tDCS – current state and perspectives

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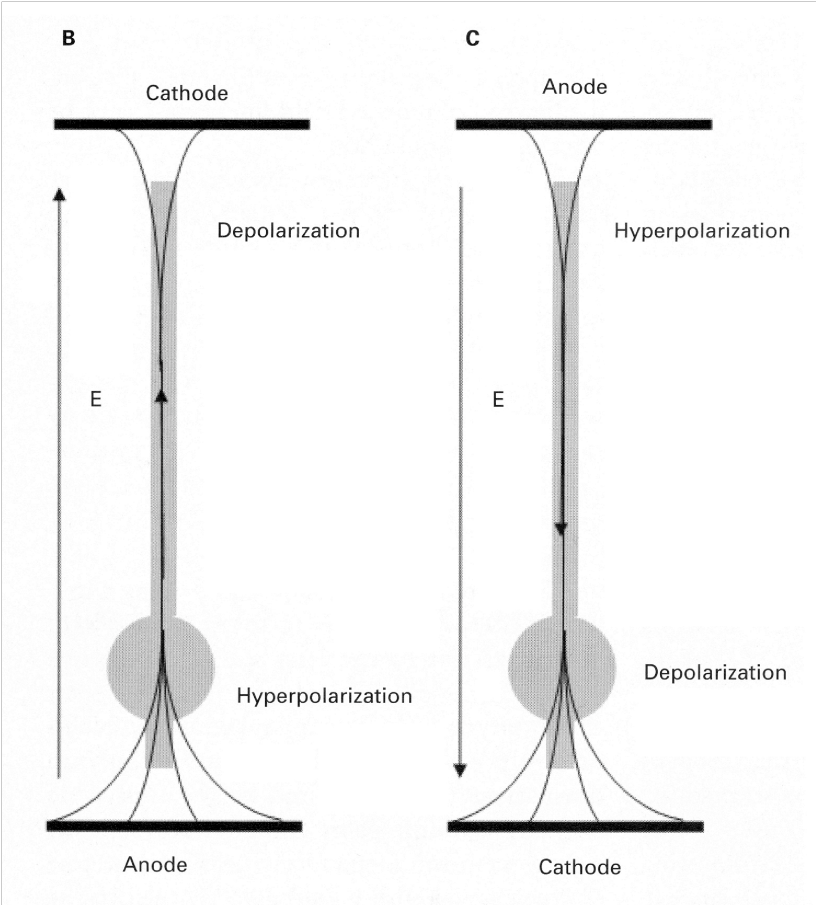
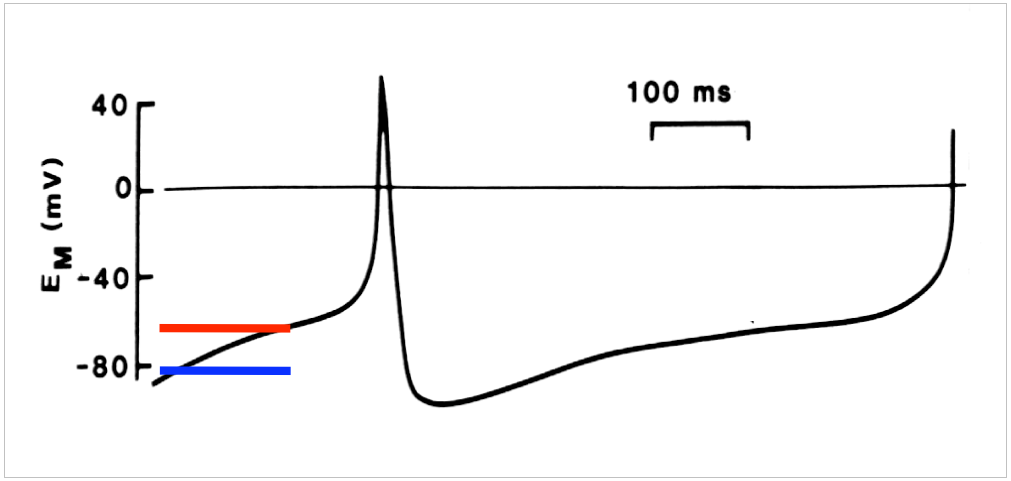
Principal action of DC-stimulation: modulation of resting membrane potential



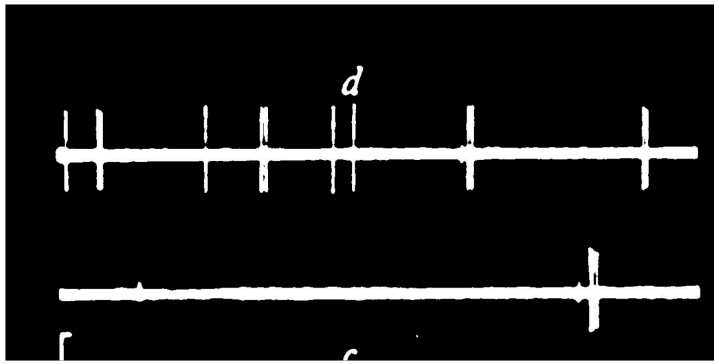


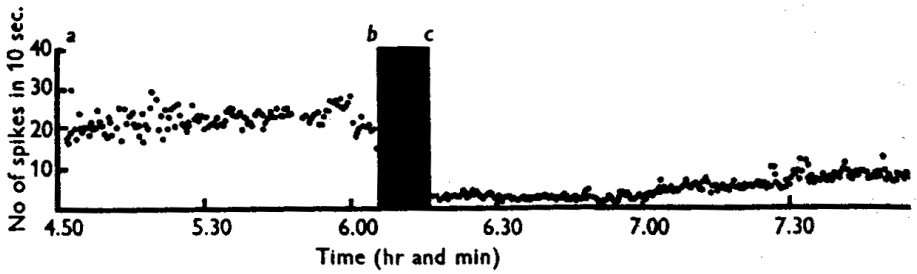
Cortical DC-stimulation of the rat

during

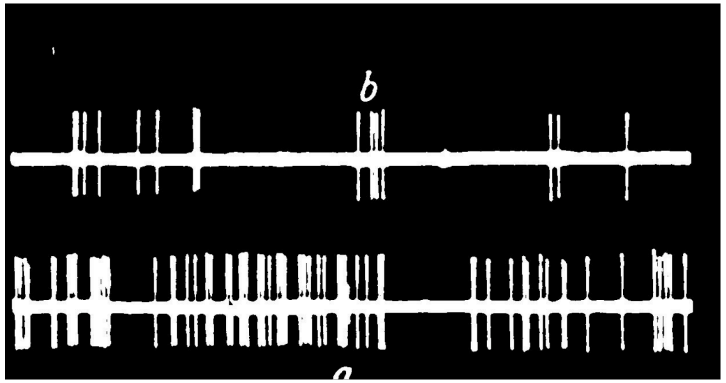
after

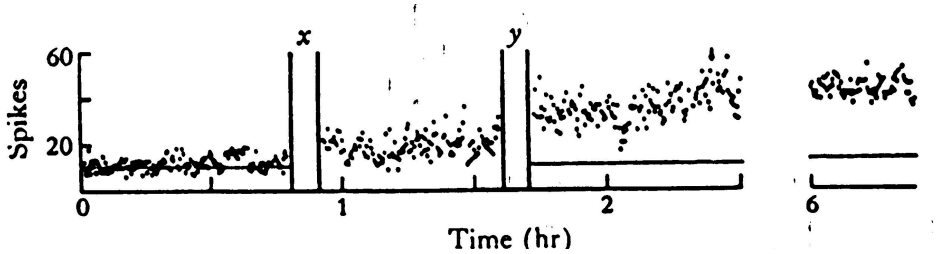
cathodal





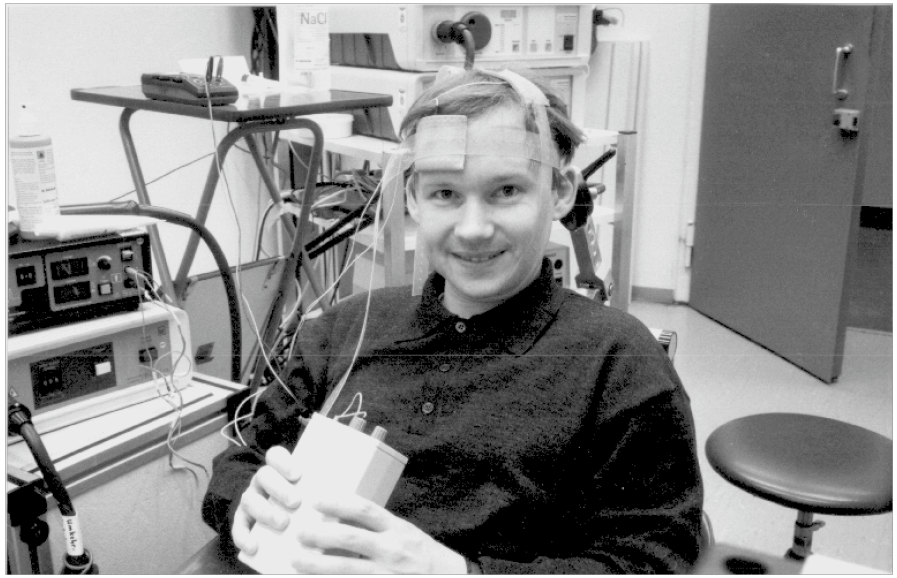
anodal

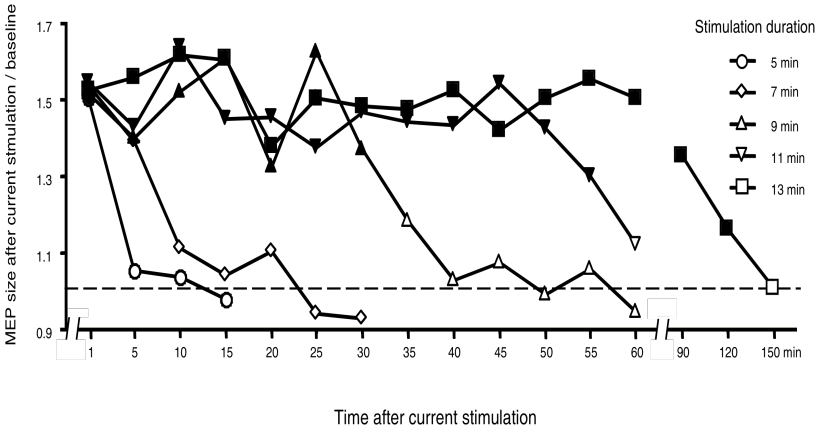


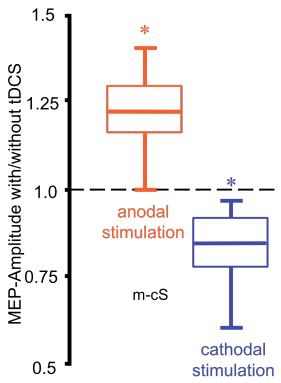


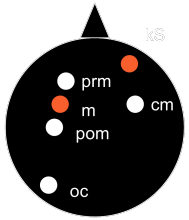
Bindman et al. 1964

Neuroplasticity induced in humans – transcranial direct current stimulation (tDCS)



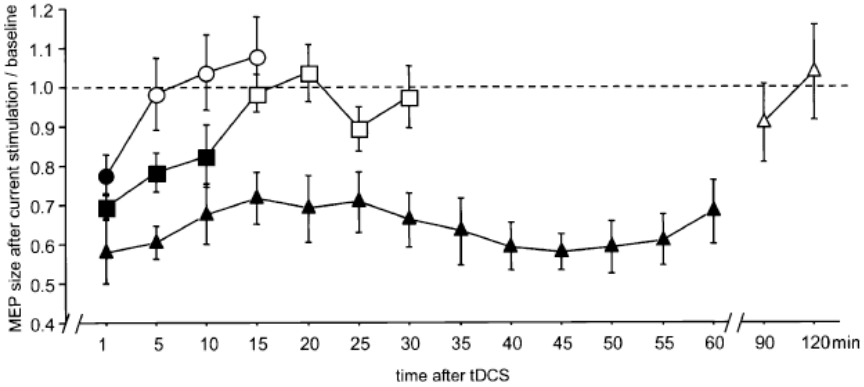






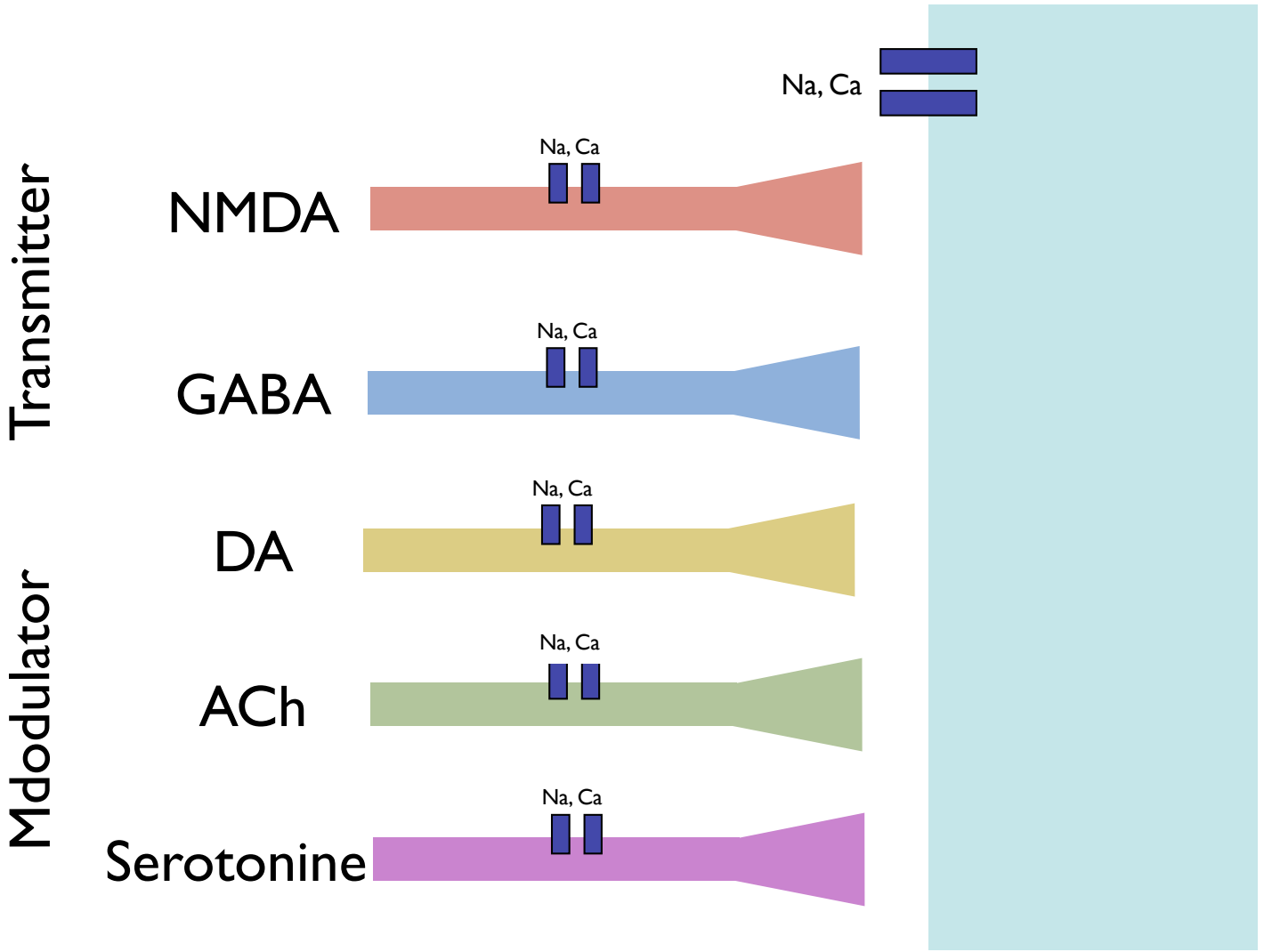
Electrode positions:

m = motor cortex; prm = premotor cortex; pom = post-motor cortex; oc = occipital; cS = contralateral forehead; cm = kontralateral motor cortex

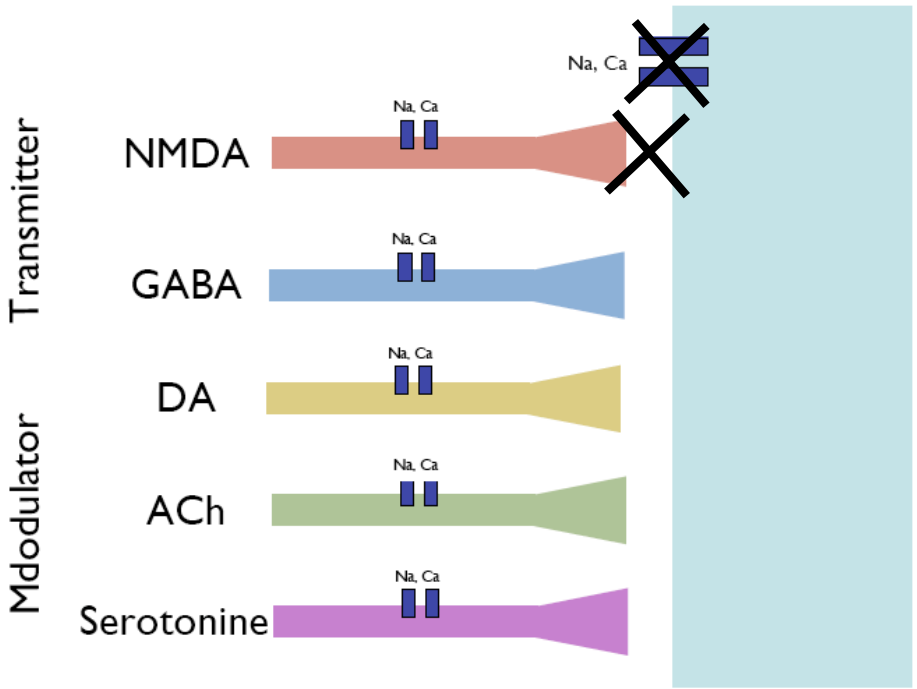


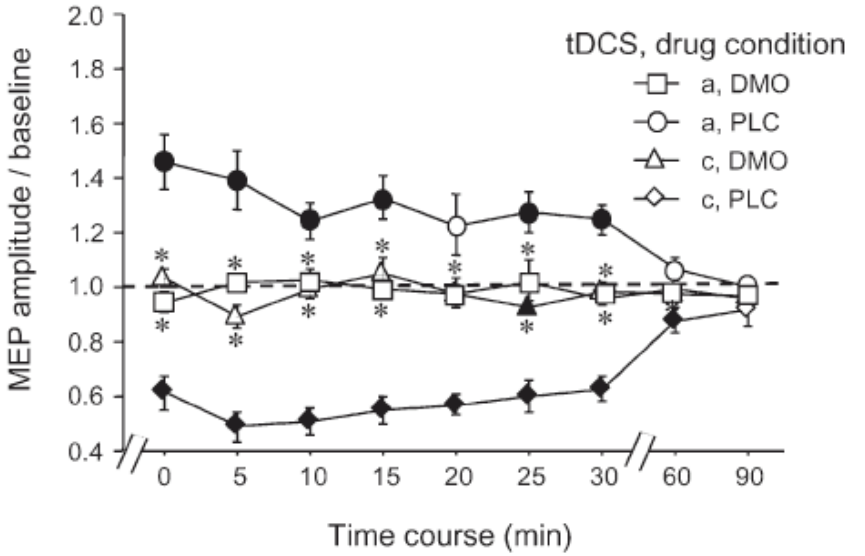
Nitsche & Paulus J Physiol 2000, Neurology 2001, Nitsche et al. Clin Neurophysiol 2003

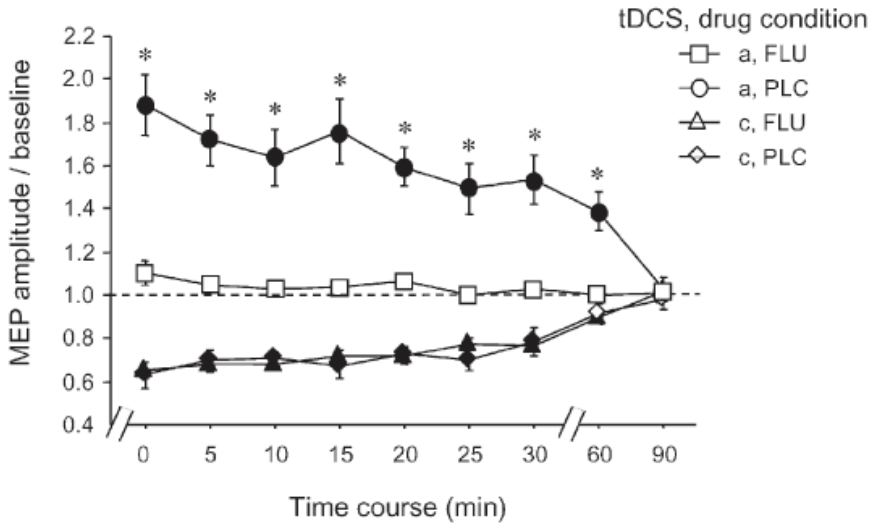
Mechanisms of action - pharmacological perspective



Pharmacological *dependence* of after-effects of tDCS

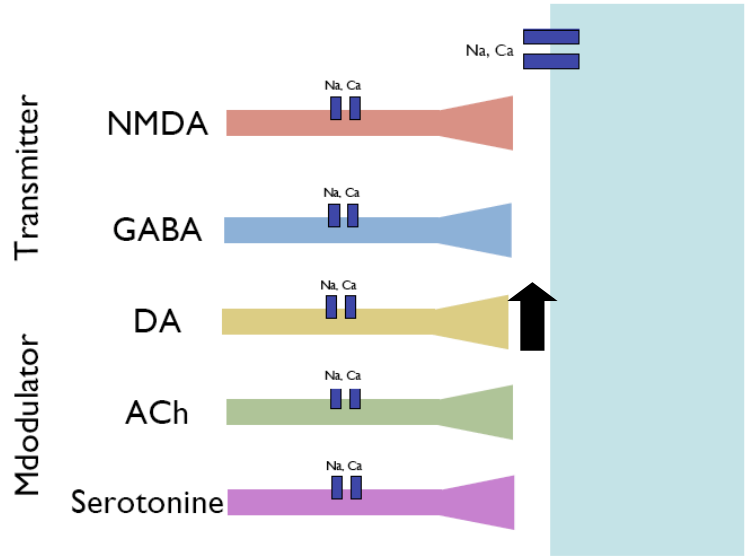


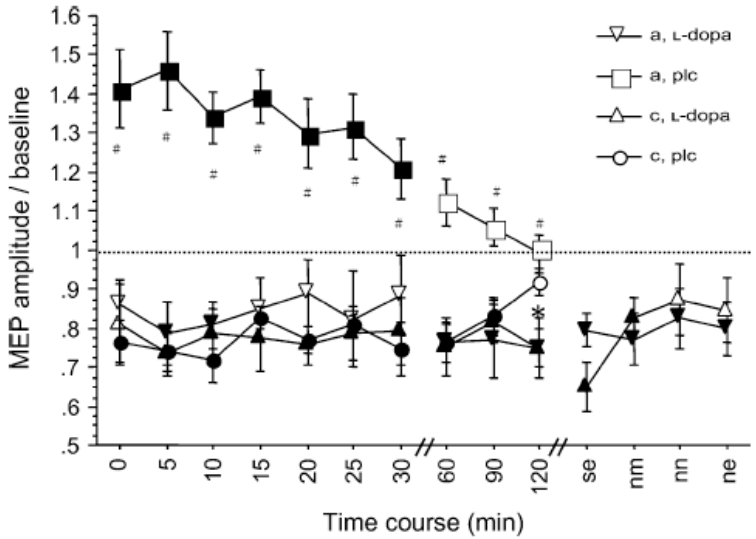


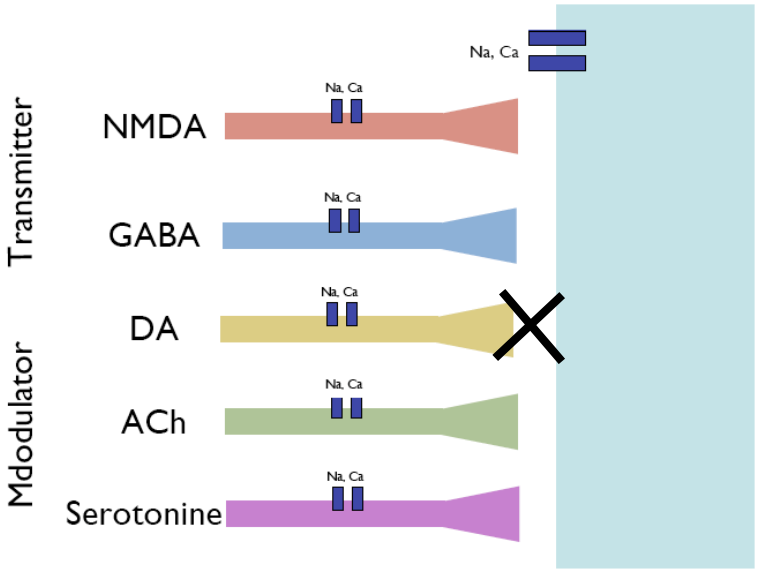


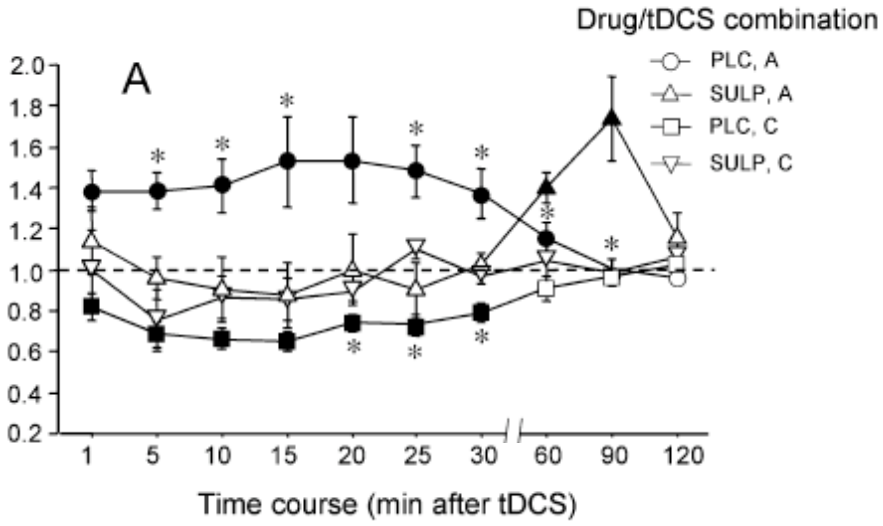
Nitsche et al. 2003

Pharmacological *modulation* of after-effects



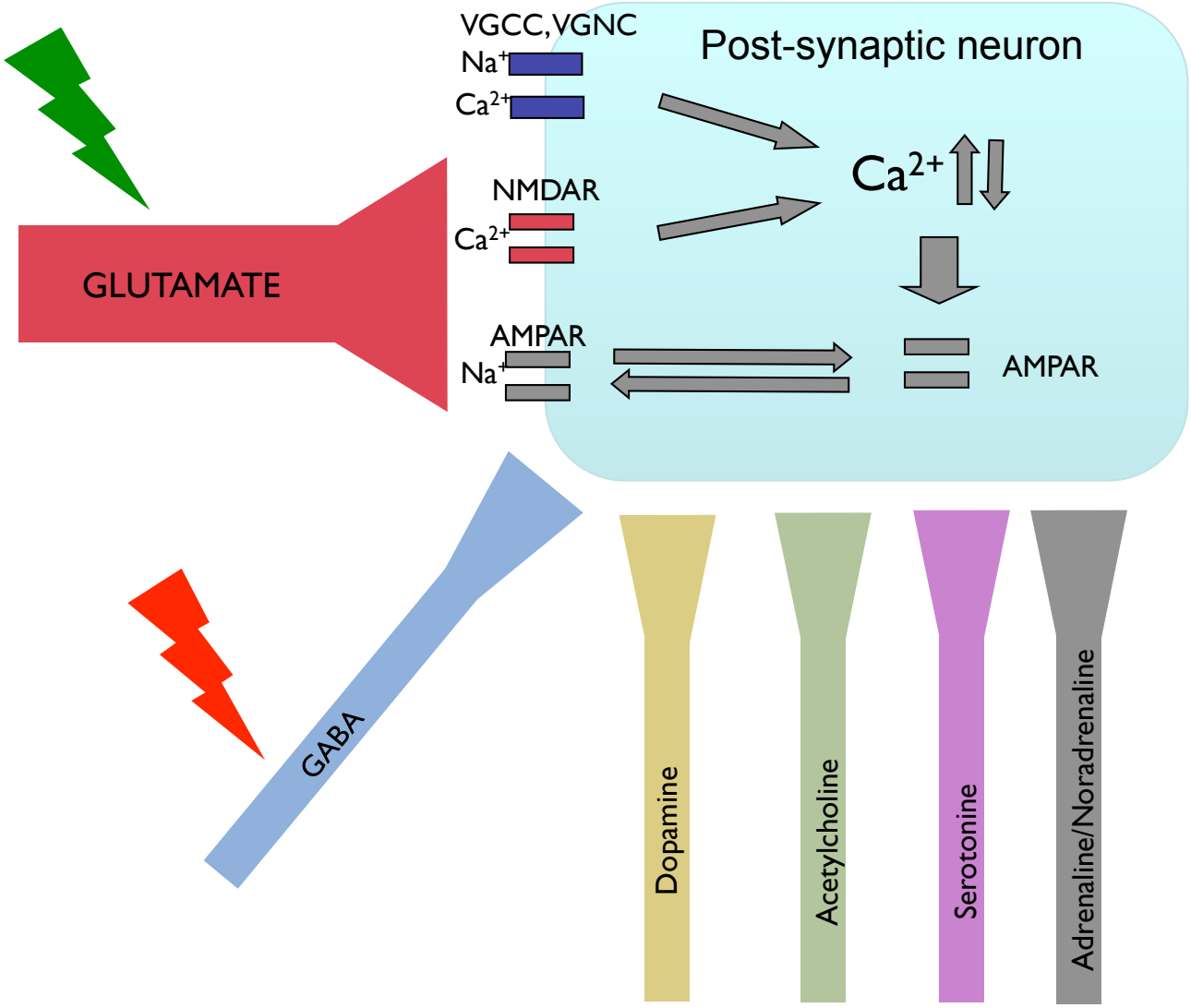






Nitsche et al. 2006, Kuo et al. 2008

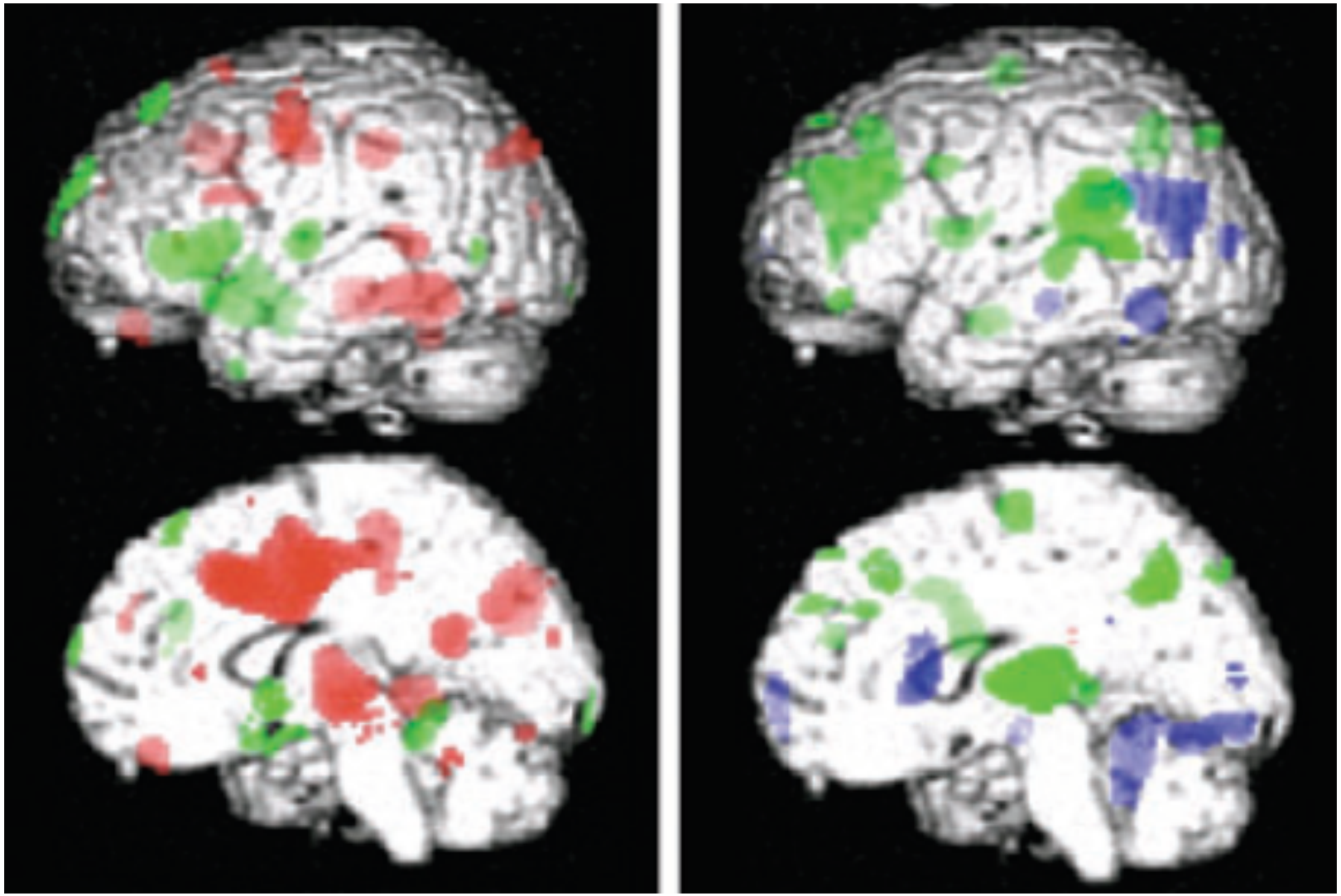
Conclusion I



Are the effects regionally restricted?

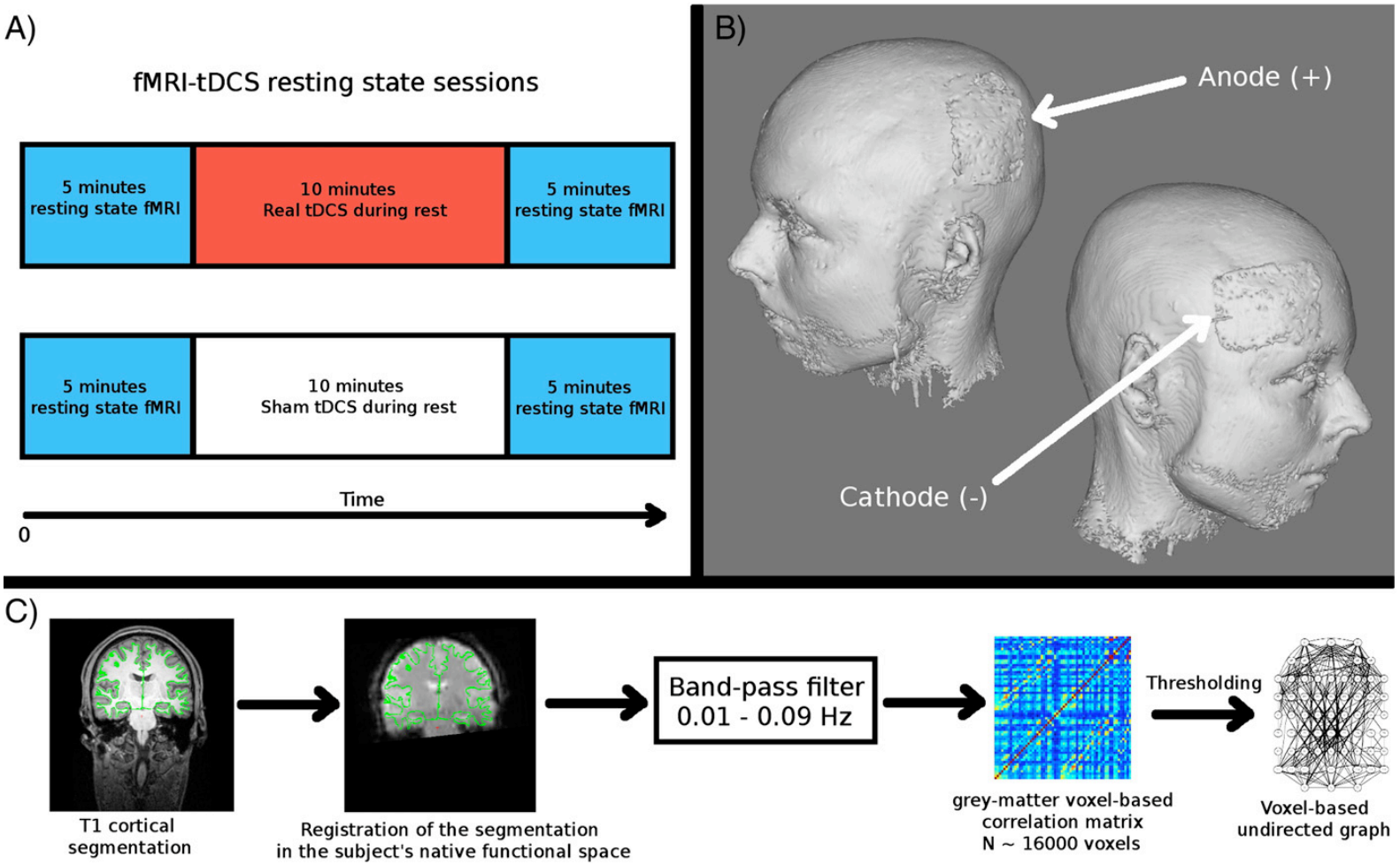
anodal

cathodal



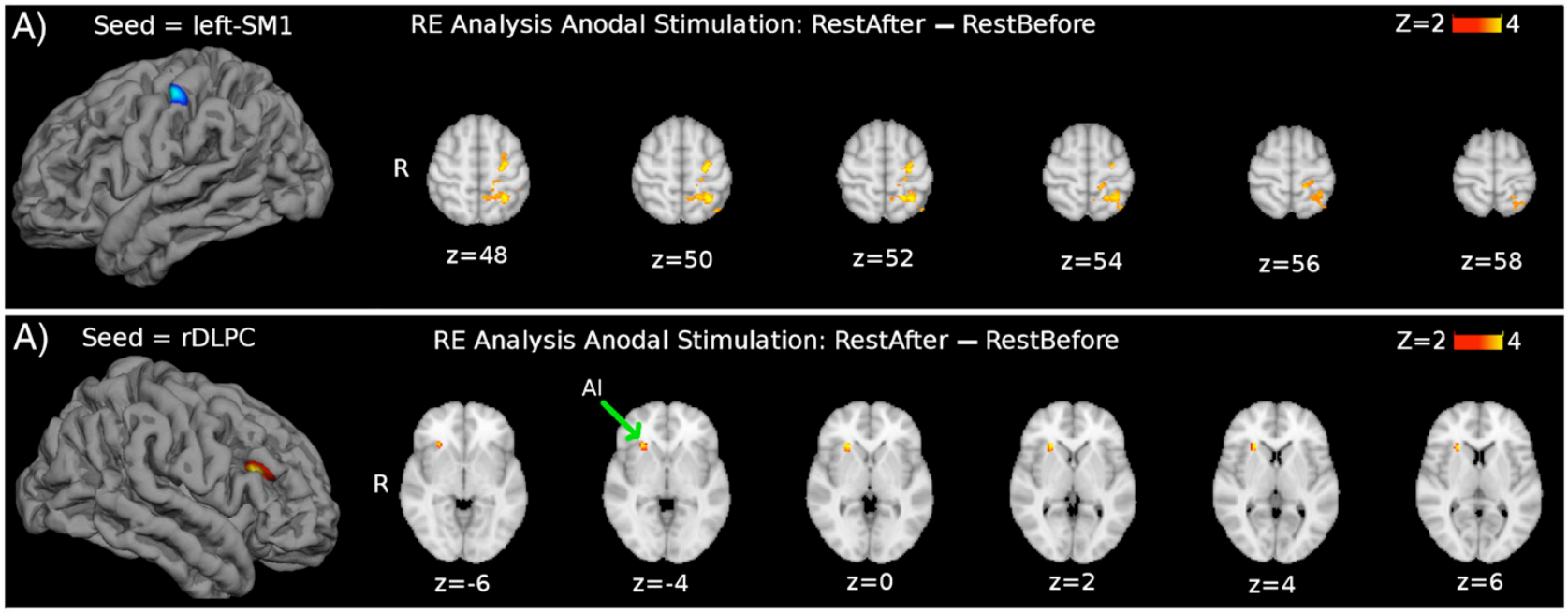
Lang et al. 2005

tDCS-induced functional connectivity alterations in motor-related networks - fMRI



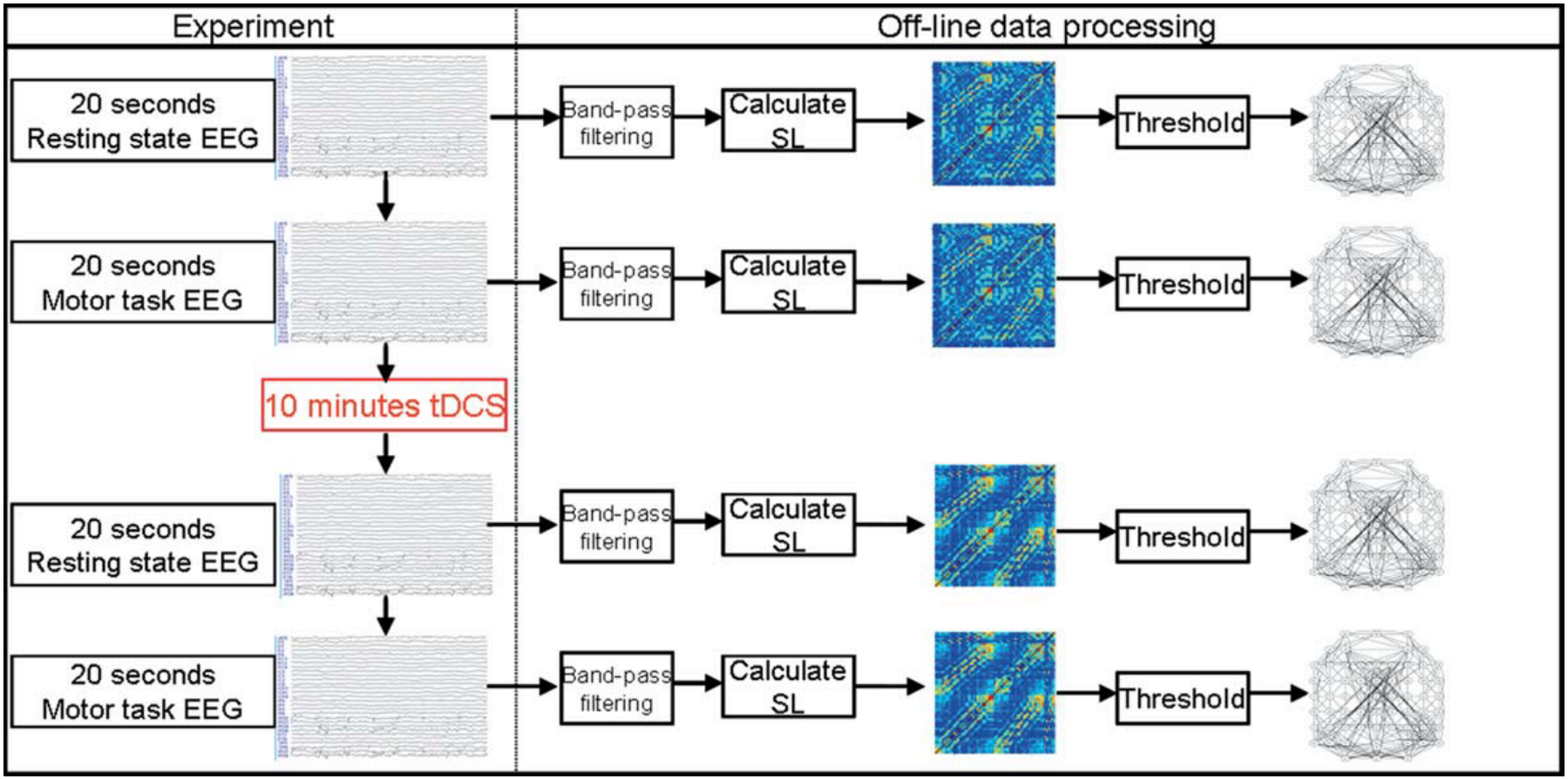
Polania et al. 2011a

tDCS-induced functional connectivity alterations in motor-related networks - fMRI



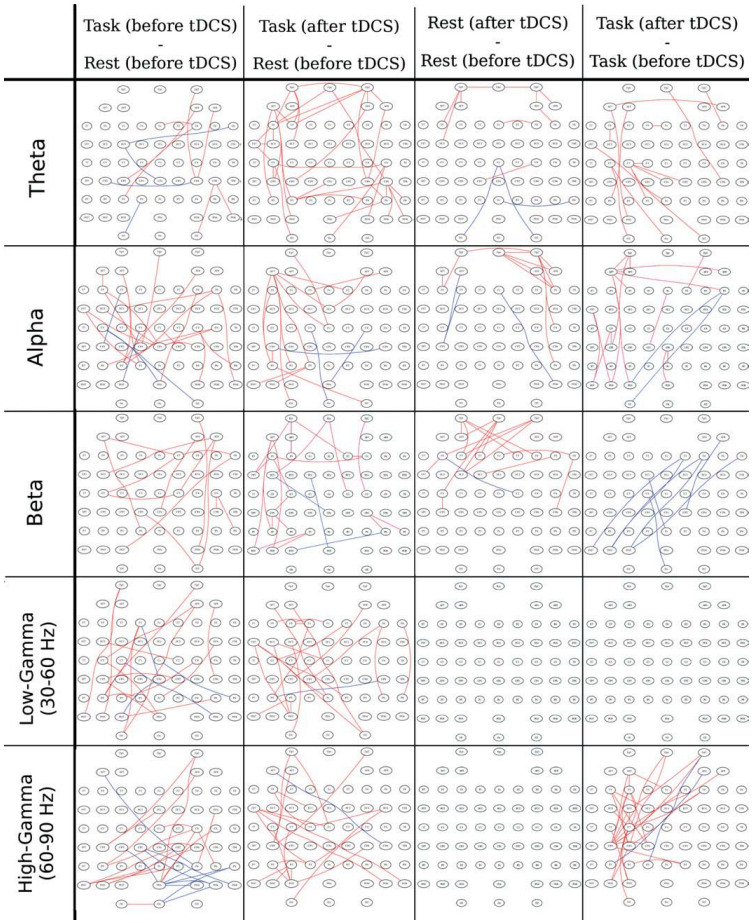
Polania et al. 2011a

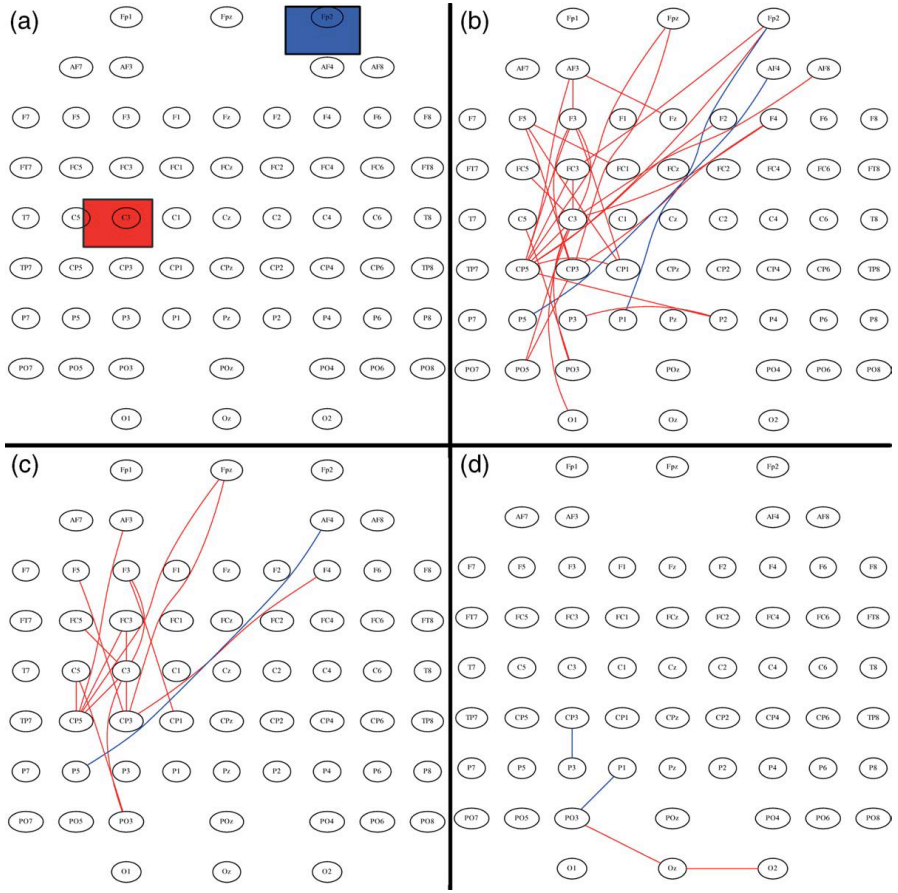
tDCS-induced functional connectivity alterations of motor cortical networks - EEG



Polania et al. 2011b

tDCS-induced functional connectivity alterations of motor cortical networks - EEG





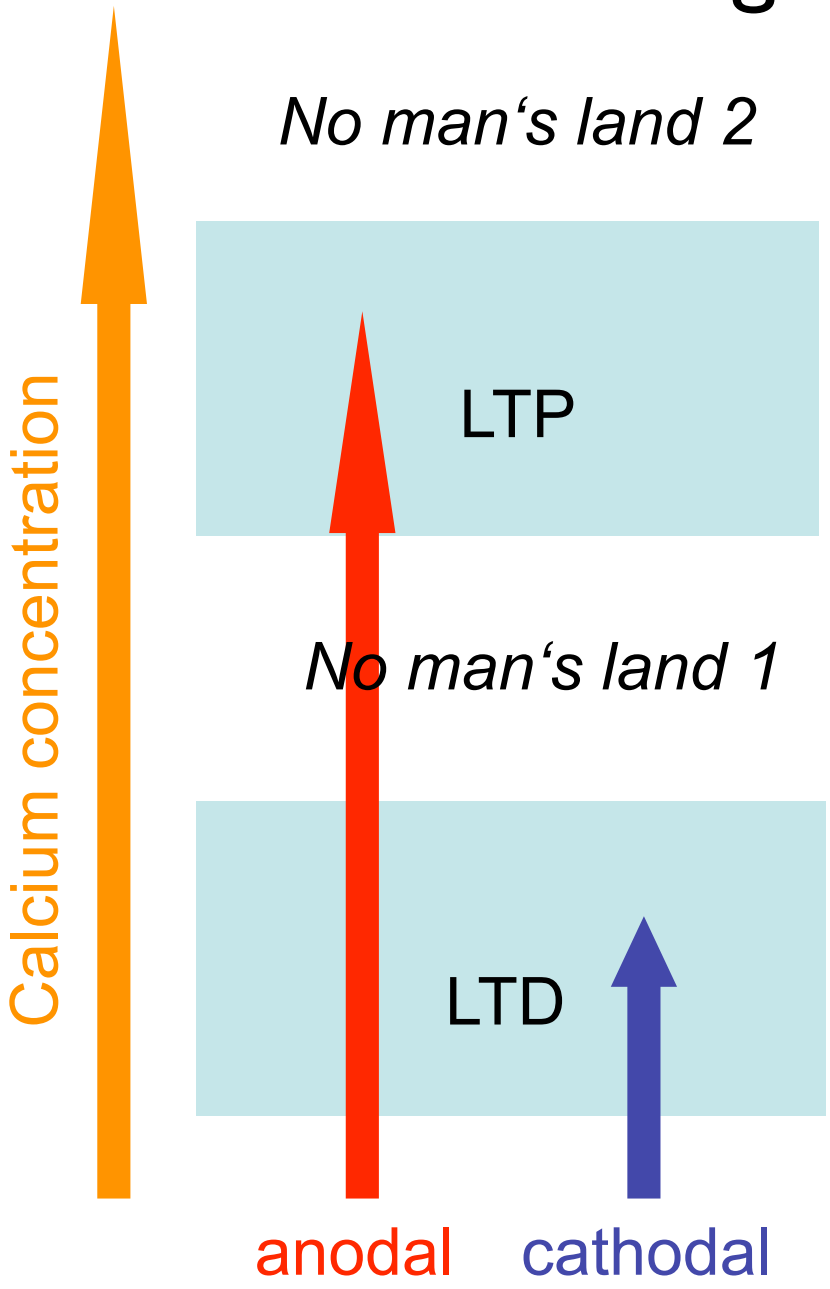
Polania et al. 2011b

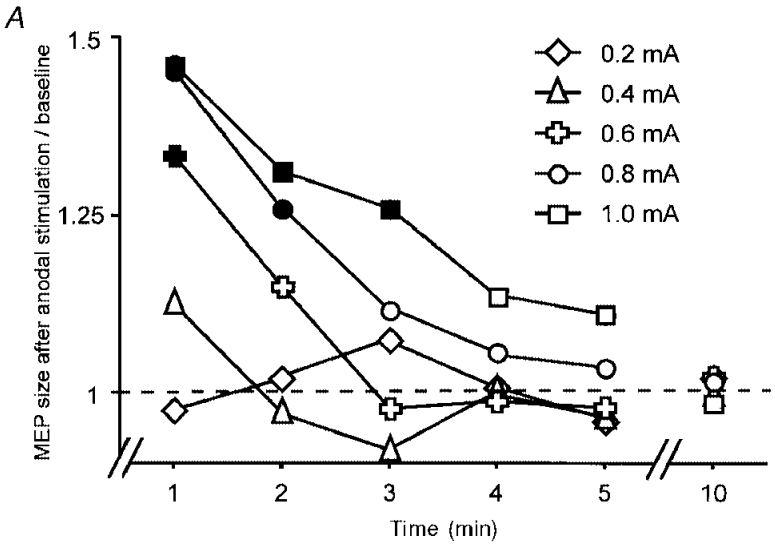
Conclusion II

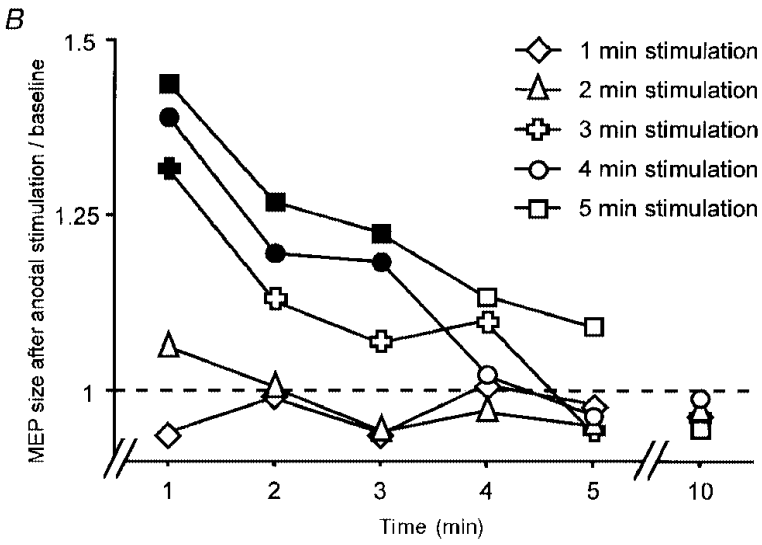
- tDCS is well suited to model plasticity in the human brain
- Regional effects on cortical excitability
- Connectional effects on functional networks

- Relatively short-lasting effects
- Relatively non-focal effects

Enhancing efficacy of tDCS I

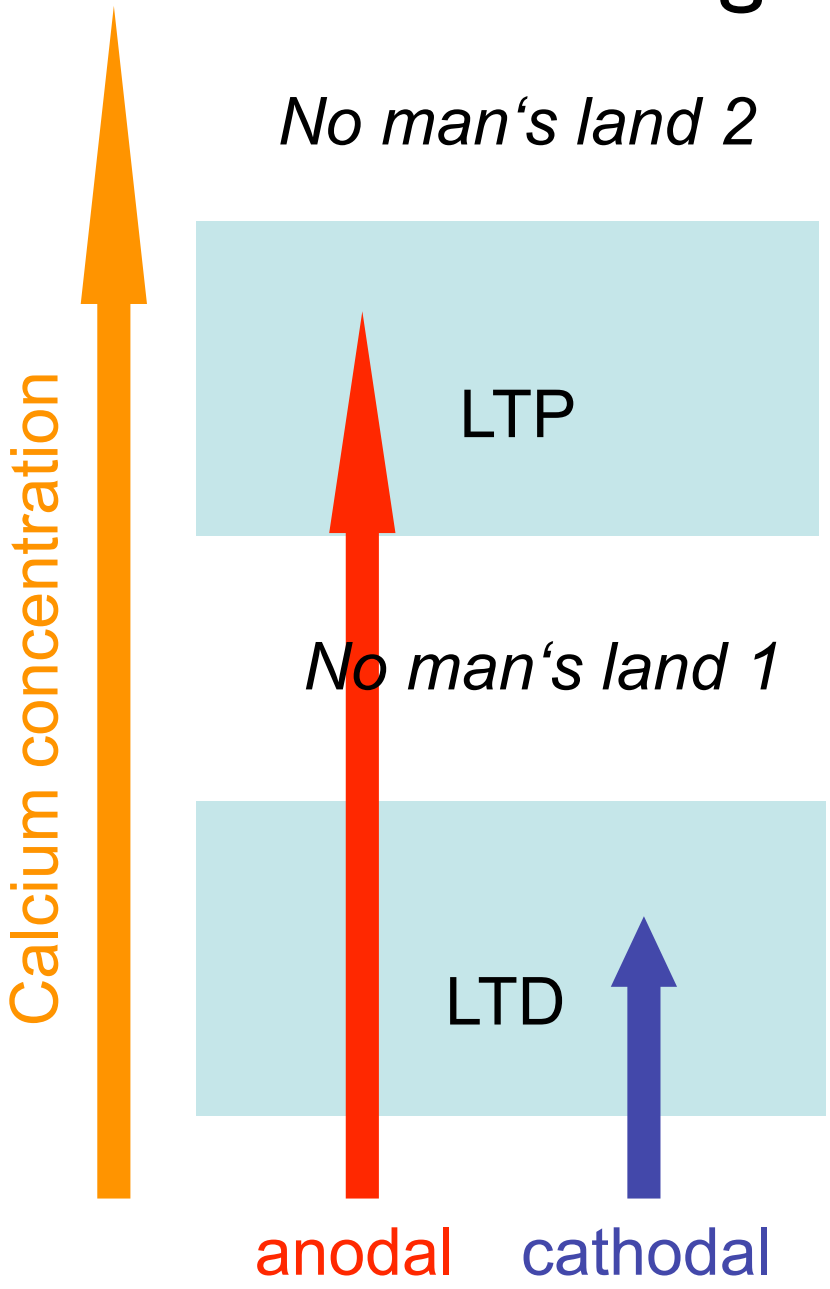


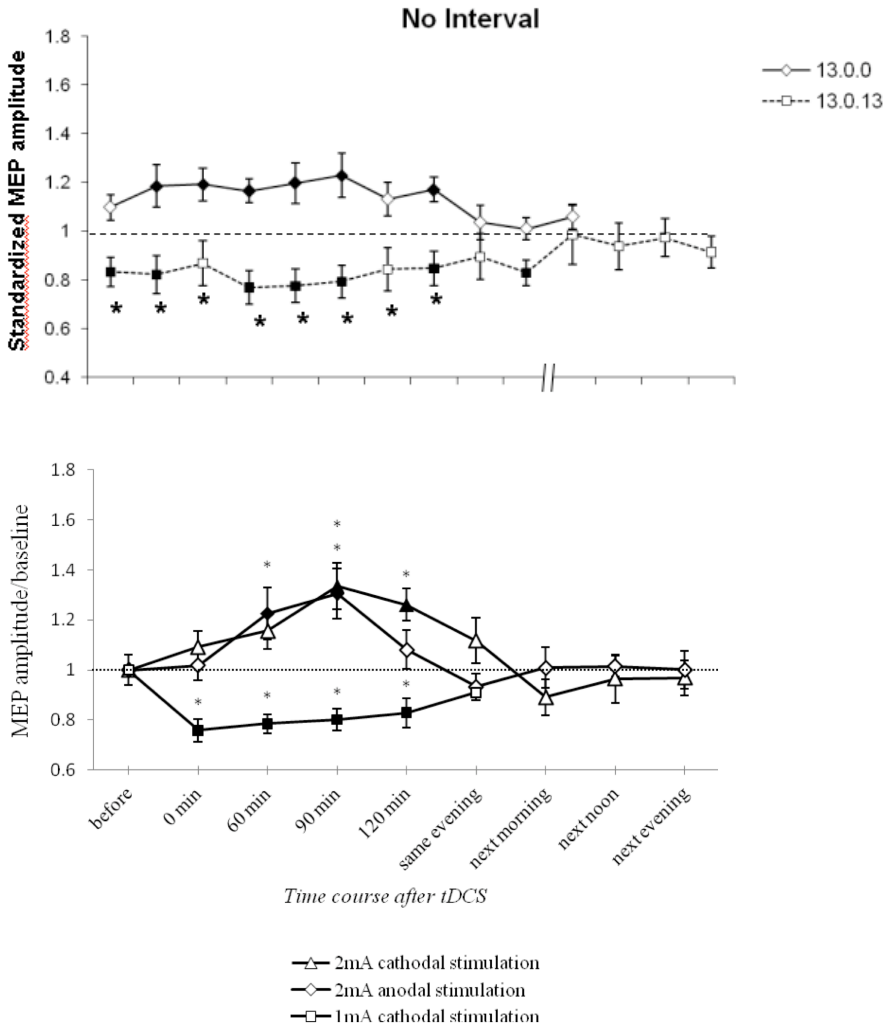




Lisman 2001, Nitsche & Paulus 2000

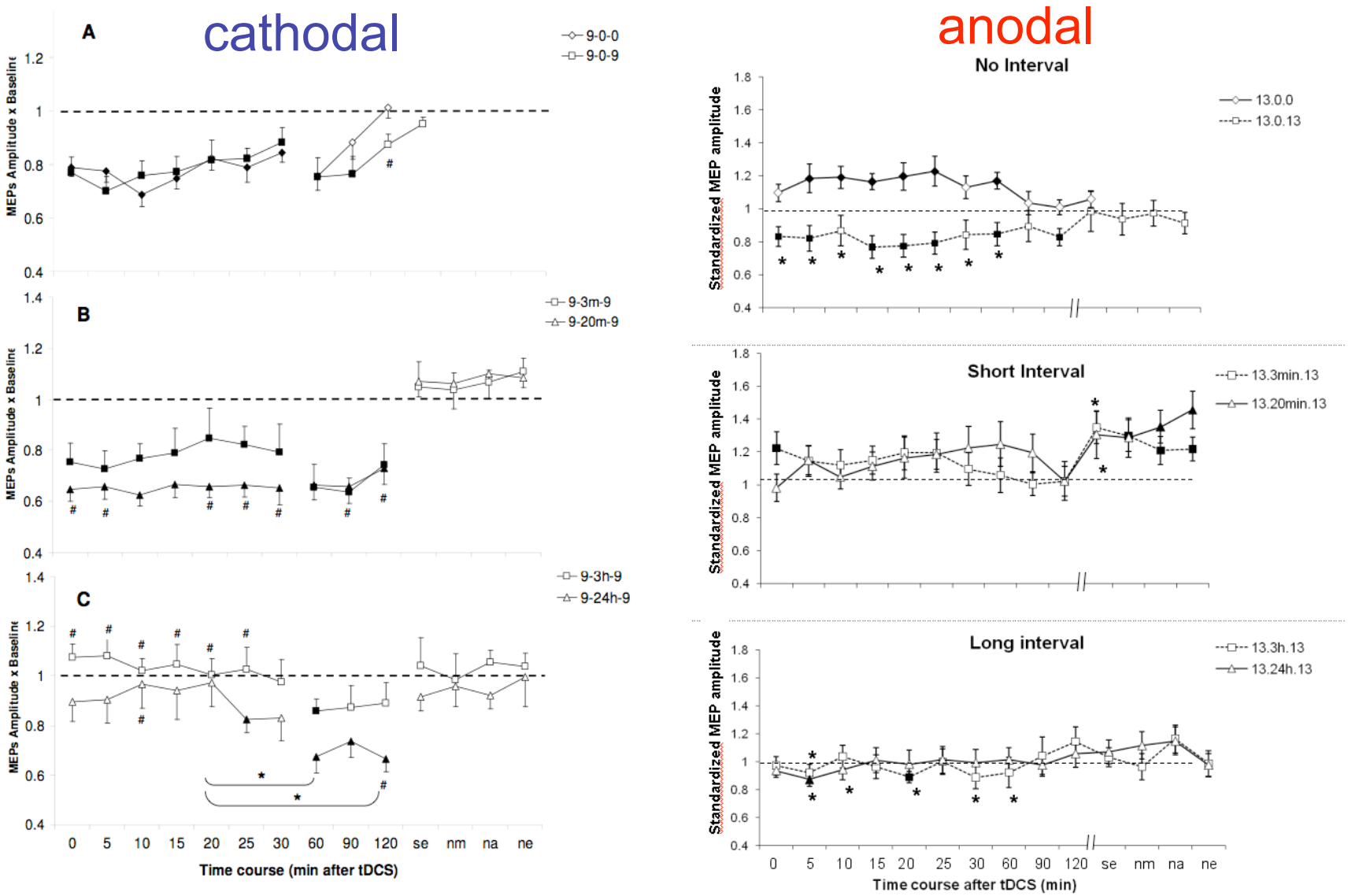
Enhancing efficacy of tDCS II





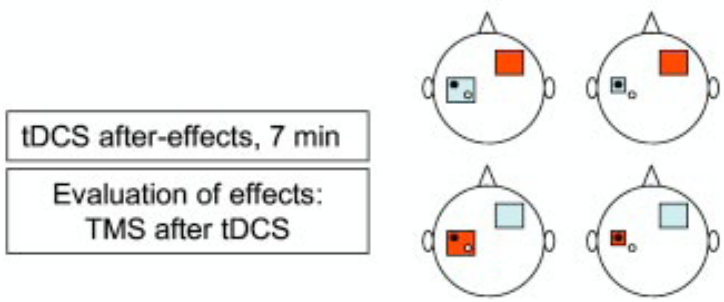
Batsikadze et al. 2013, Monte-Silva et al. 2013

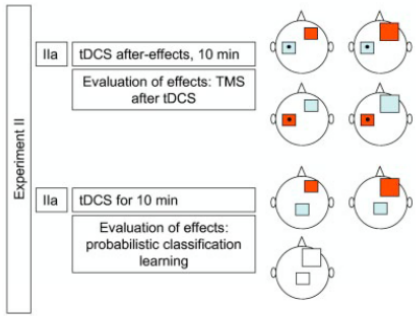
Enhancing efficacy of tDCS III

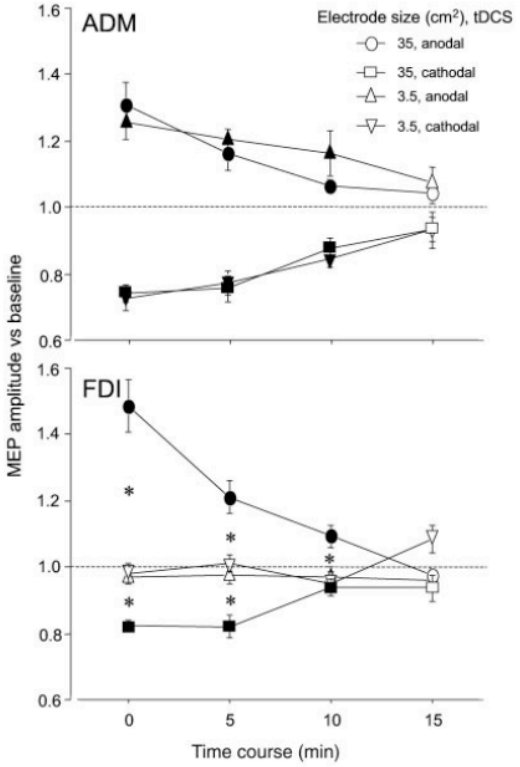


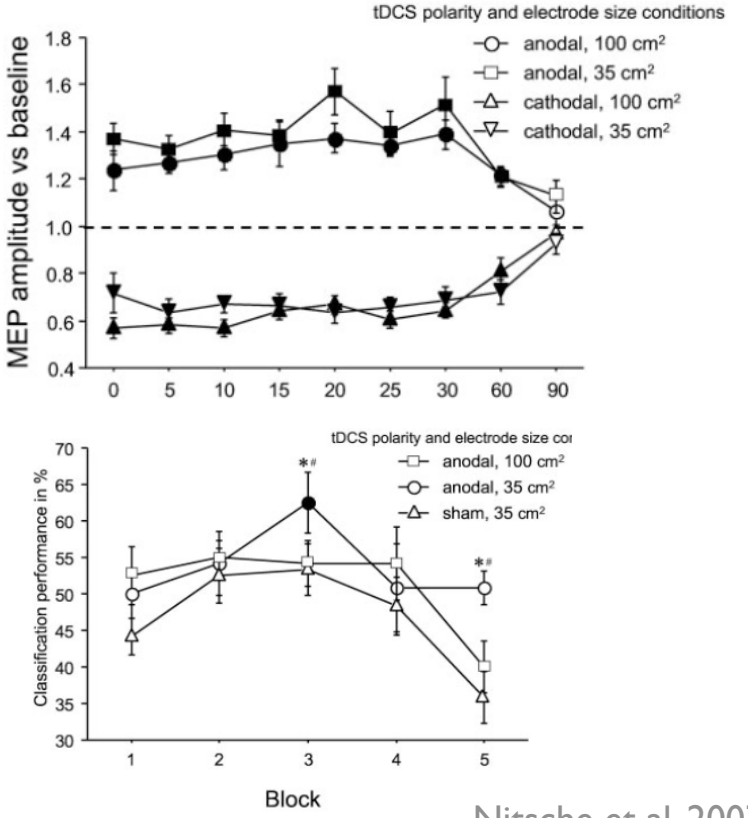
Monte-Silva et al. 2010, 2013

Increasing focality of tDCS I



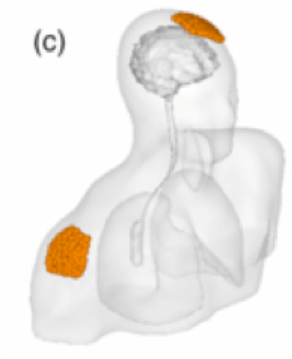






Nitsche et al. 2007

Increasing focality of tDCS II



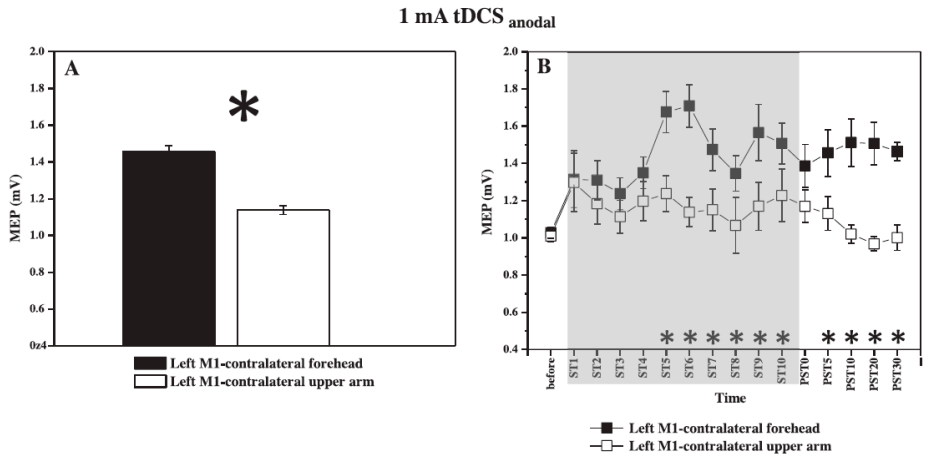
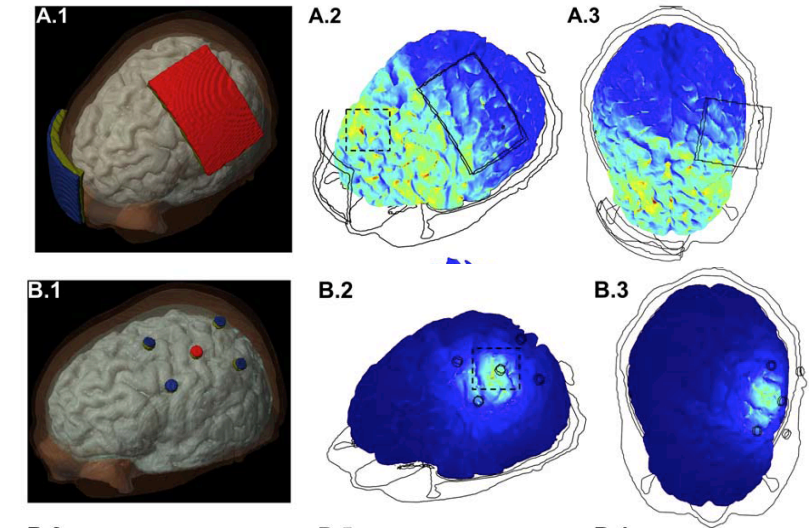
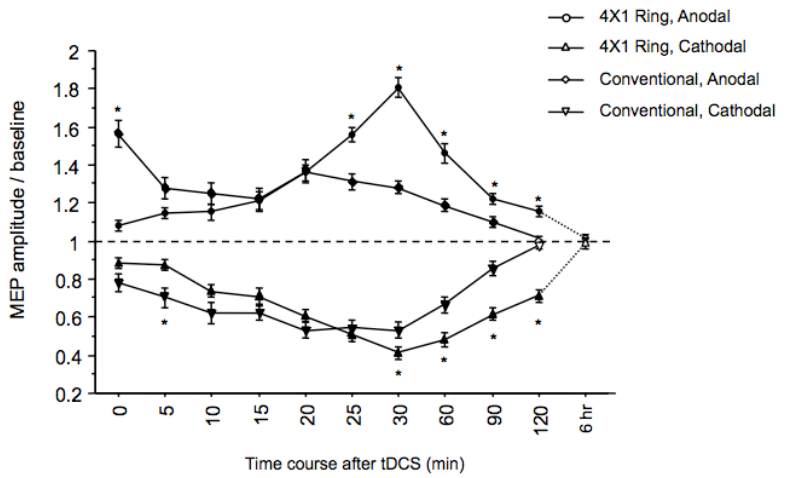


Fig. 1. *Left M1 – contralateral forehead vs. Left M1 – contralateral upper arm.* (A) Comparison of the 1 mA $tDCS_{anodal}$ induced effects on cortical excitability using the *Left M1 – contralateral forehead vs. Left M1 – contralateral upper arm* electrode montage. The bar graph shows the mean MEP value from ST1 to PST30, averaged over 9 subjects. Error bars indicate standard errors. An asterisk indicates $P < 0.05$. (B) The figure shows mean amplitudes of MEPs and their SEMs during 10 min of stimulation and up to 30 min after stimulation (9 subjects). Significantly increased MEPs were observed in Left M1- contralateral forehead montage at the ST5-ST10 and PST5-PST30 time points compared to the corresponding time points using the *Left M1 – contralateral upper arm montage* ($P < 0.05$).





Kuo et al. 2012, Moliadze et al. 2010

Conclusion III

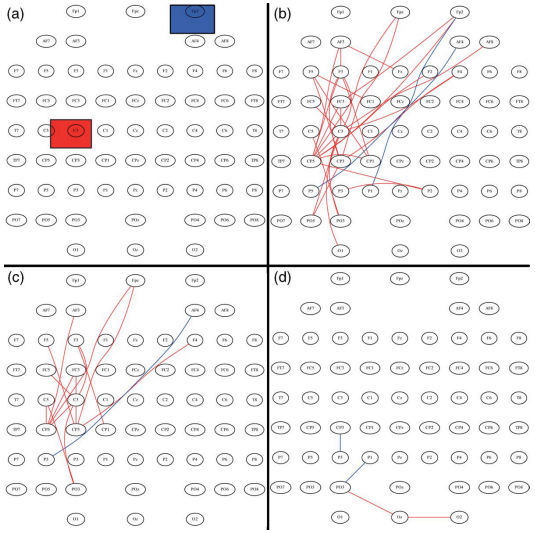
- effect size, and focality of tDCS can be improved

- Simple prolongation/enhancing of stimulation intensity might not be sufficient
- Non-linear effects might emerge
- Specific repetition intervals might be superior

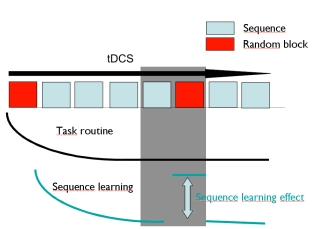
- Focality of tDCS can be improved by
- reducing size of the target electrode
- enhancing size or remote position of return electrode
- new electrode arrangements (e.g. „HD-tDCS“?)

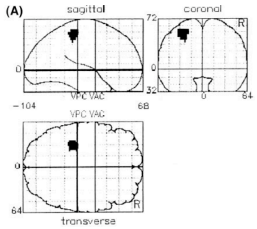
General remarks – to what end?

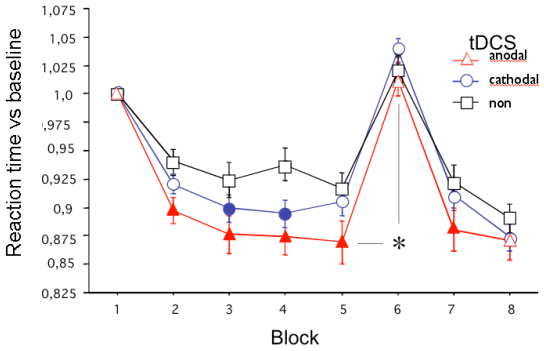
Physiology of plasticity



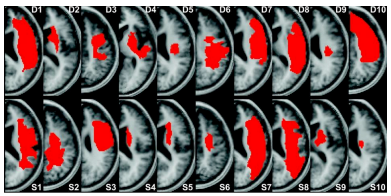
Physiology of cognition

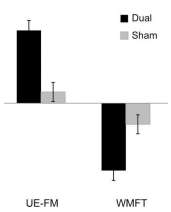


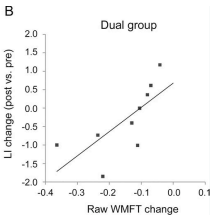


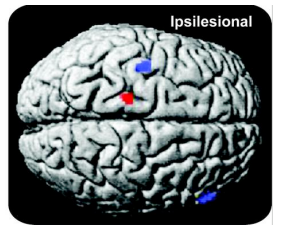


Clinical application









Lindenberg et al. 2010, Nitsche et al. 2003, Polania et al. 2011


BS|ENERGY
Starkstrom im Stadion
BS|ENERGY
Starkstrom im Stadion
BS|ENERGY
YOU CAME TO THE WRONG NEIGHBOURHOOD