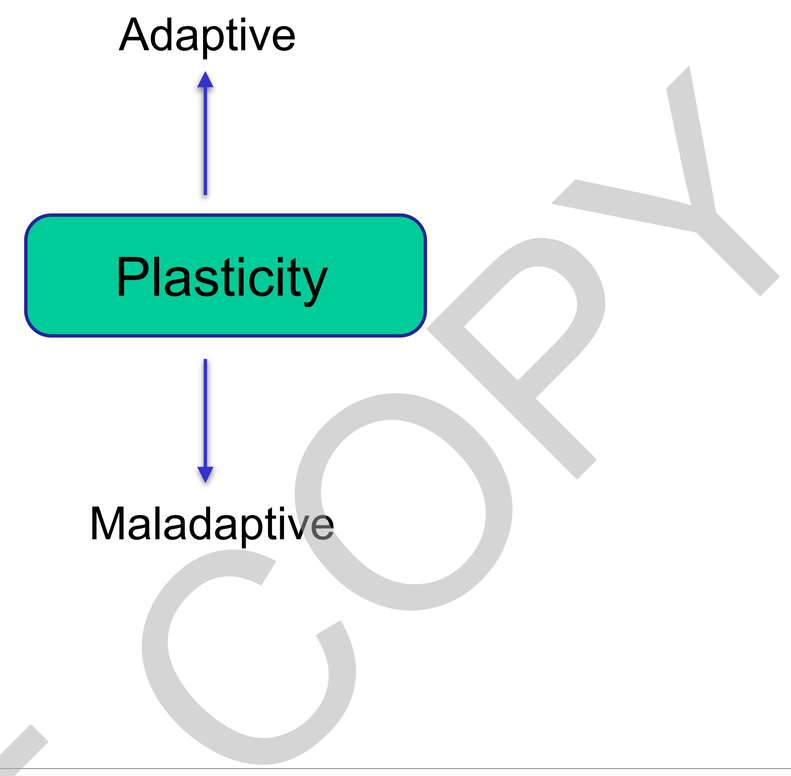
Berenson-Allen Center for Noninvasive Brain Stimulation
Beth Israel Deaconess Medical Center
Harvard Medical School

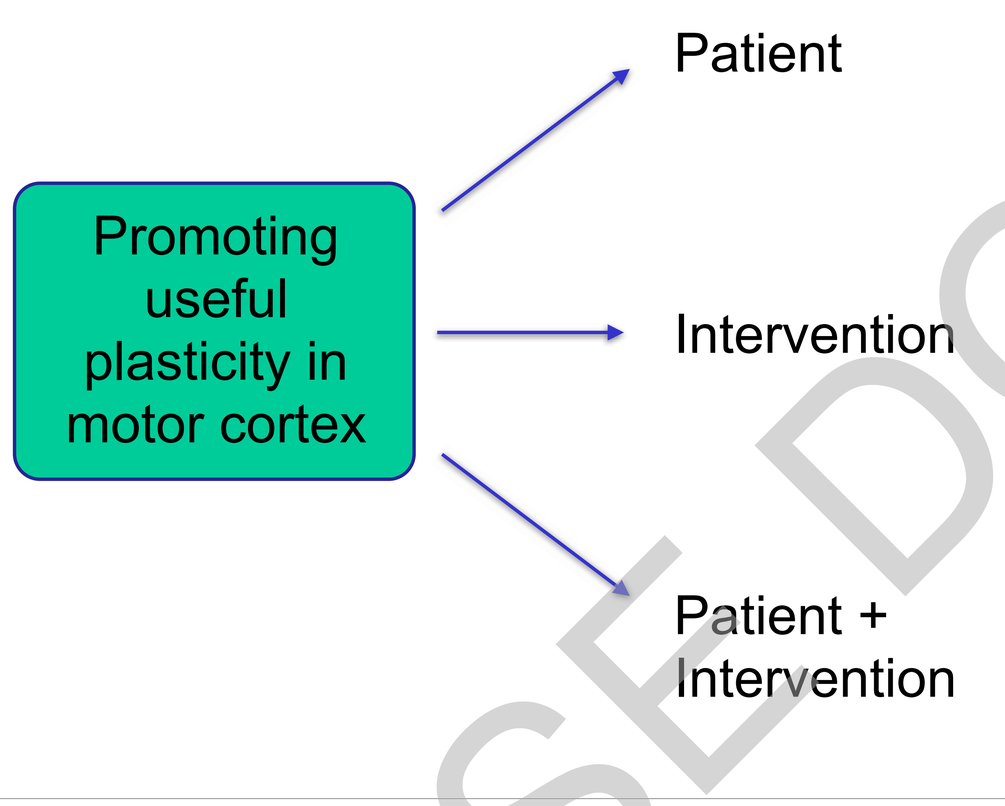
Behavioral Intervention Research Using tDCS

Dylan J. Edwards PhD

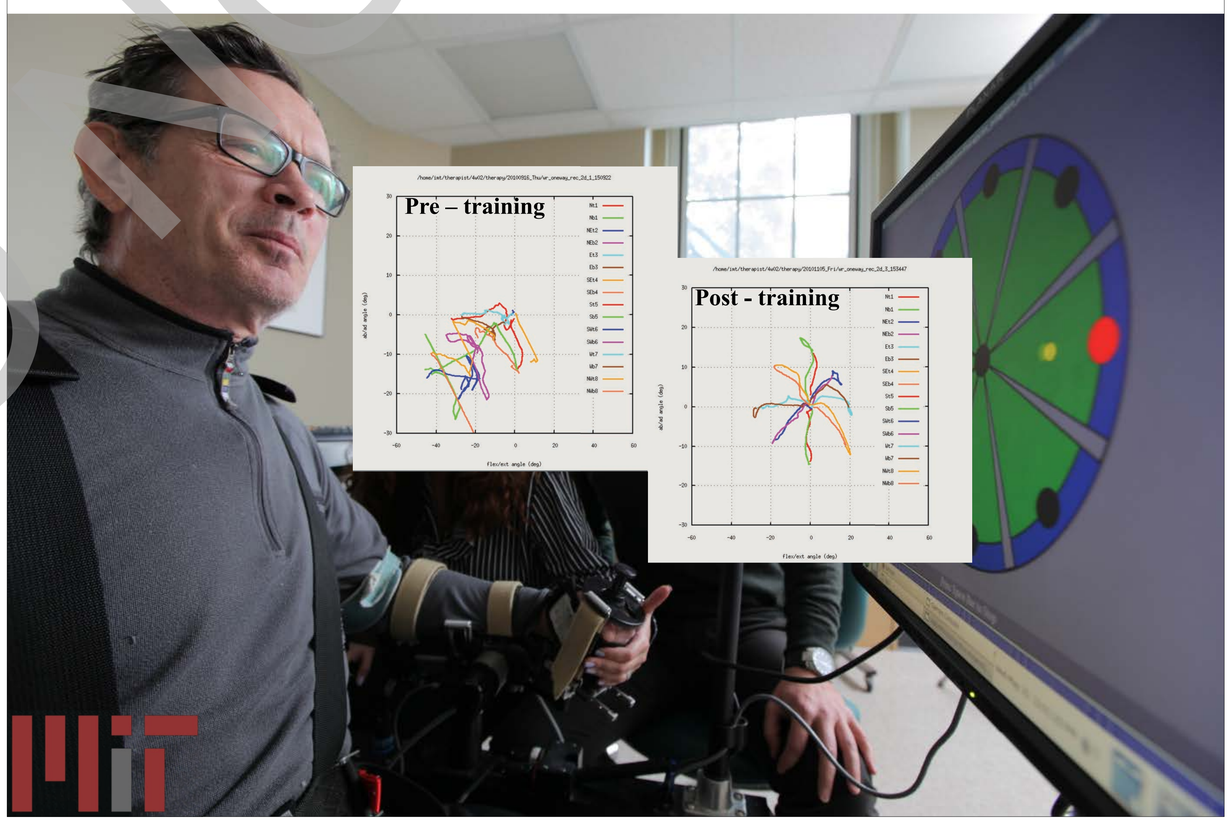
Director, Moss Rehabilitation Research Institute, Philadelphia

Professor of Neuroscience, ECU Australia

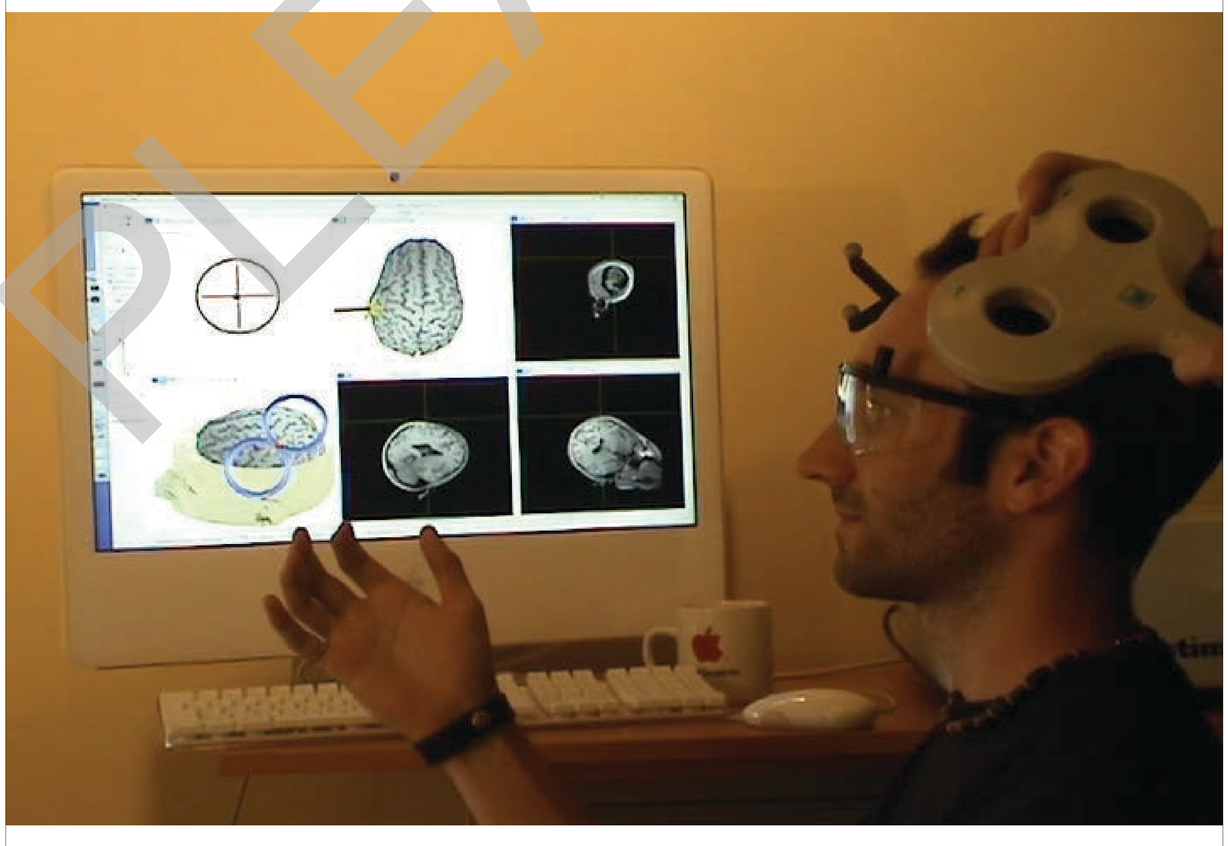




Robotics for assessment of performance kinematics



TMS Demonstration

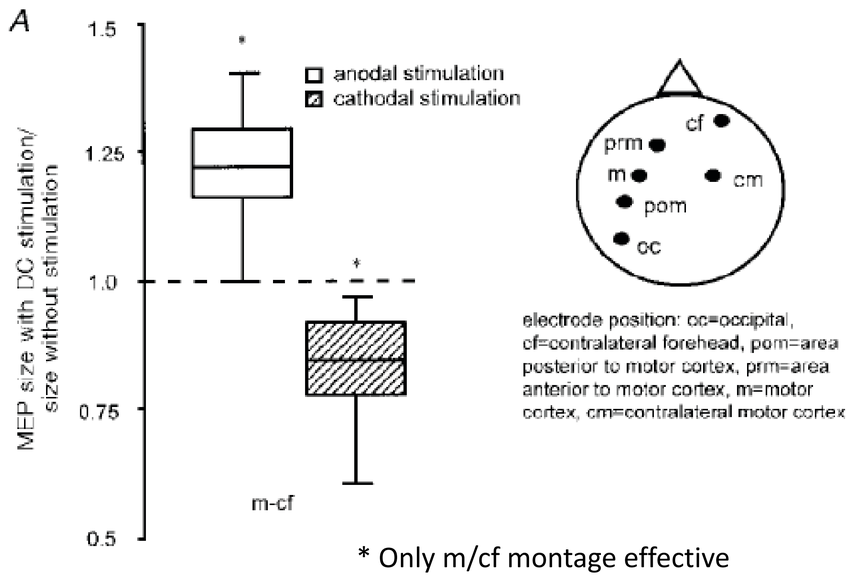


tDCS

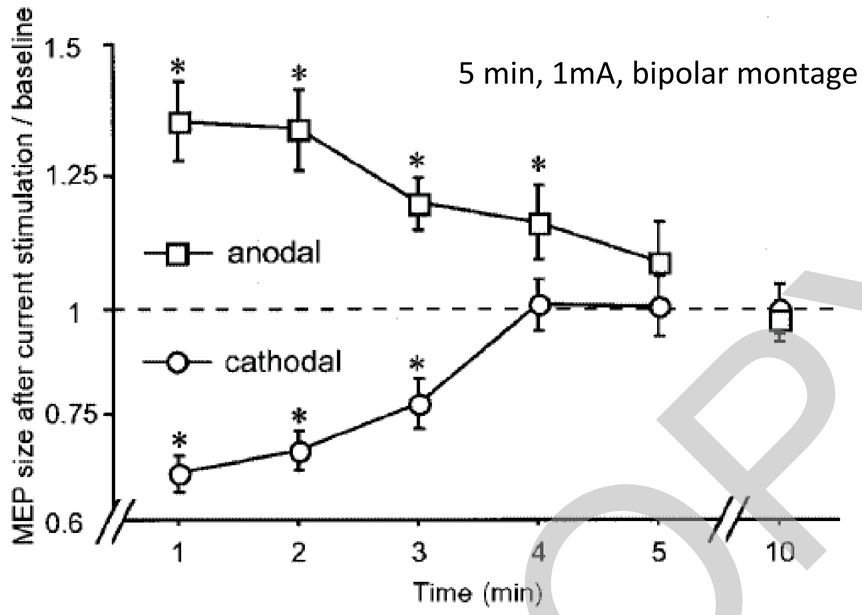
Journal of Physiology (2000), **527.3**, *pp.*633–639

Excitability changes induced in the human motor cortex by weak transcranial direct current stimulation

M. A. Nitsche and W. Paulus



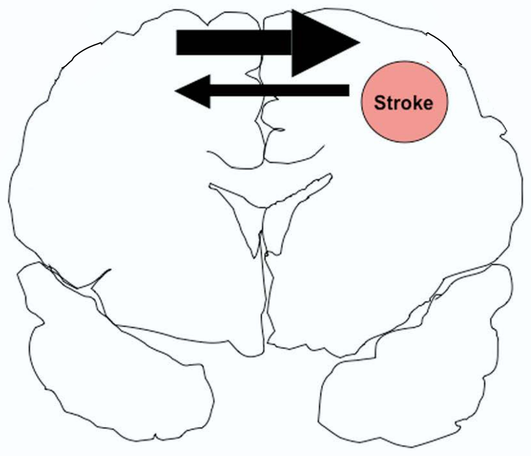
* Only m/cf montage effective



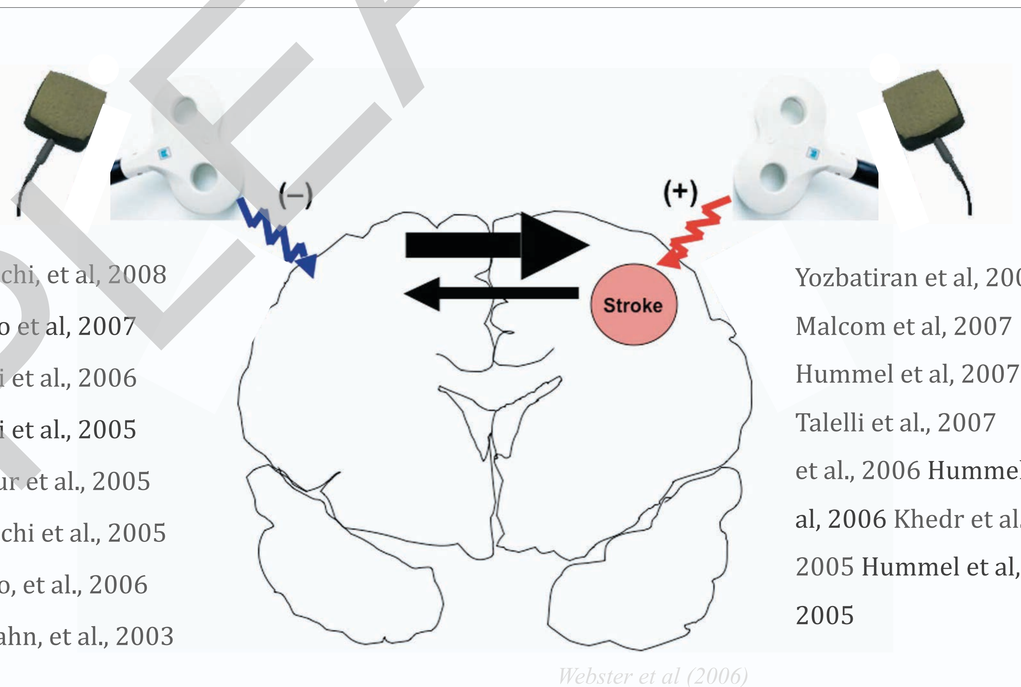
"In order to induce aftereffects, a stimulus duration of at least 3 min at 1 mA or an intensity of 0·6 mA for 5 min"

Nitsche et al, 2000

Corticomotor excitability in stroke



Webster et al (2006)



Takeuchi, et al, 2008
Boggio et al, 2007
Fregni et al., 2006
Fregni et al., 2005
Mansur et al., 2005
Takeuchi et al., 2005
Boggio, et al., 2006
Werhahn, et al., 2003

Yozbatiran et al, 2009
Malcom et al, 2007
Hummel et al, 2007
Talelli et al., 2007 Kim et al., 2006 Hummel et al, 2006 Khedr et al., 2005 Hummel et al, 2005

Webster et al (2006)

IMPROVED CORTICOMOTOR OUTPUT FROM IPSI-LESIONAL M1 & IMPROVED MOTOR BEHAVIOUR

Functional Improvements

sRT/cRT

Pinch force acceleration

fingers/thumb AROM

Movement accuracy

Purdue Pegboard

JTT

TMS correlates

Resting MT

Transcallosal Inhibition

MEP Amplitude

IMPROVED CORTICOMOTOR OUTPUT FROM IPSI-LESIONAL M1 & IMPROVED MOTOR BEHAVIOUR

Anodal tDCS favors clinical improvement in stroke…

Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Invited Review

Does anodal transcranial direct current stimulation enhance excitability of the motor cortex and motor function in healthy individuals and subjects with stroke: A systematic review and meta-analysis

A. Bastani, S. Jaberzadeh *

Department of Physiotherapy, School of Primary Health Care, Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, Australia

Restorative Neurology and Neuroscience 25 (2007) 123–129

Repeated sessions of noninvasive brain DC stimulation is associated with motor function improvement in stroke patients

Paulo S. Boggio[a,b,1], Alice Nunes[a,1], Sergio P. Rigonatti[a], Michael A. Nitsche[c], Alvaro Pascual-Leone[d,e] and Felipe Fregni[d,*]

[a]*Department of Experimental Psychology and Department of Psychiatry, University of Sao Paulo, Sao Paulo, Brazil (address where the work was carried out)*

[b]*Jcleo Neurociências Mackenzie University, Sao Paulo, Brazil*

[c]*Department of Clinical Neurophysiology, Georg-August-University, Goettingen, Germany*

[d]*Center for Noninvasive Brain Stimulation, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, USA*

[e]*Institute Gutmann for Neurorehabilitation, Barcelona, Spain*

SPECIAL ISSUE

A Meta-analysis of the Efficacy of Anodal Transcranial Direct Current Stimulation for Upper Limb Motor Recovery in Stroke Survivors

Butler et al.

Level of Evidence: Level 1a.

J HAND THER. 2012;■■:■–■.

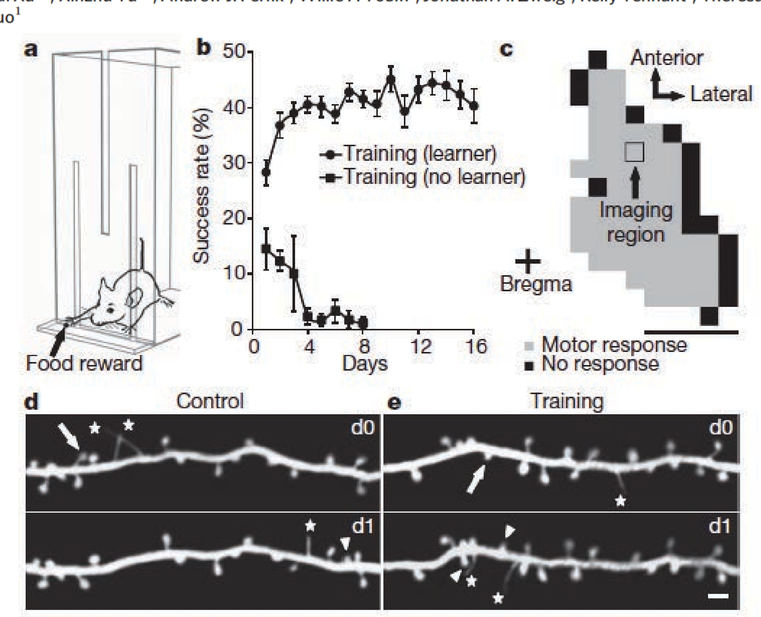
How does repetitive behavior affect motor cortex?

doi:10.1038/nature08389 nature

LETTERS

Rapid formation and selective stabilization of synapses for enduring motor memories

Tonghui Xu[1]*, Xinzhu Yu[1]*, Andrew J. Perlik[1], Willie F. Tobin[1], Jonathan A. Zweig[1], Kelly Tennant[2], Theresa Jones[2] & Yi Zuo[1]



Neurobiology of Learning and Memory **74,** 27–55 (2000)

Effects of Repetitive Motor Training on Movement Representations in Adult Squirrel Monkeys: Role of Use versus Learning

Erik J. Plautz,* Garrett W. Milliken,† and Randolph J. Nudo‡§

Department of Neurobiology and Anatomy, University of Texas–Houston, Houston, Texas 77030; †Department of Psychology, College of Charleston, Charleston, South Carolina 29424; and ‡Department of Molecular and Integrative Physiology and §Center on Aging, University of Kansas Medical Center, Kansas City, Kansas 66160

Motor map does not change unless in skill context

Exp Brain Res (2006) 174: 199–209
DOI 10.1007/s00221-006-0440-8

RESEARCH ARTICLE

S. Koeneke · K. Lutz · U. Herwig · U. Ziemann
L. Jäncke

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

Simple repetitive finger movements increase excitability

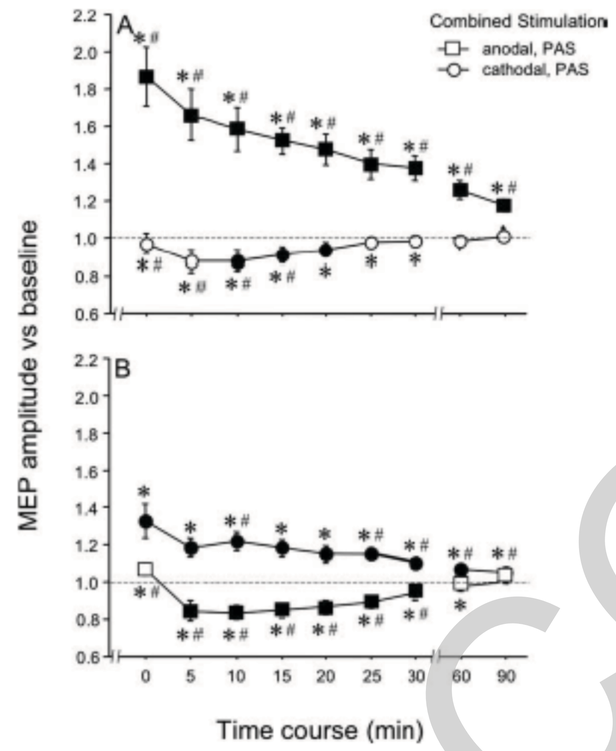
Journal of NeuroEngineering and Rehabilitation

BioMed Central

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

Viola Giacobbe[1,#], Bruce T. Volpe[1], Gary W. Thickbroom[2], Felipe Fregni[3,6], Alvaro Pascual-Leone[3,5], Hermano I. Krebs[4], Dylan J. Edwards[1,2,3]

How does combined intervention affect motor cortex?

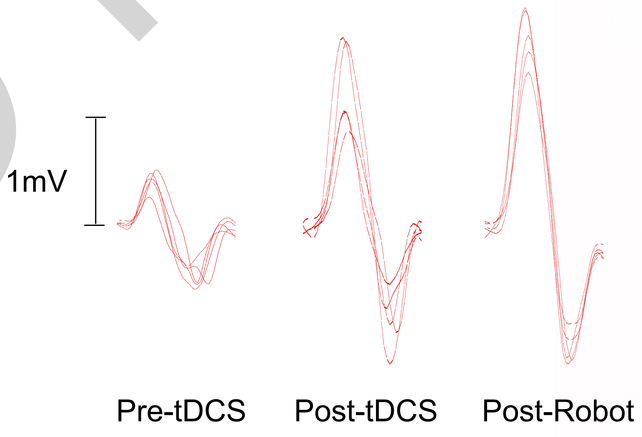


Anodal tDCS prior to excitatory PAS further boosts excitability, while during tDCS reverses effect to reduced excitability

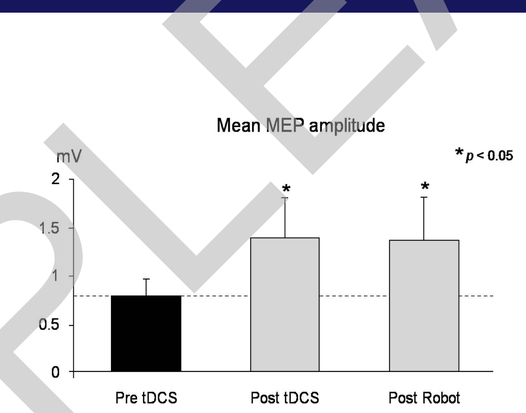
Nitsche et al (2007)

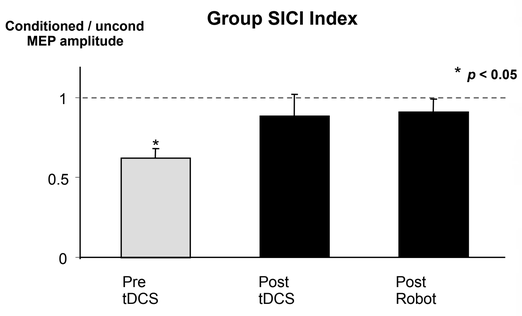
Is coupling tDCS with training good?

Anodal tDCS combined with robotic motor training



Anodal tDCS combined with robotic motor training





Edwards et al (2009)

Relevance of kinematic measures to clinical function

Movement Speed (peak, mean)

Movement Smoothness

Aim

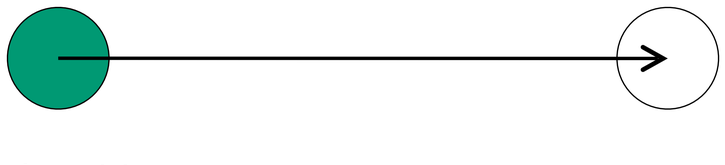
Deviation

Highest correlation with clinical function

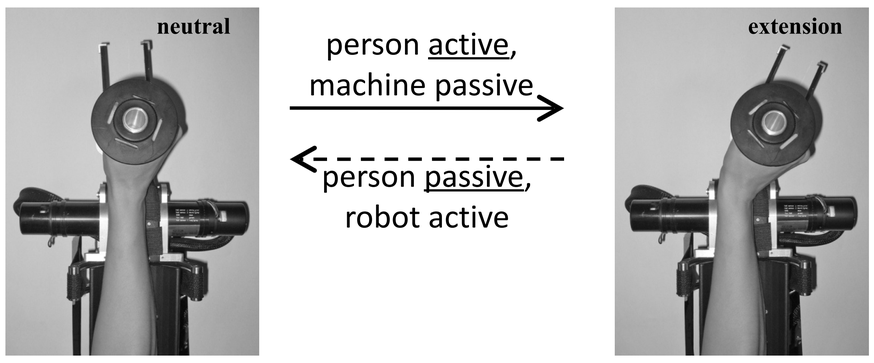
"Kinematic Robot-Based Evaluation Scales and Clinical Counterparts to Measure Upper Limb Motor Performance in Patients With Chronic Stroke" (Bosecker et al, 2009)

Movement Training Paradigm

Visual Cue & Feedback



Hand position



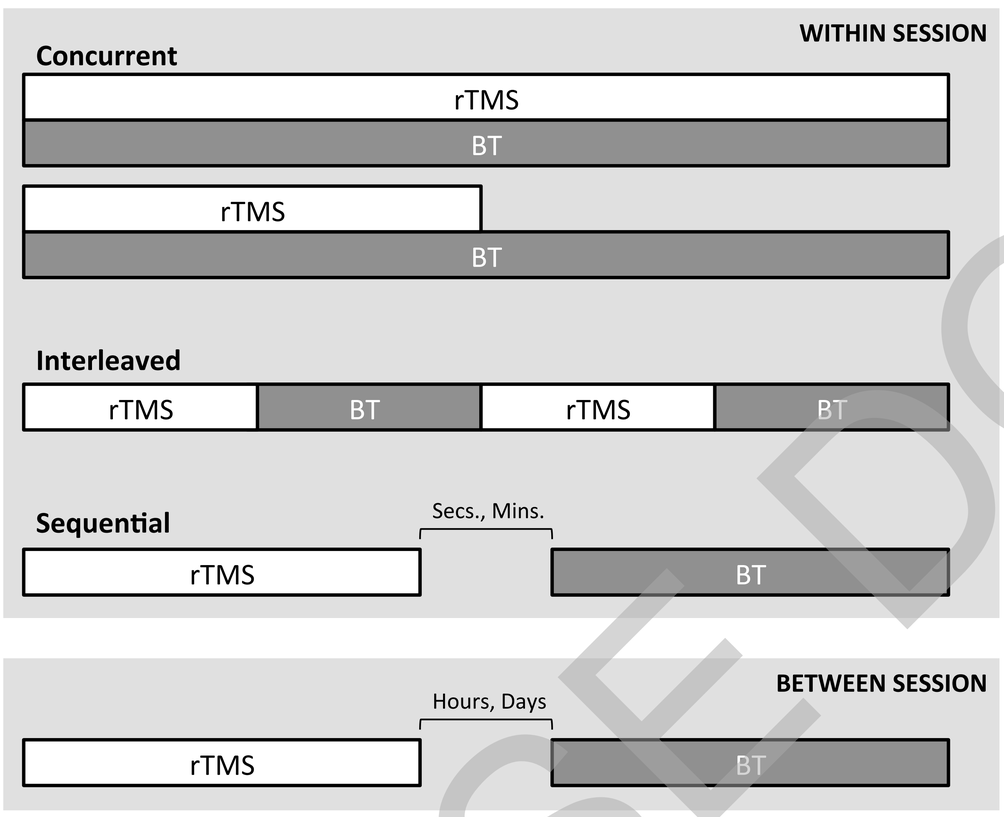
20mins, 0.2Hz movement (4mins movt, 1 min rest) x4

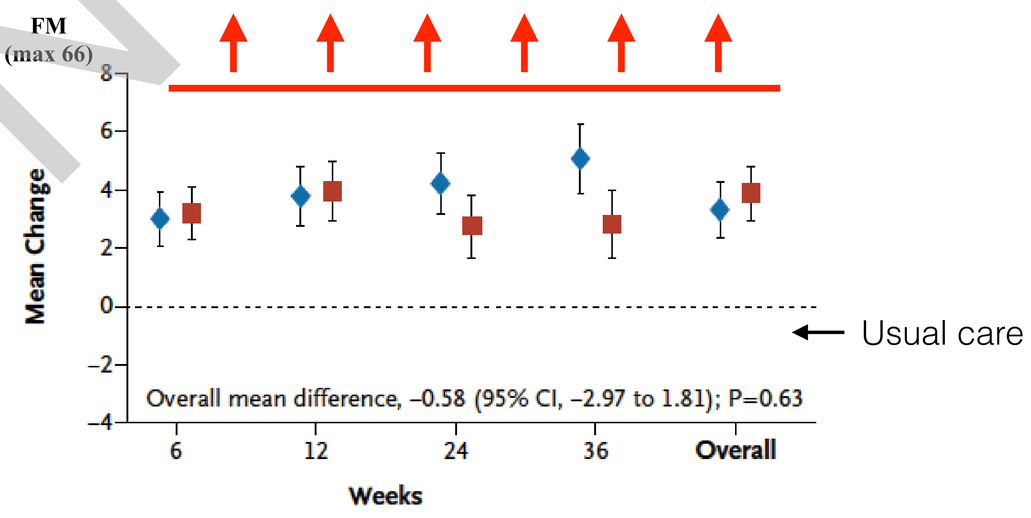
Key Findings: Effect of Intervention on Motor Performance

Group Data n=12

Giacobbe et al., (2013)

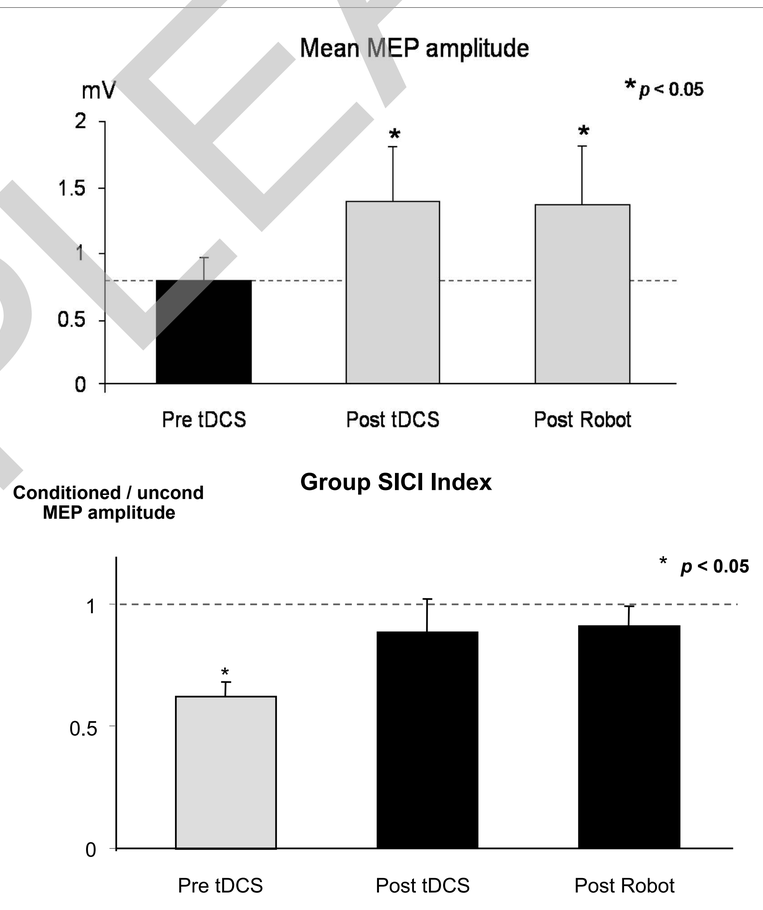
Timing of tDCS and behavioral therapy





** 36 session protocol chronic stroke*

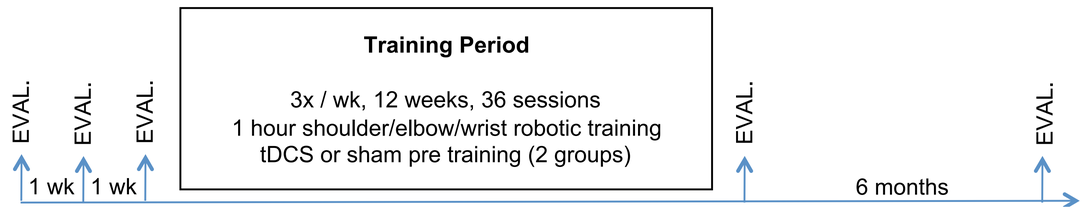
Lo et al, NEJM (2010)



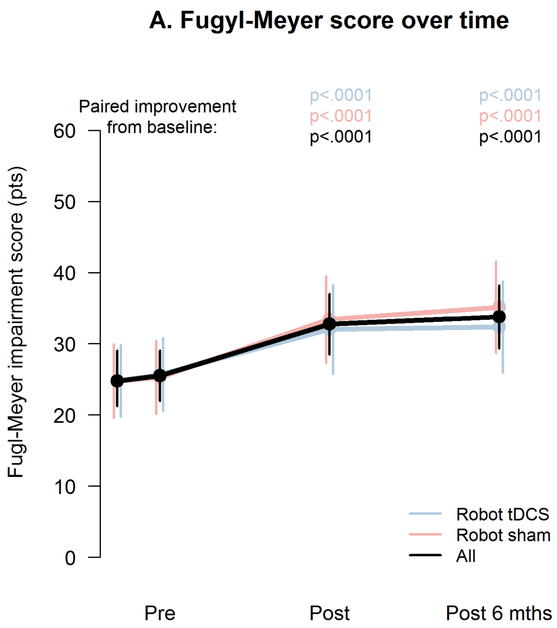
Edwards et al (2009)

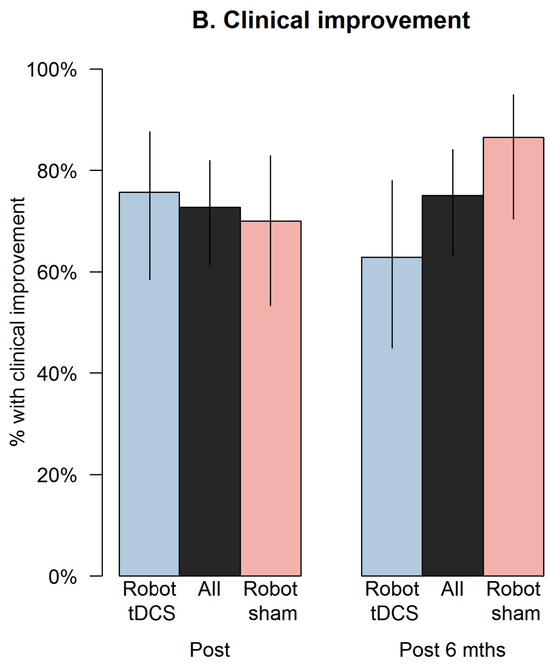
Giacobbe et al (2013)

H_1: $Robot_{+tDCS}$ > $Robot_{+\mathbf{SHAM}tDCS}$ on UEFM improvement

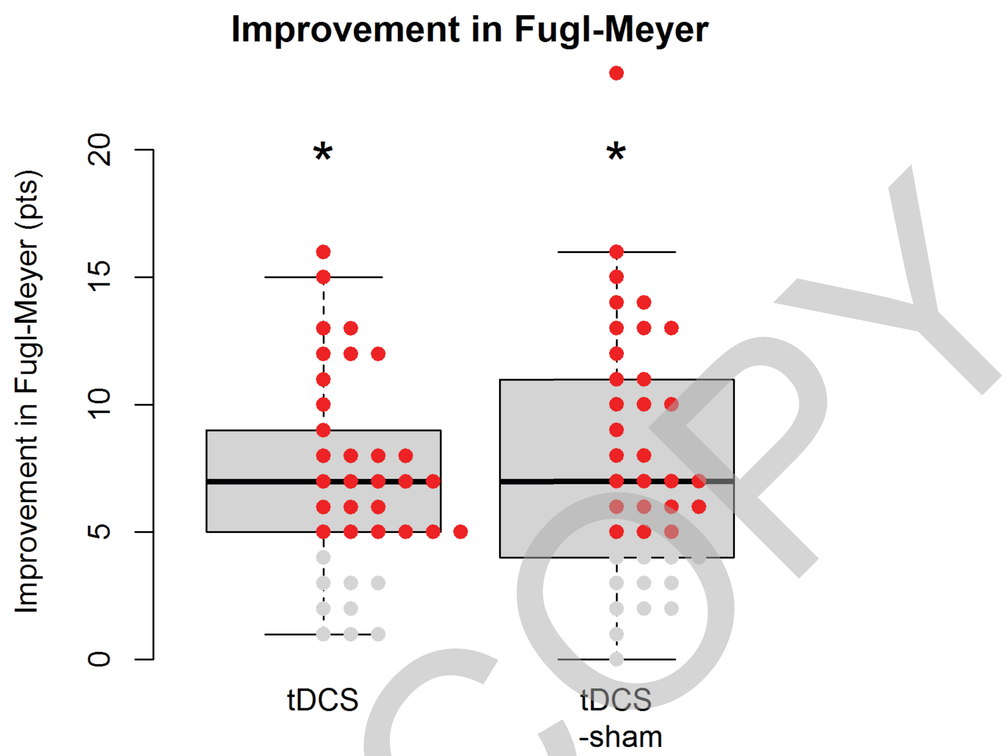


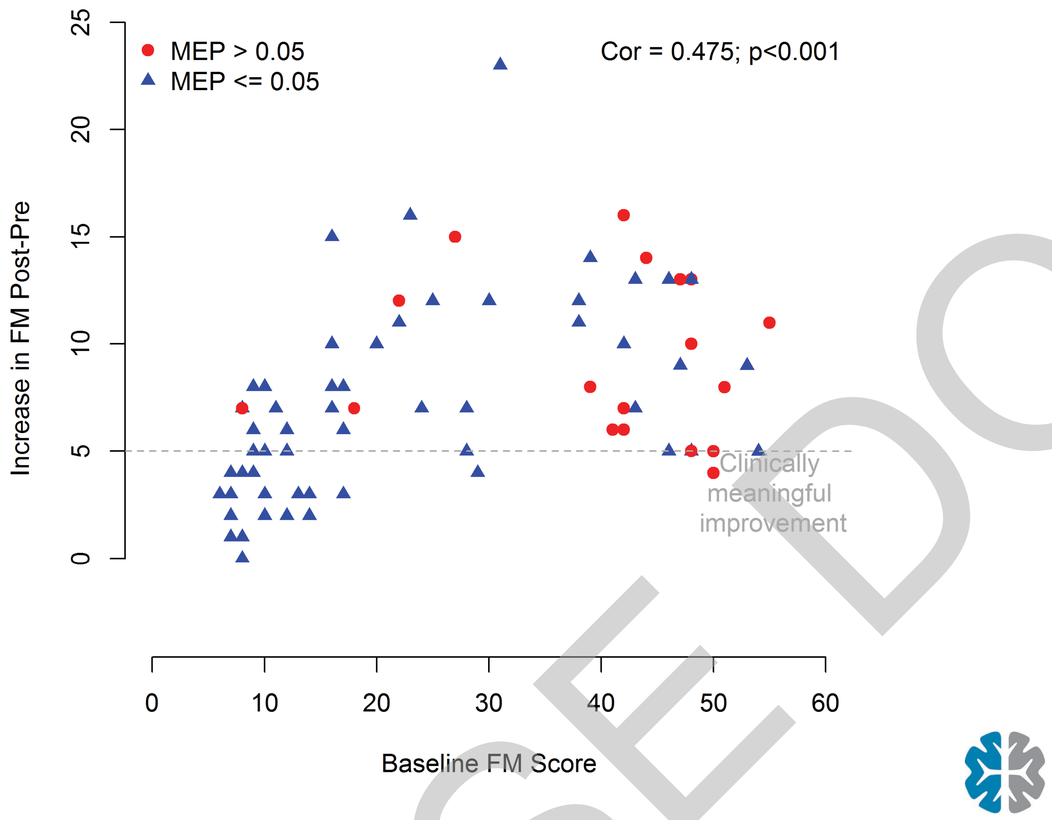
- 82 patients, right hemiparesis
- >6 mnths post first ischemic stroke
- Robotic protocol alternates S/E-wrist robot across sessions
- tDCS 2mA, 35cm², 0.9% NaCl soaked sponges

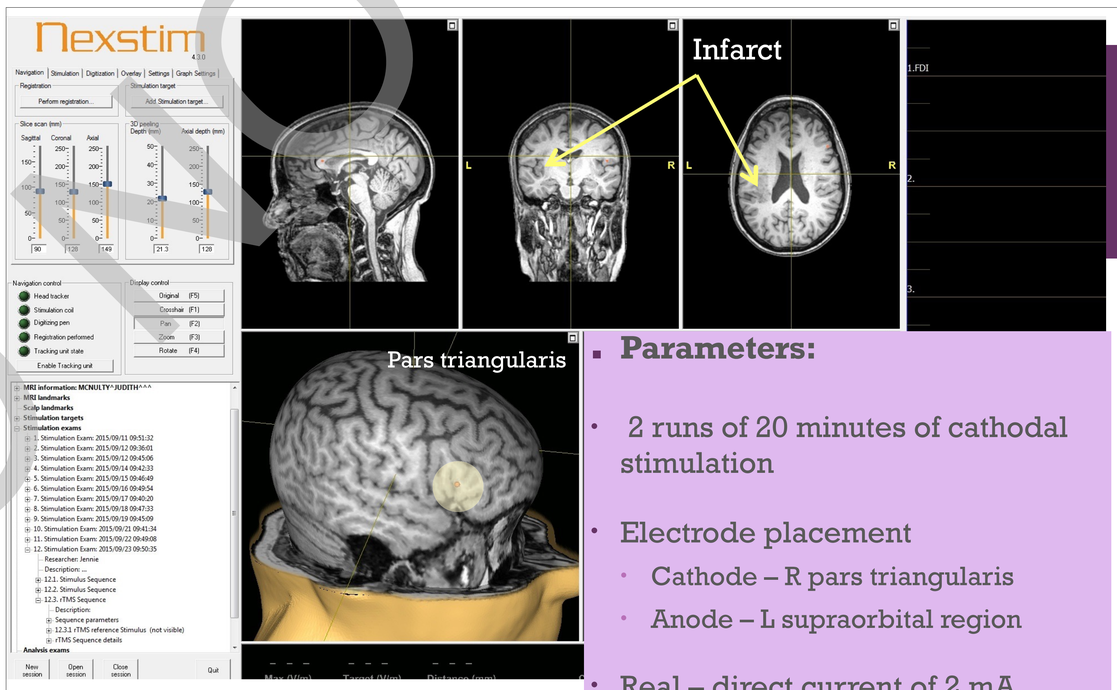




*Edwards et al. Accepted



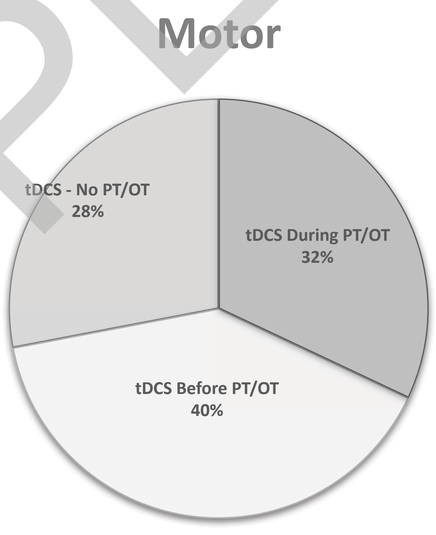


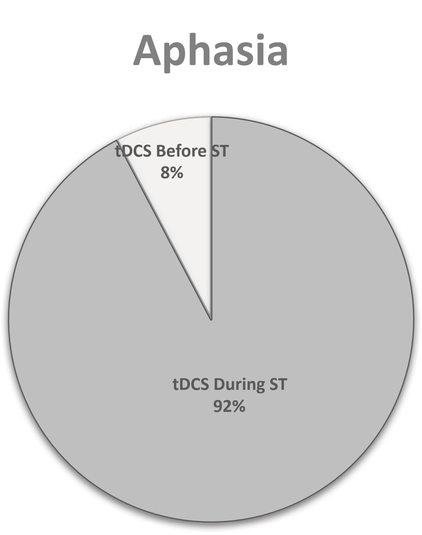


Northstar Trial

tDCS for aphasia rehabilitation

- primarily studied as a complement to speech therapy

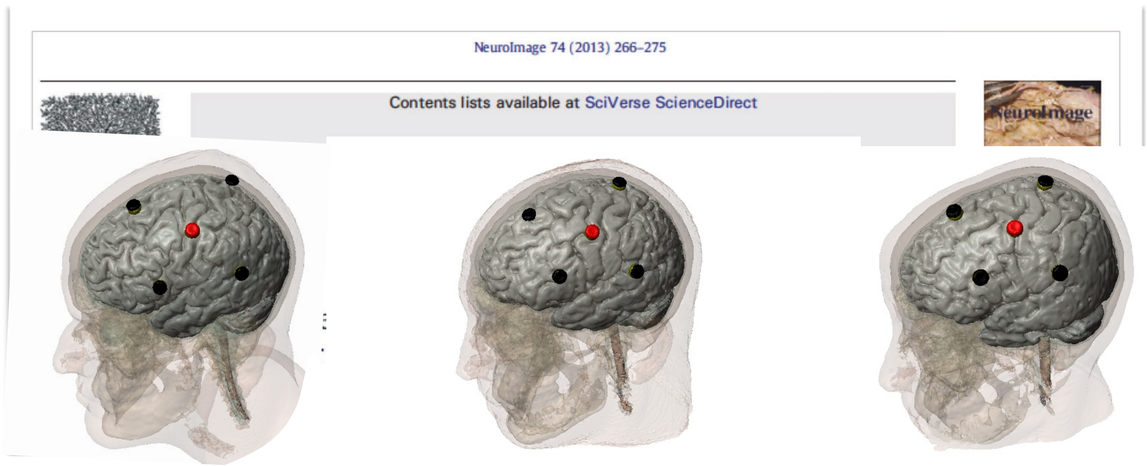


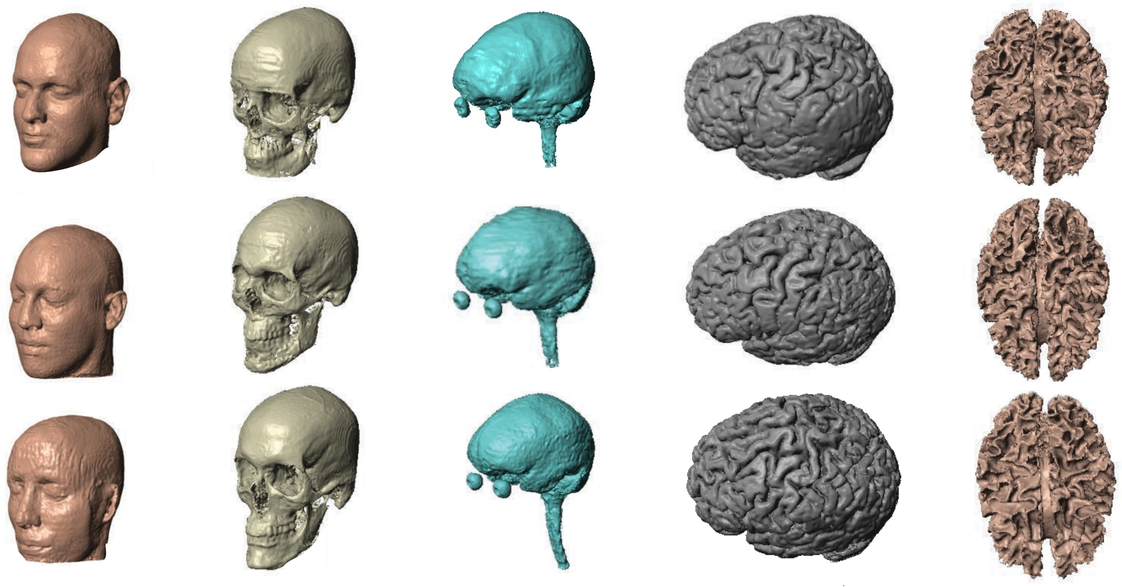


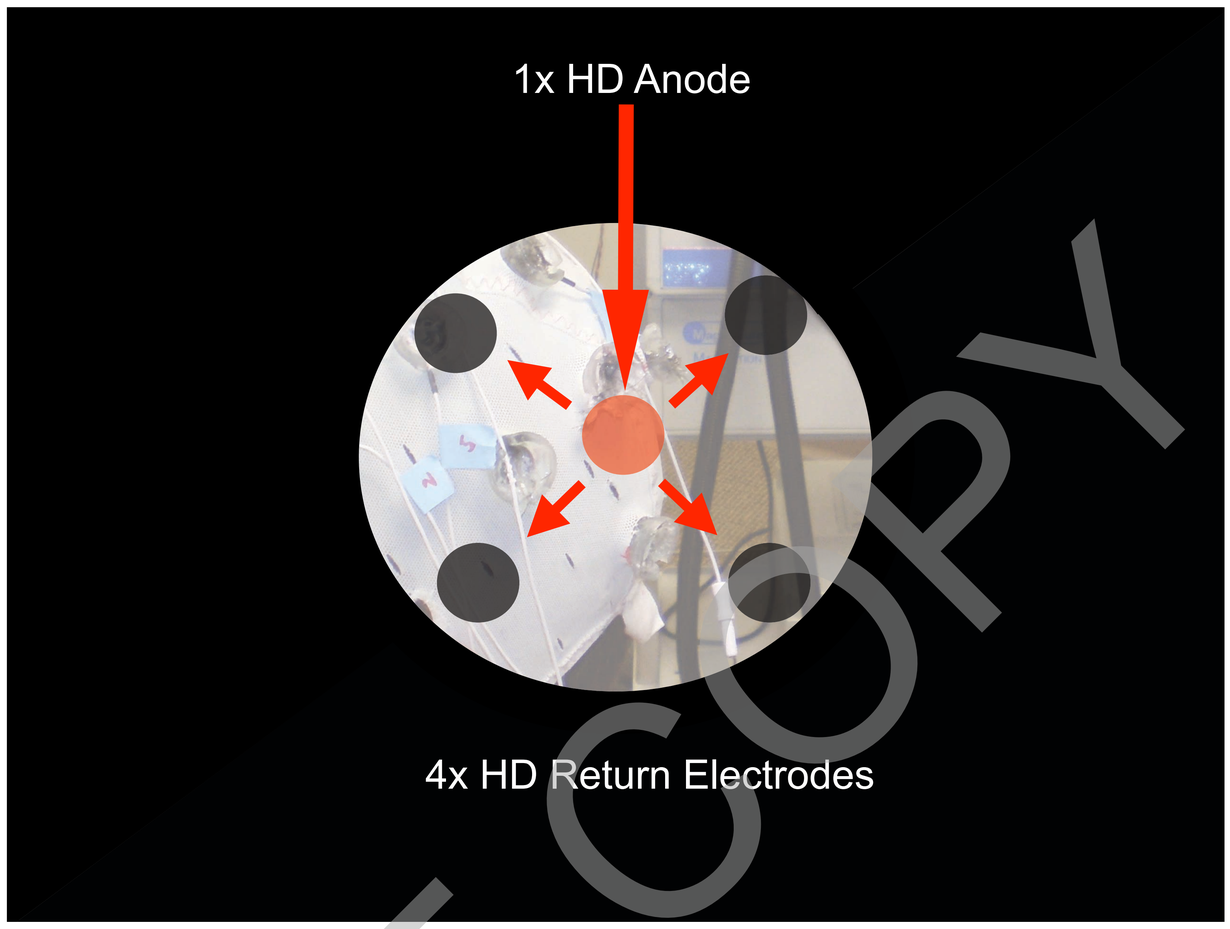
BURKE Rehabilitation & Research

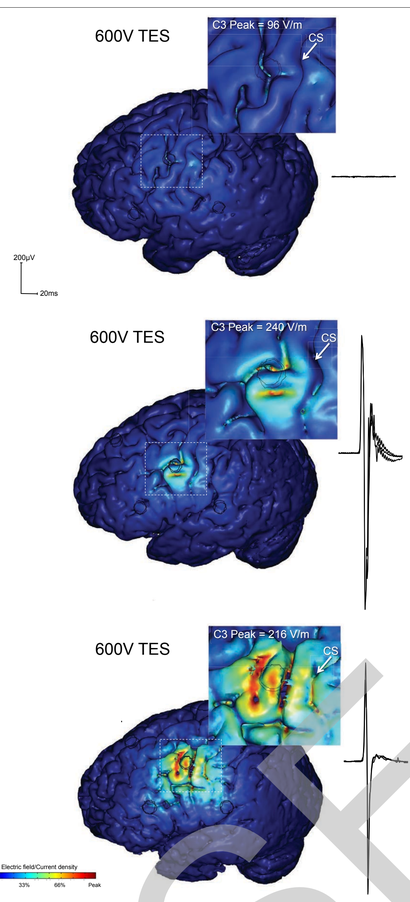
2014-2015 Publications

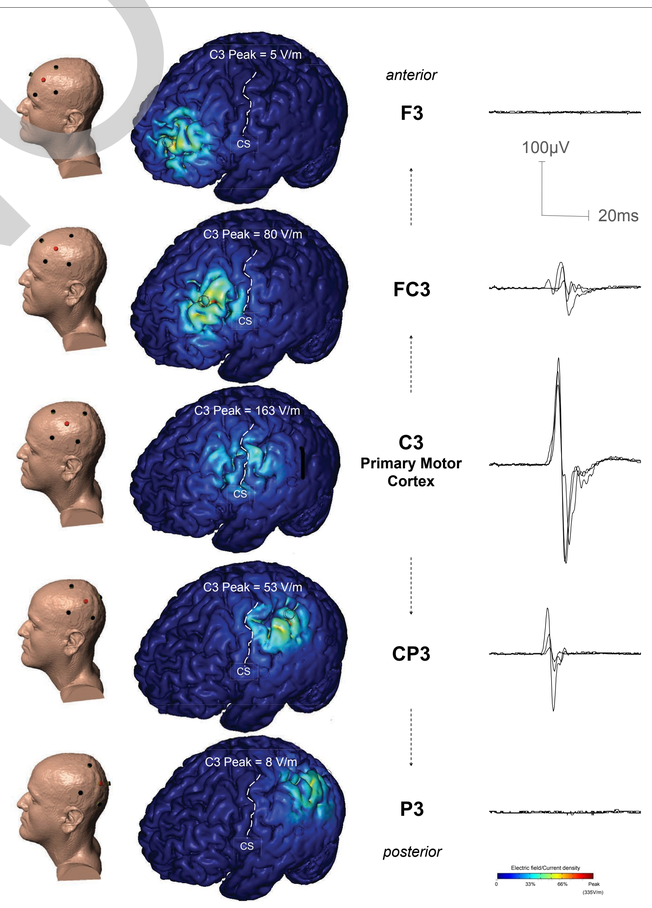
Weill Cornell Medicine



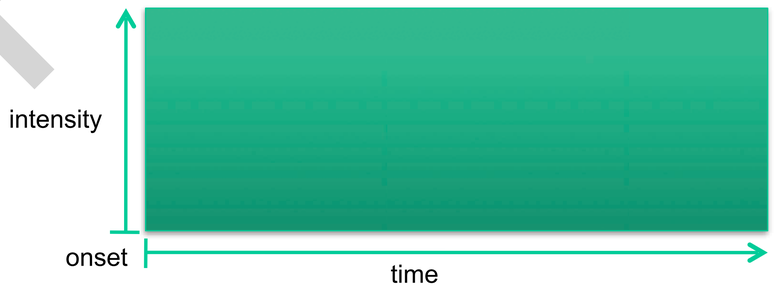


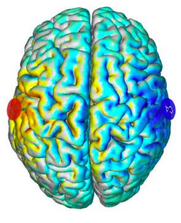






Physical presence of DC field in human tissue with tDCS
(magnitude v time)

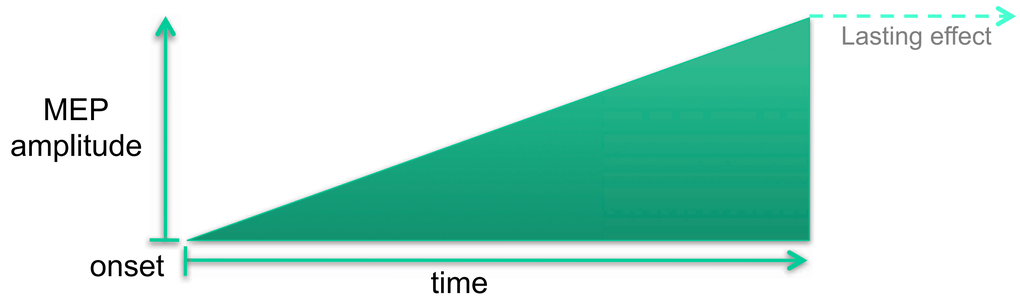


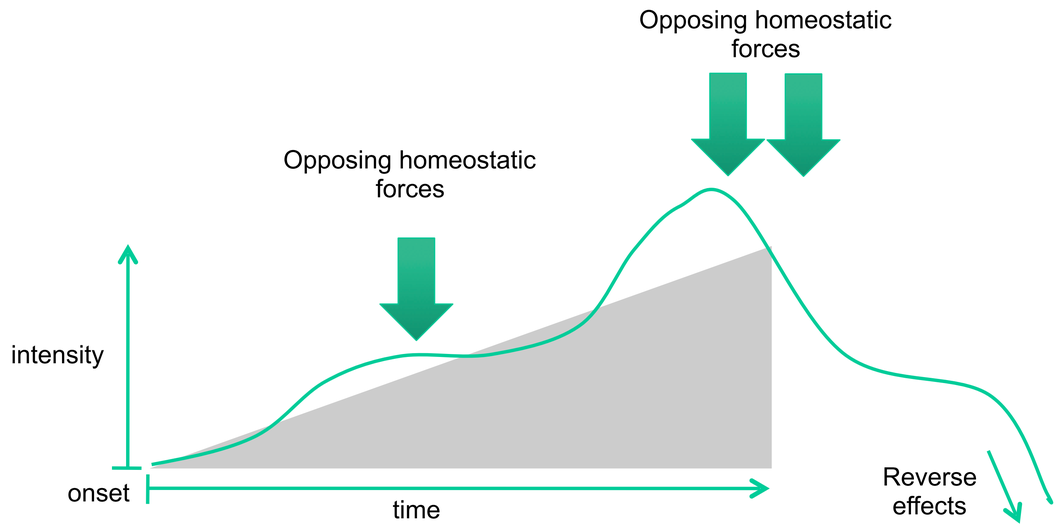


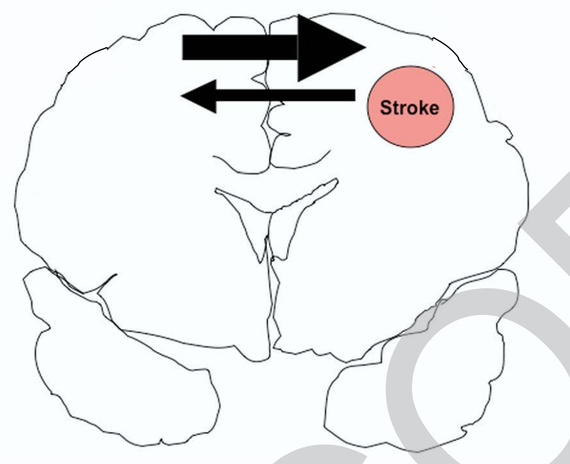
Courtesy StarLab

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

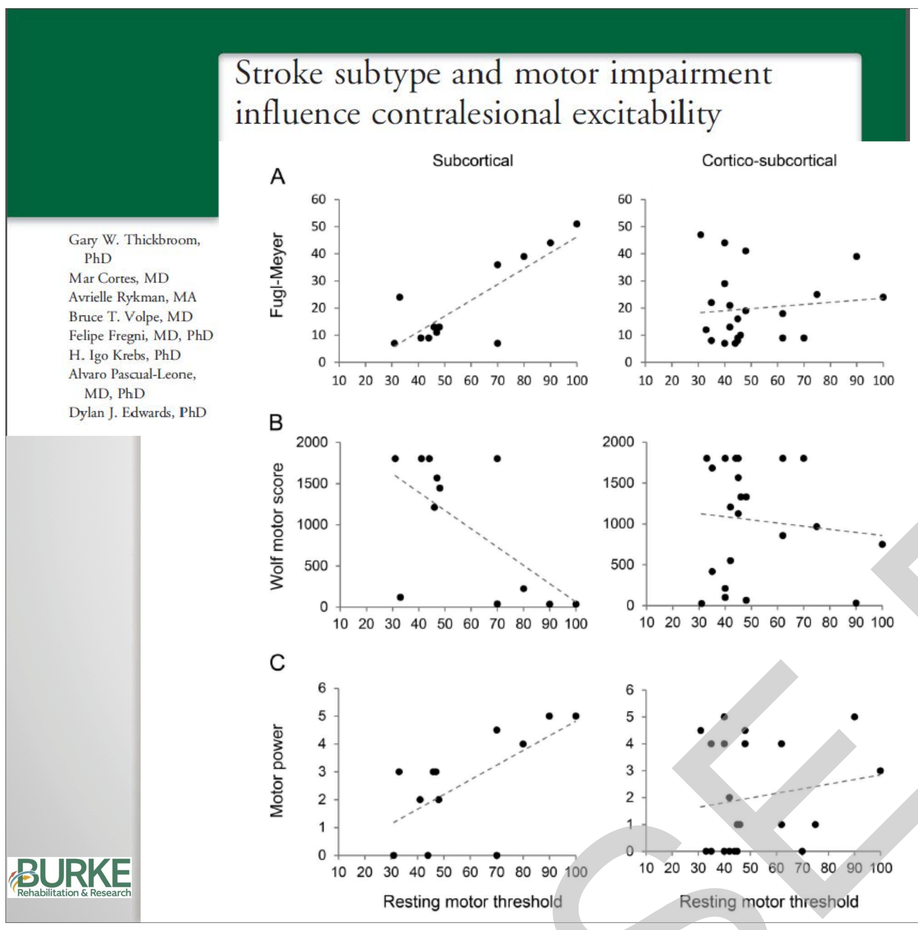
Note: Theoretical

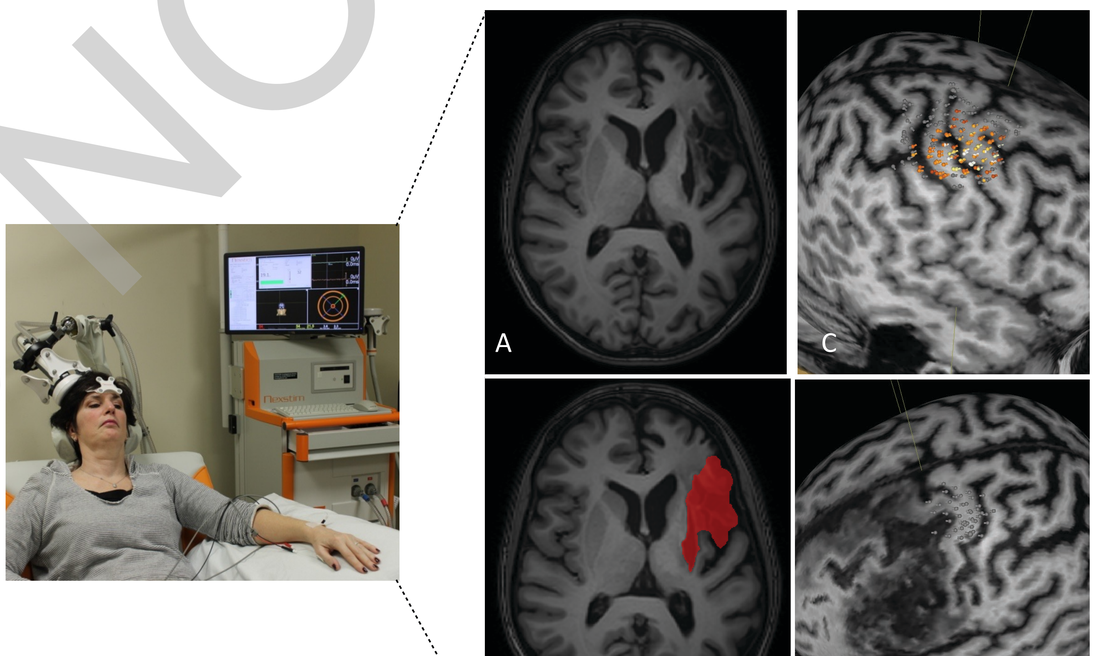






Webster et al (2006)

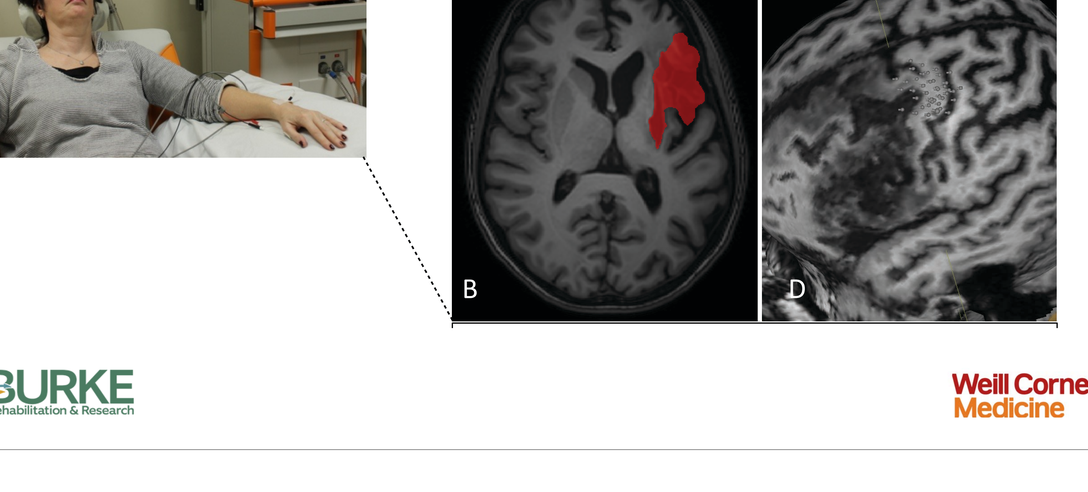




NeuroMeasure: a software package for quantification of cortical motor maps using frameless stereotaxic transcranial magnetic stimulation

Michael B. Gerber[1*], Alasdair C. McLean[1], Samuel J. Stephen[1], Alex G. Chalco[1], Usman M. Arshad[1], Gary Thickbroom[2], Josh Silverstein[3, 4, 5, 2], Zoe Tsagaris[3, 2], Amy Kuceyeski[6], Kathleen Friel[3, 4, 5, 2], Taiza E. Santos[7], Dylan J. Edwards[8, 9, 7*]

** Gerber et al, 2019*



https://github.com/EdwardsLabNeuroSci/NeuroMeasure