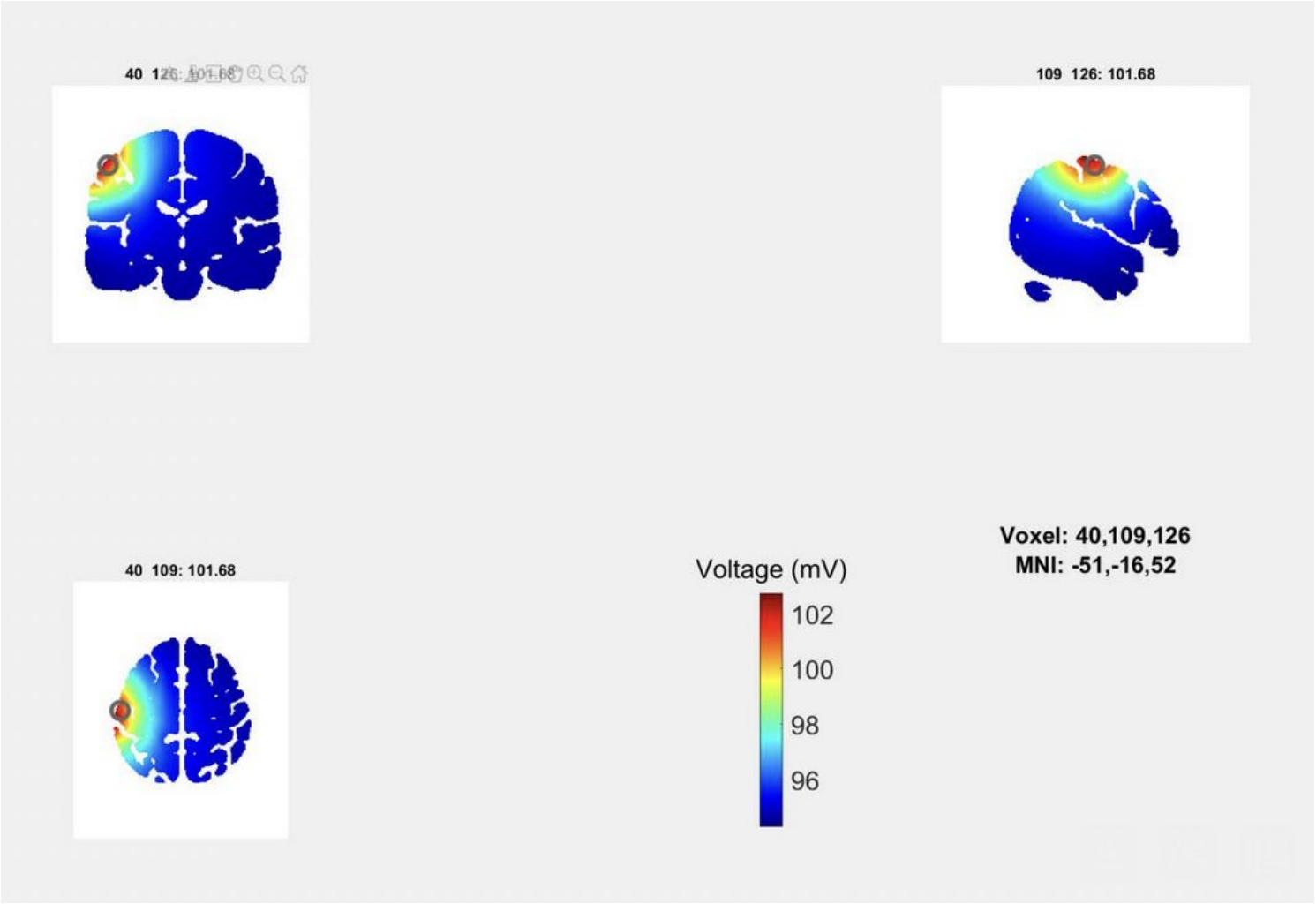
ROAST simulations (Voltage maps)



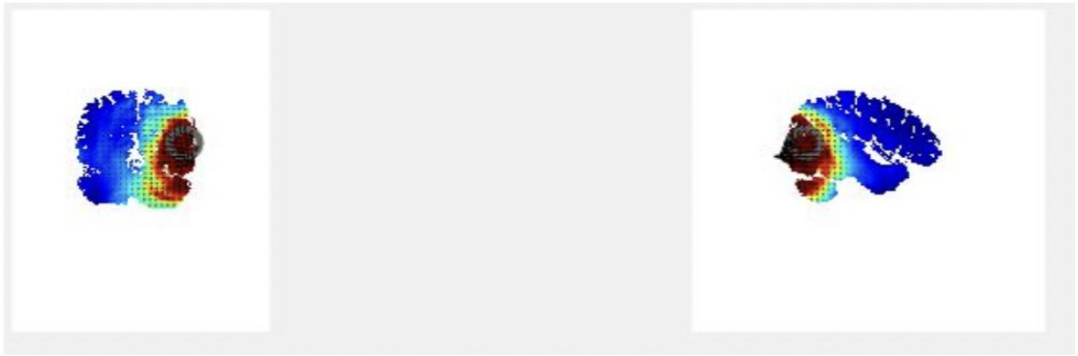
ROAST (Electric field map) & 2x3 optimal Electrode placement for stimulation of right MT region

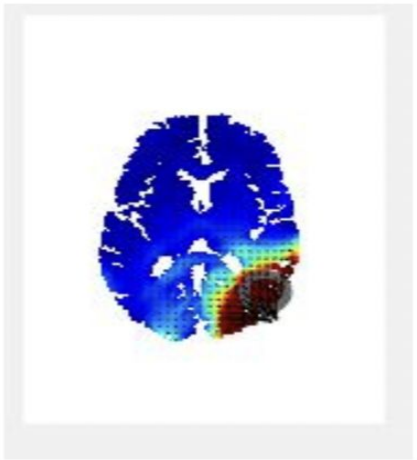
Cathodal:

PO4:-1.5000, TP8:0.7389, PO10:0.9973, O2:1.2638, PO8:-1.5000

Anodal:

PO4: 1.5000, TP8:-0.7389, PO10:-0.9973, O2:-1.2638, PO8:1.5000



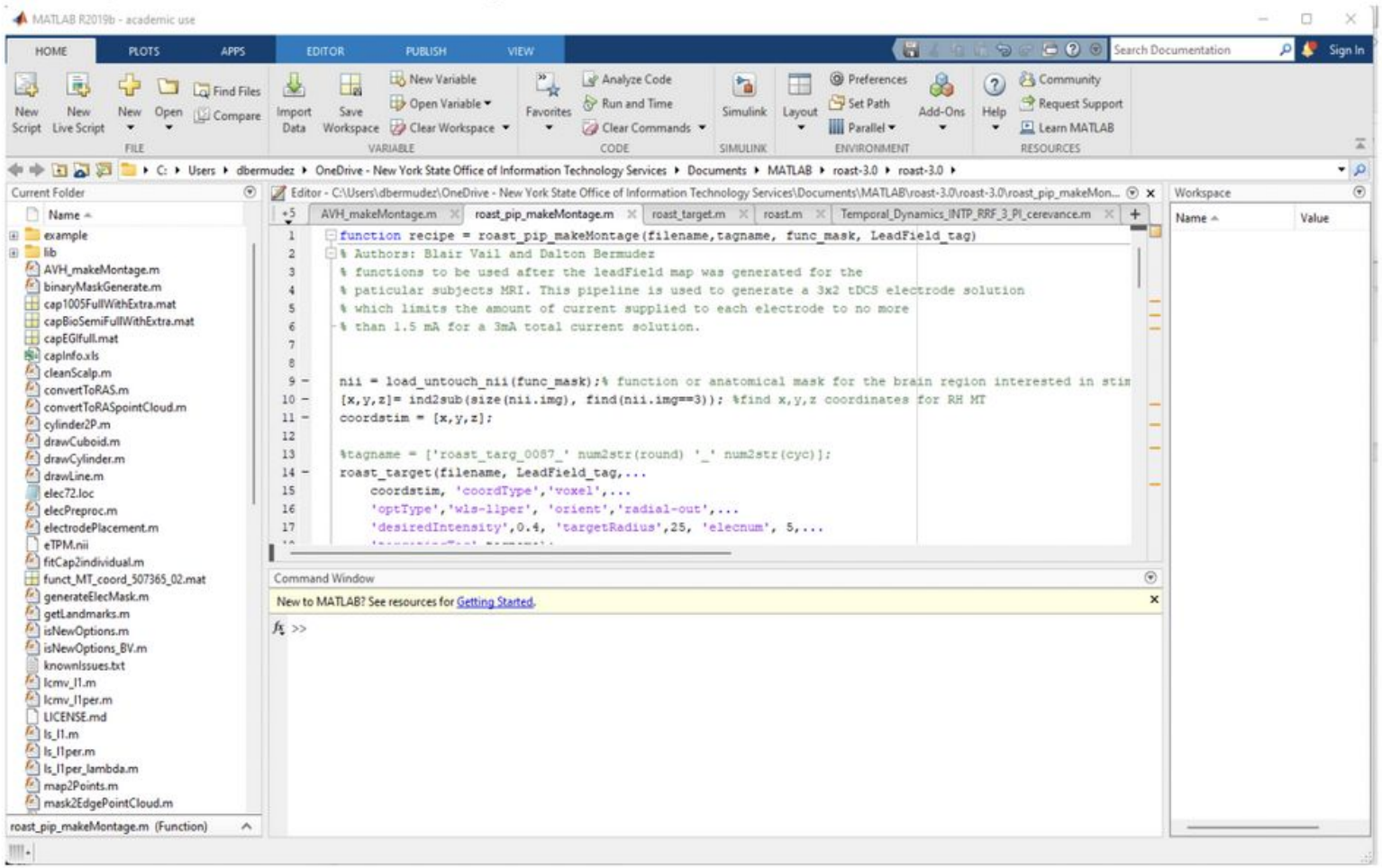


Cathodal and Anodal HD-tDCS stimulation are just inverse polarity of one another

Optimal subject specific HD-tDCS electrode placement for stimulation of anatomical specific MT region

Process to generate Optimal electrode placement for a 2x3 HD-tDCS solution using ROAST (Part 1)

1) Go into roast-3.0 directory.



Process to generate Optimal electrode placement for a 2x3 HD-tDCS solution using ROAST (Part 2)

2) Convert all the dicom raw HCP (T2w) and MPRANGE (T1w) to nifty using the dicm2nii-master.

```
dicm2nii('C:\Users\dbermudez\OneDrive - New York State Office of Information Technology Services\Desktop\507365_5731\HCP_SPACE_012', ...
    'C:\Users\dbermudez\OneDrive - New York State Office of Information Technology Services\Desktop\507365_5731\', 'nii')
```

3) Convert the T1w and T2w nifty files to RAS orientation for ROAST to use by using the convertToRAS function within the roast-3.0 directory.

```
>> [mriRAS,isNonRAS] = convertToRAS('C:\Users\dbermudez\OneDrive - New York State Office of Information Technology Services\Desktop\507365_5731\T1w_5731.nii')
```

4) Use the RAS version of the T1w and T2w nifty files to generate the Lead Field for the subject by using the roast function withing the roast-3.0 directory. (Takes about a day to generate the Lead Field)

```
roast('C:\Users\dbermudez\OneDrive - New York State Office of Information Technology Services\Desktop\507365_5731\T1w_5731_ras.nii', ...
    'leadField', 'zeroPadding', 20, 'simulationTag', '5731LF', 'T2', ...
   'C:\Users\dbermudez\OneDrive - New York State Office of Information Technology Services\Desktop\507365_5731\T2w_5731_ras.nii')
```

Process to generate Optimal electrode placement for a 2x3 HD-tDCS solution using ROAST (Part 3)

7)Make functional based anatomical ROI pixel coordinate of the brain region you want to stimulate.

6) Use the T1w nifty files in RAS format, files generated by the roast function (Lead Field), and the MT based functional mask generated in AFNI within the roast_pip_makeMontage function to generate the most optimal tDCS electrode placement for each subject.

```
recipe = roast_pip_makeMontage('C:\Users\dbermudez\OneDrive - New York State Office of Information Technology Services\Desktop\507365_5731\T1w_5731_ras.nii', ...
    '5731_roast_tag', 'C:\Users\dbermudez\OneDrive - New York State Office of Information Technology Services\Desktop\507365_5731\funct_mask_5731.nii', ...
    '5731LF');
```

ROAST software and script can be found here:https://www.opensourceimaging.org/project/roast/#:~:text=ROAST%3A%20A%20fully%20automated%2C%20Realistic,such%20as%20iso2mesh%20and%20getDP.