

Transcranial electrical stimulation as tool to interfere with cognitive functions: shifting excitability and shaping oscillations.

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Physiological correlates of psychological and behavioural processes

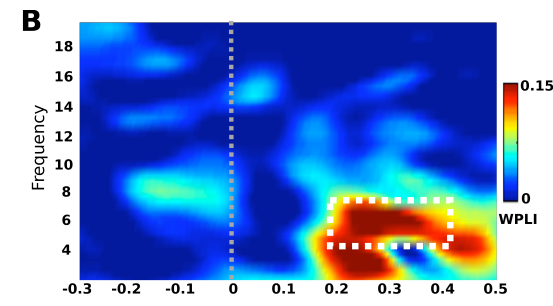
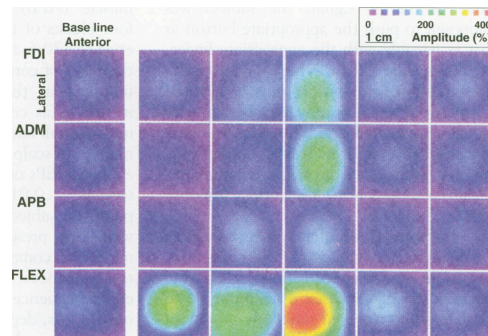
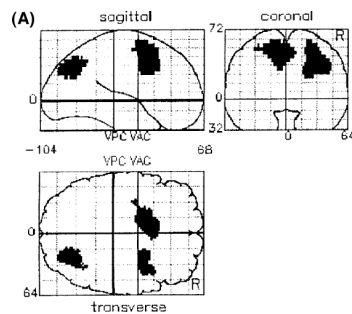
Stimuli

- visual
- auditory
- somatosensible
- gustatory
- olfactory
- vegetative

perception

behaviour

cognition, emotion, motivation



Induction of cortical excitability and activity alterations in humans

Plasticity

rTMS



PAS

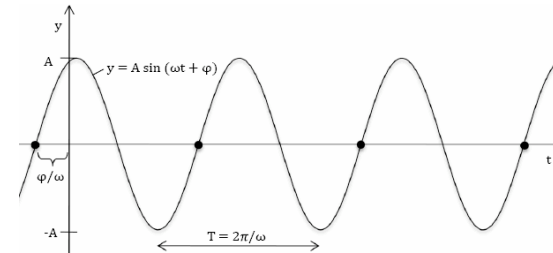


tDCS

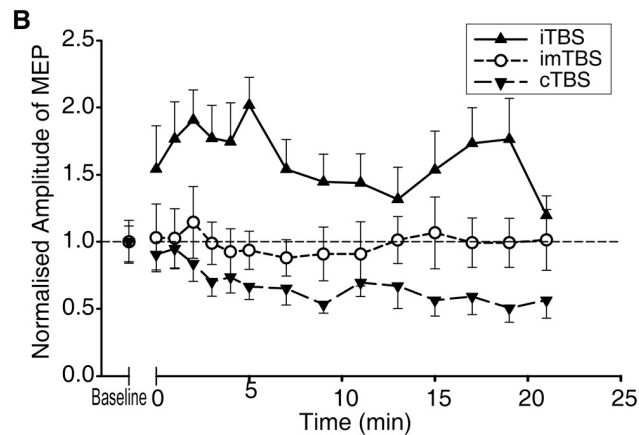
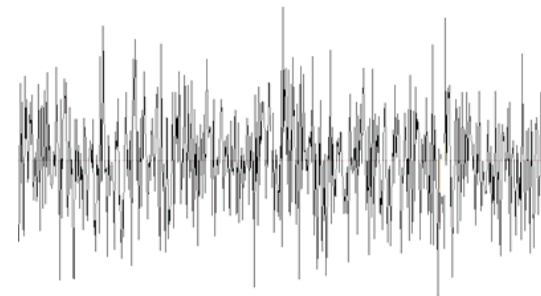


Oscillations

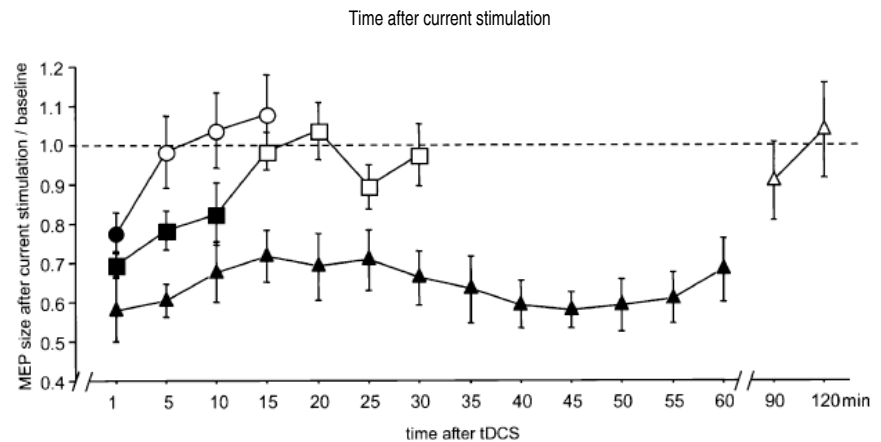
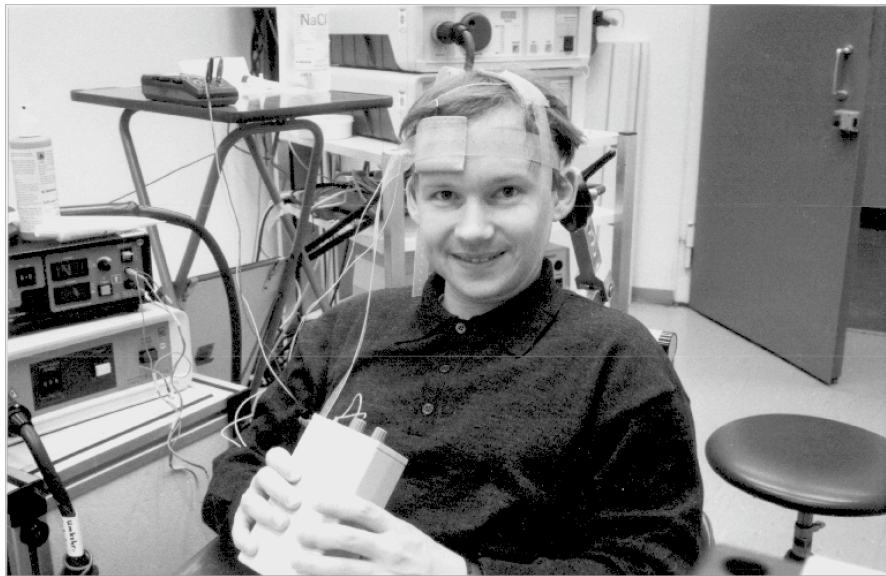
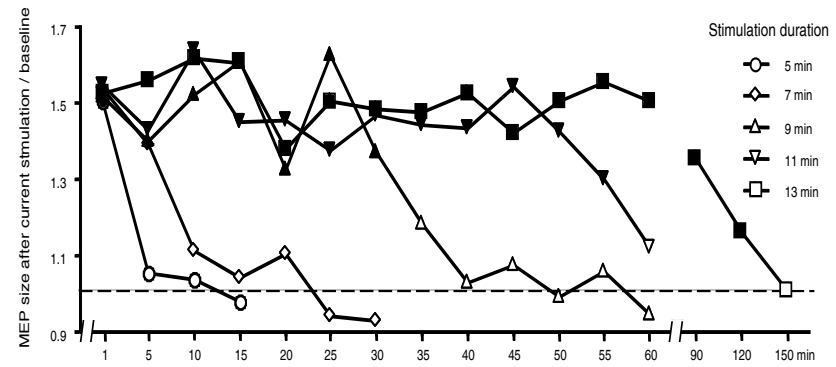
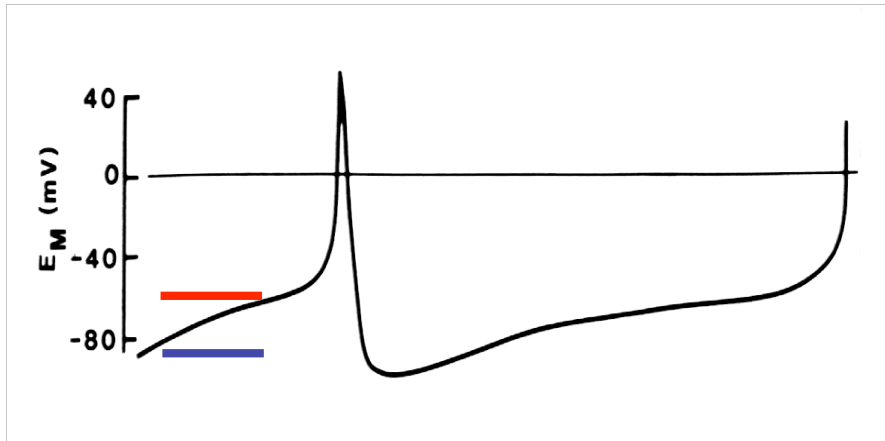
tACS



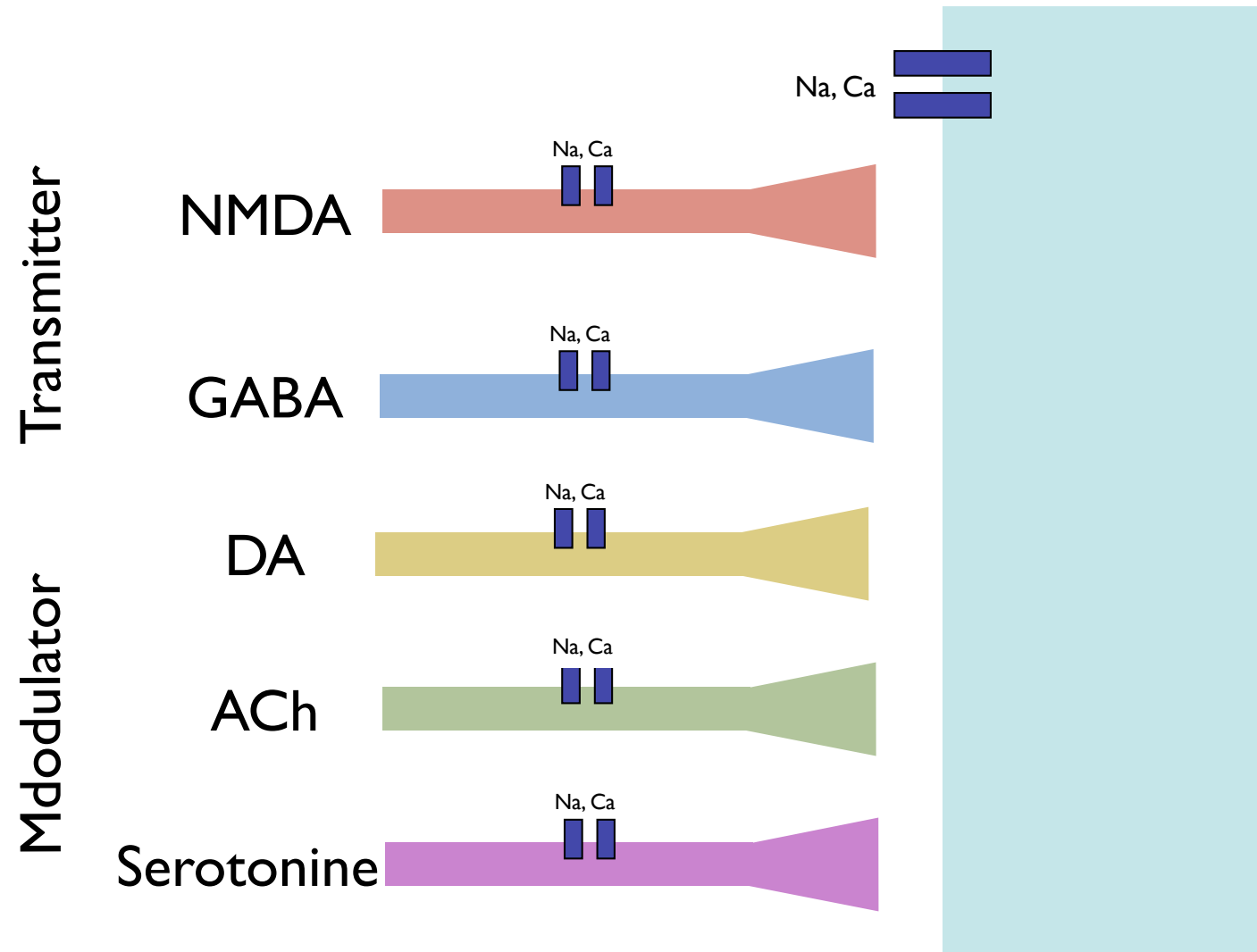
tRNS



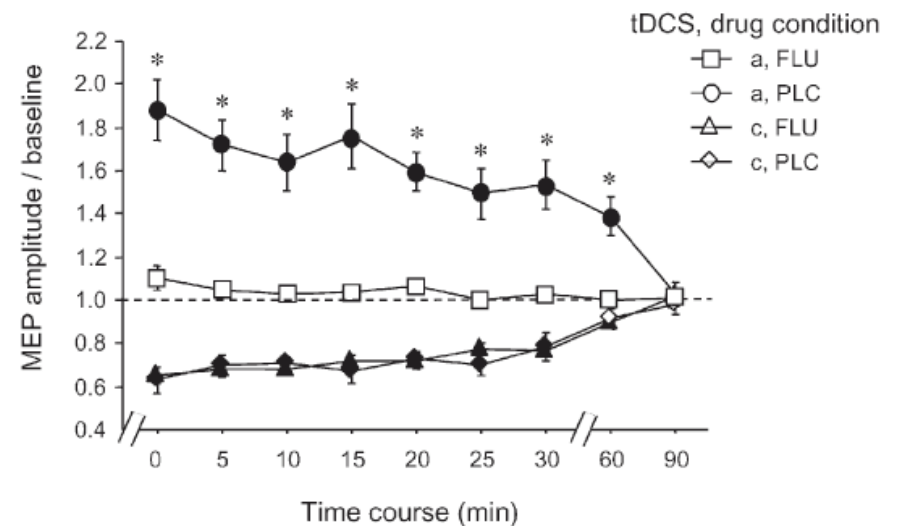
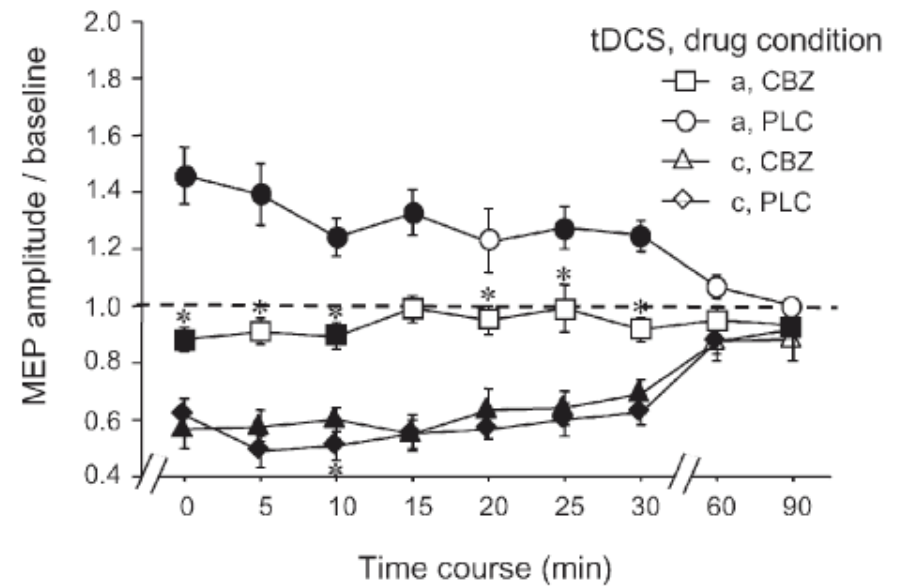
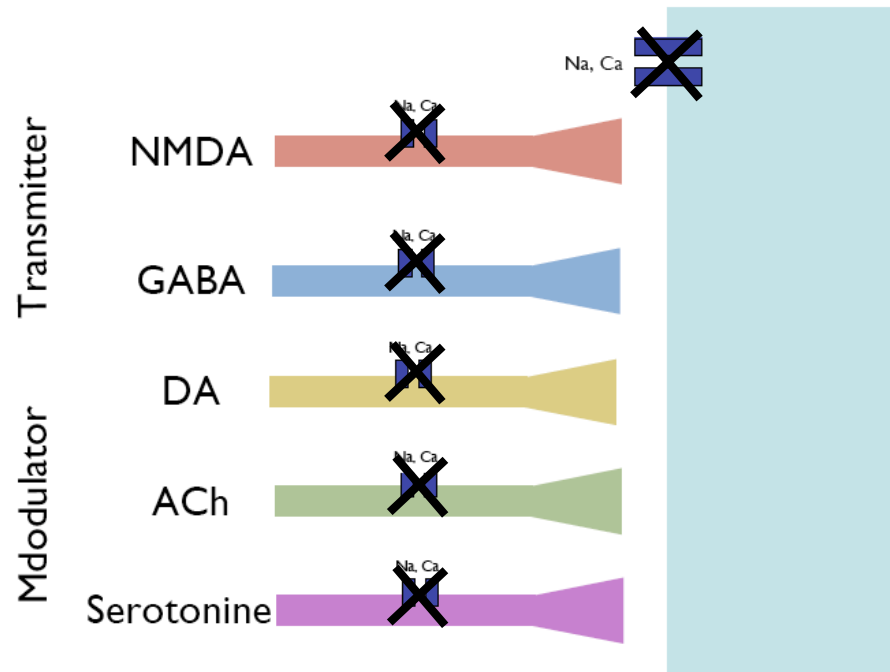
tDCS: The “classical” protocols



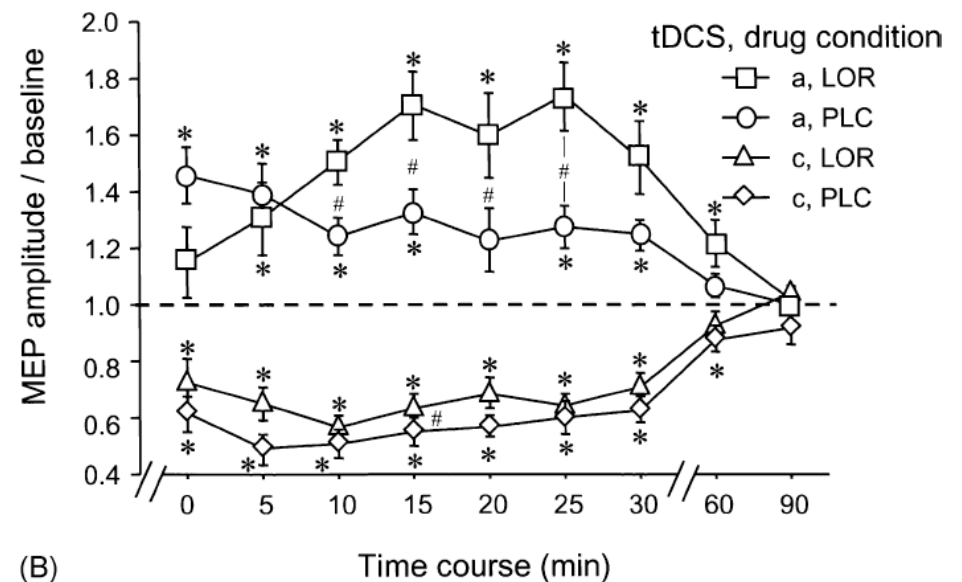
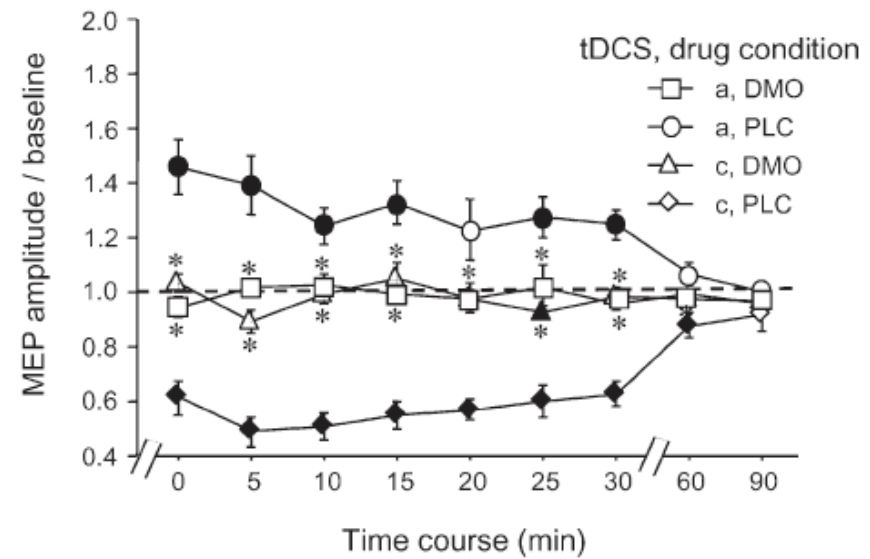
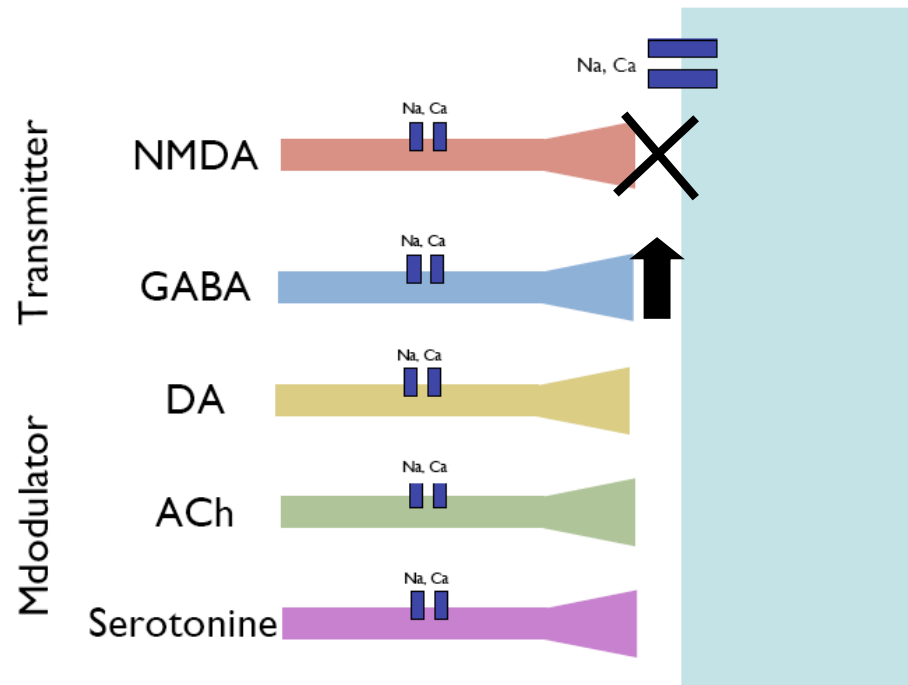
Mechanisms of action - pharmacological perspective



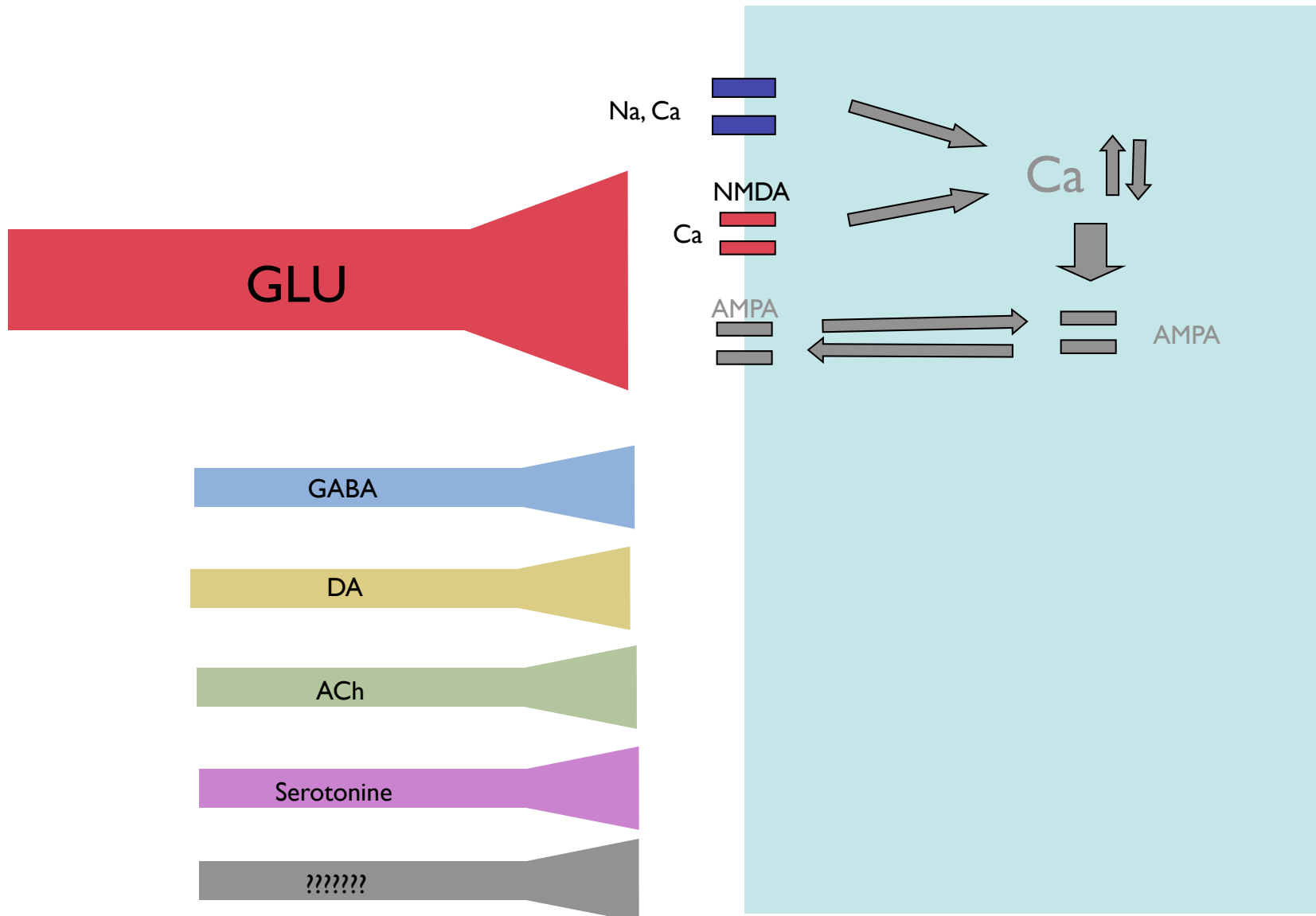
Pharmacological *dependence* of after-effects of tDCS I



Pharmacological *dependence* of after-effects of tDCS II

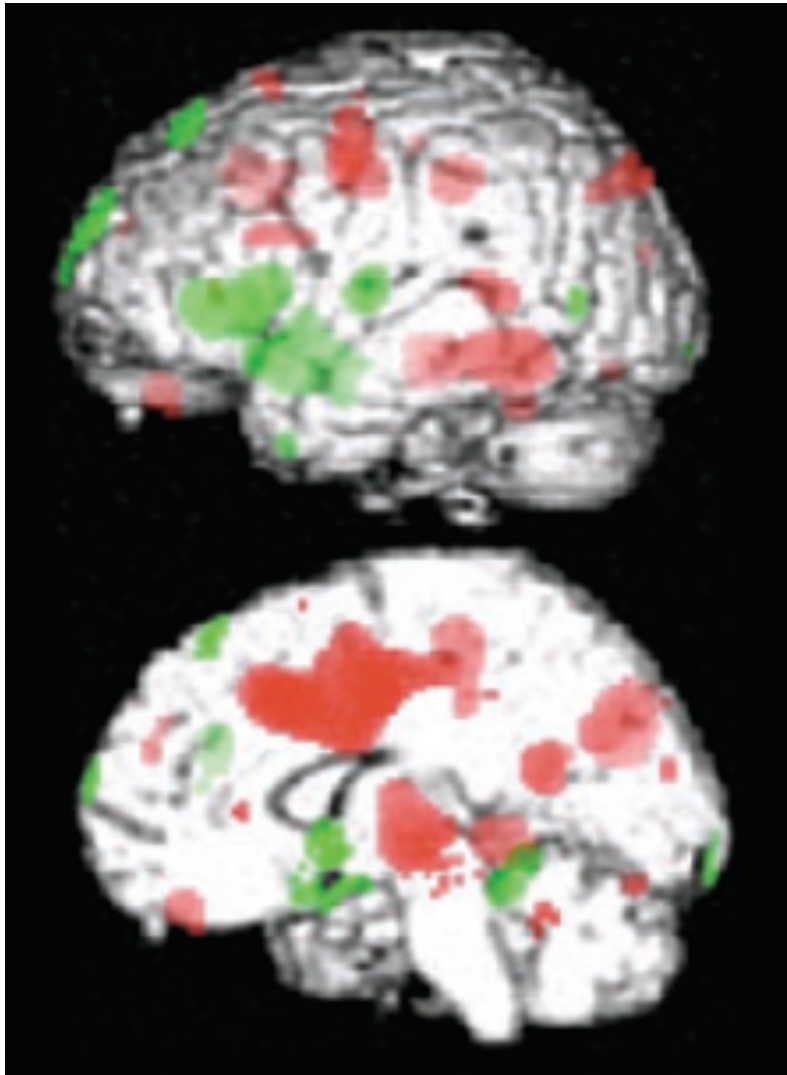


Conclusion I

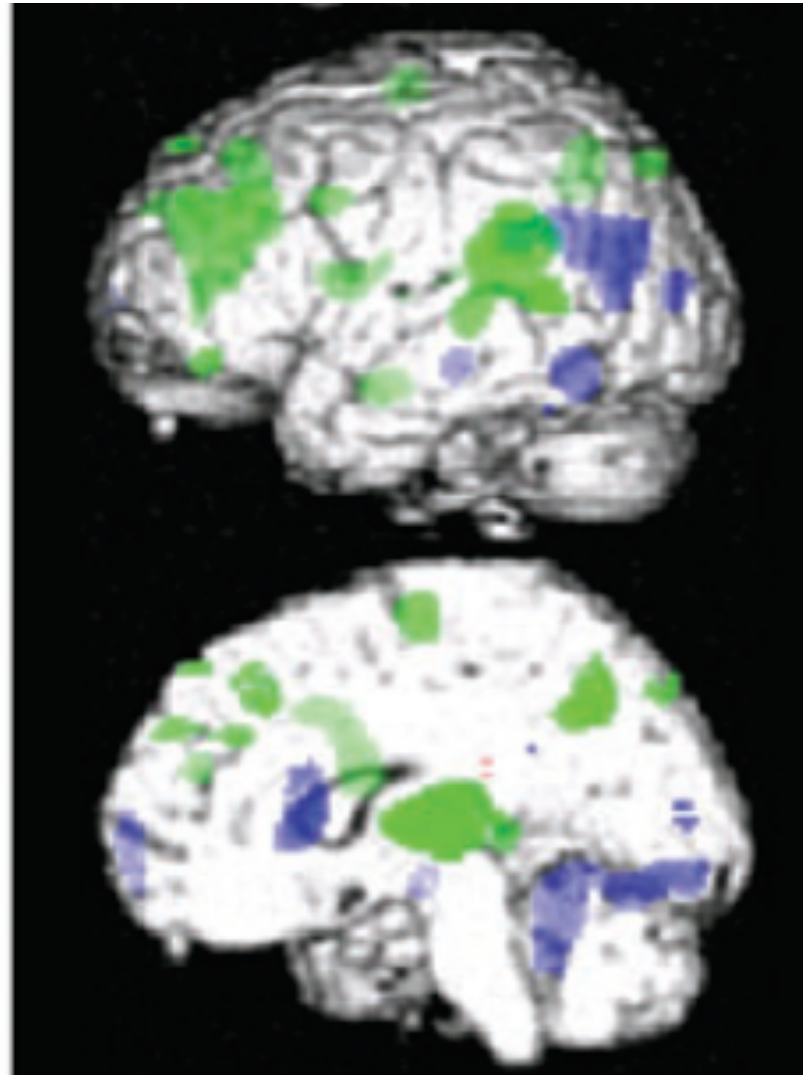


Network effects of tDCS

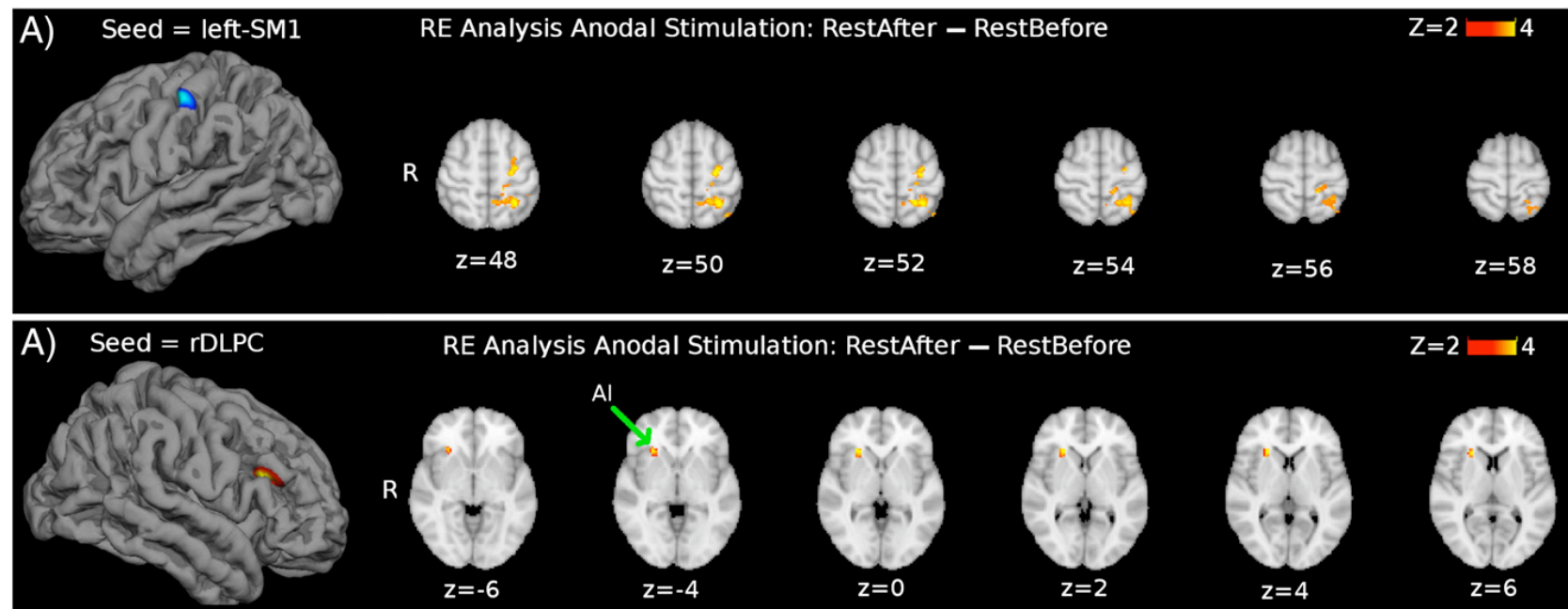
anodal



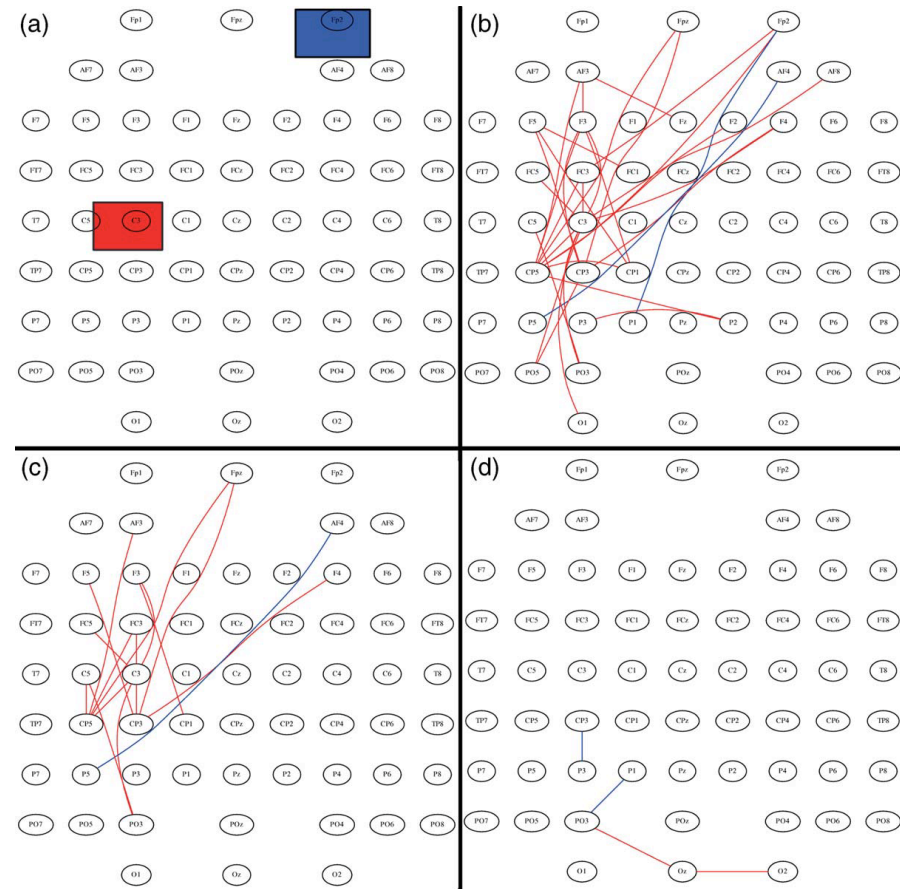
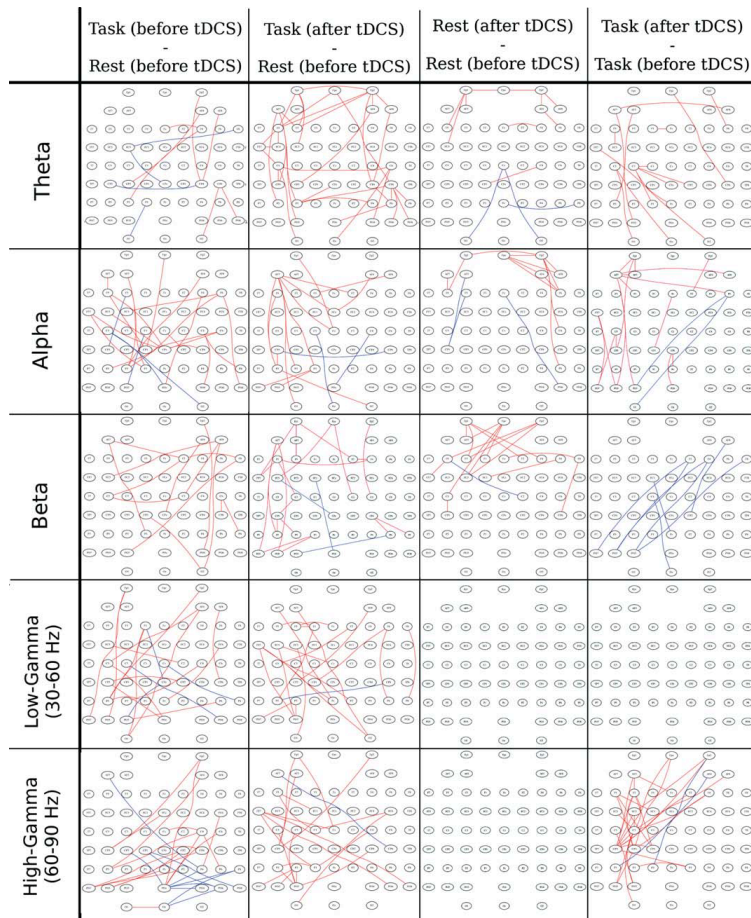
cathodal



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



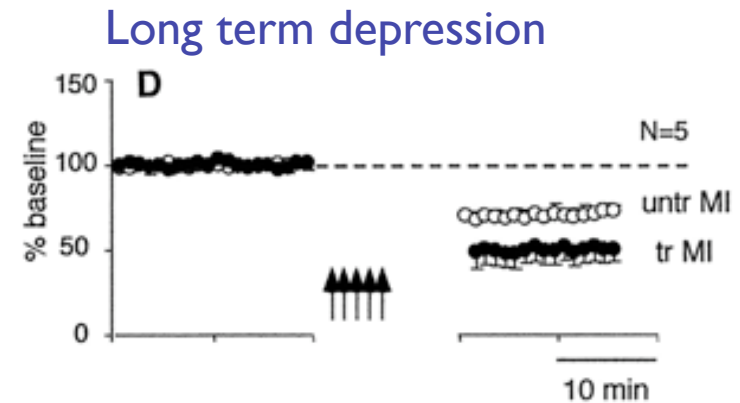
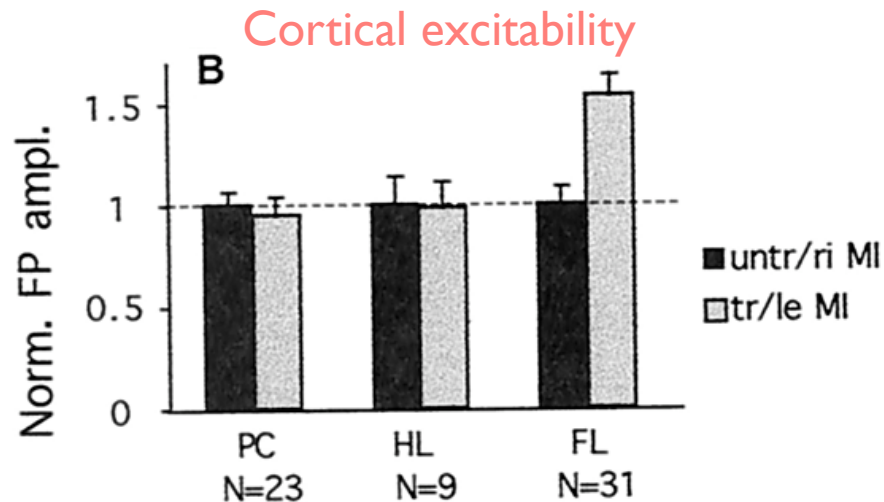
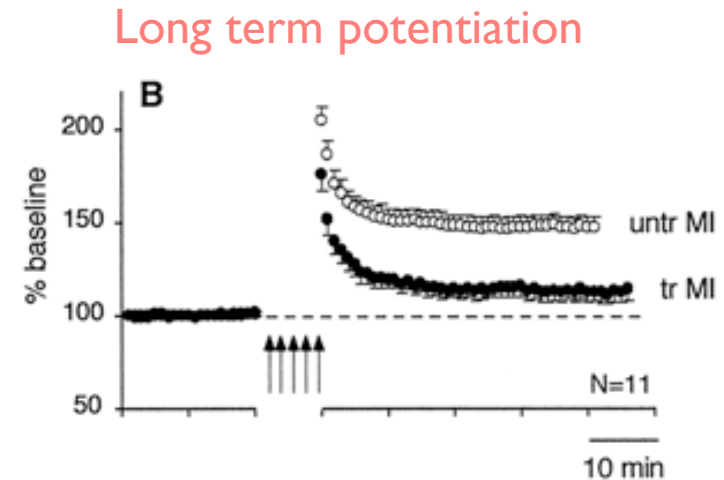
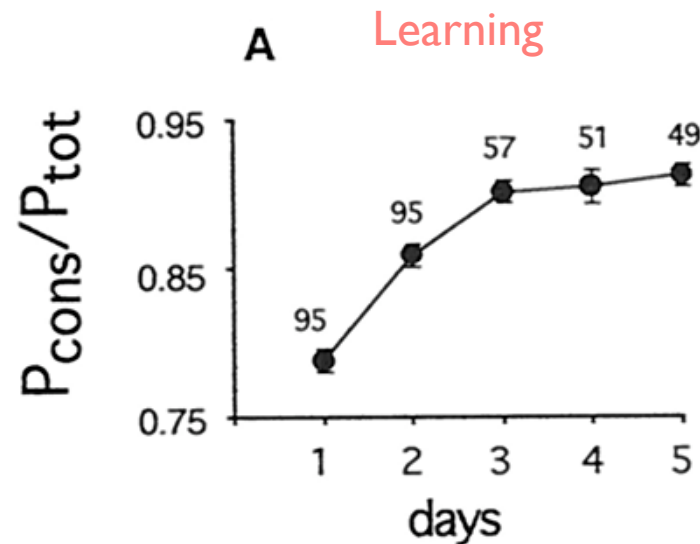
tDCS-induced functional connectivity alterations of motor cortical networks - EEG



Conclusion I

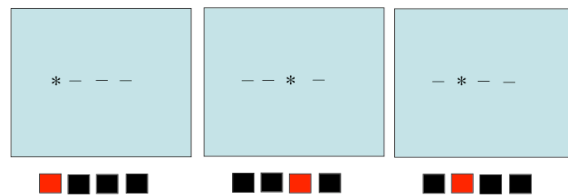
- tDCS modulates cortical excitability
- tDCS is well suited to model non-focal plasticity in the human brain
- Not only regional, but also network effects

The rationale for behavioural effects - Learning I

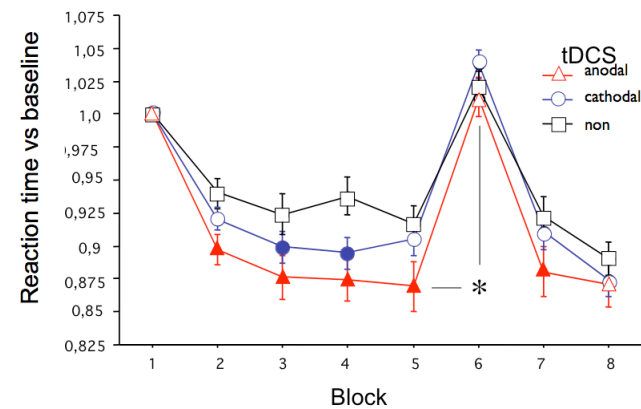
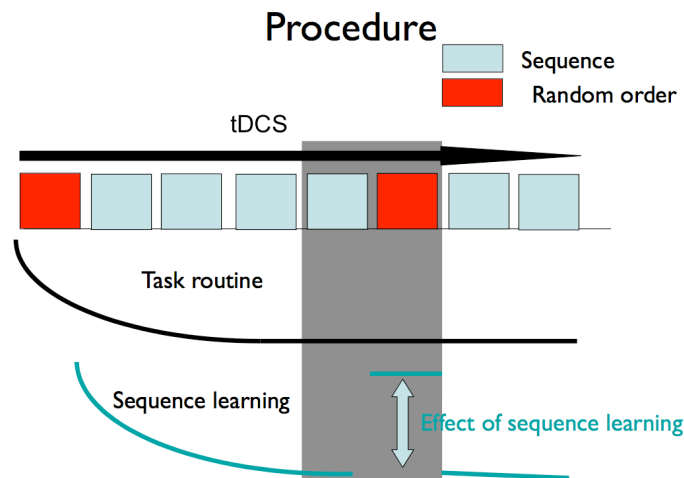
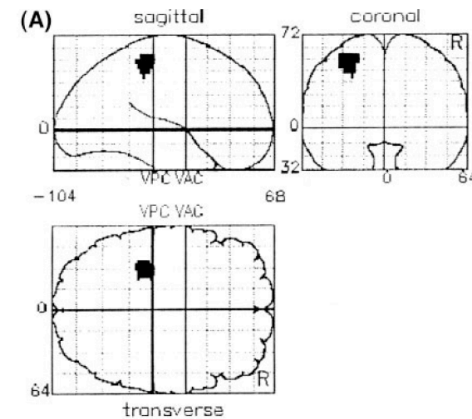


The rationale for behavioural effects - Learning II

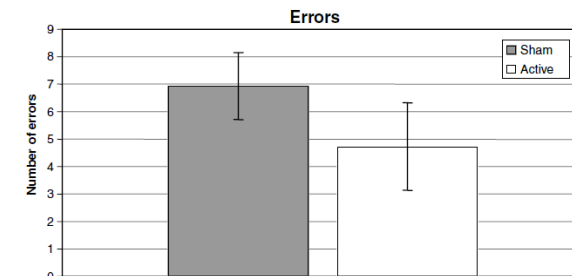
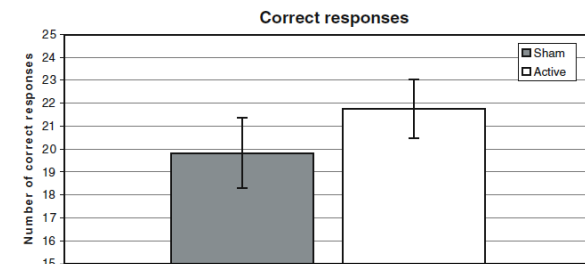
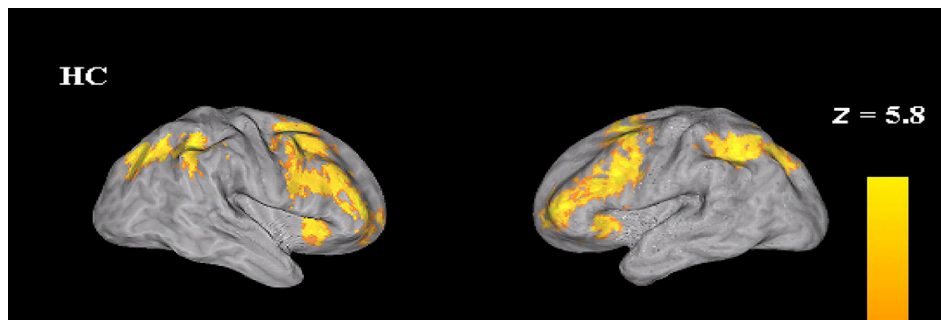
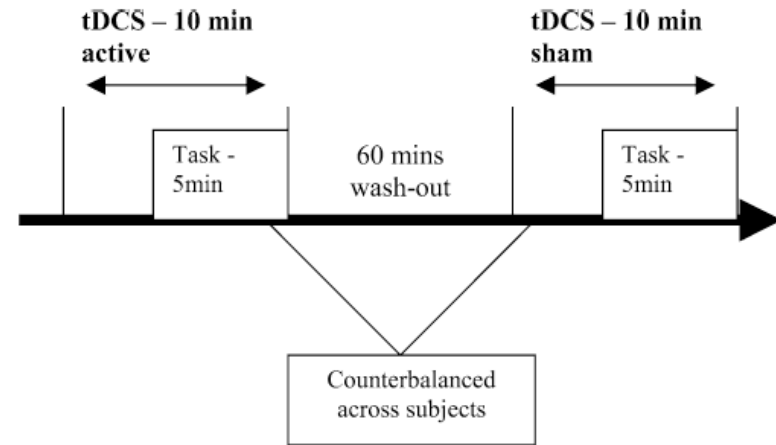
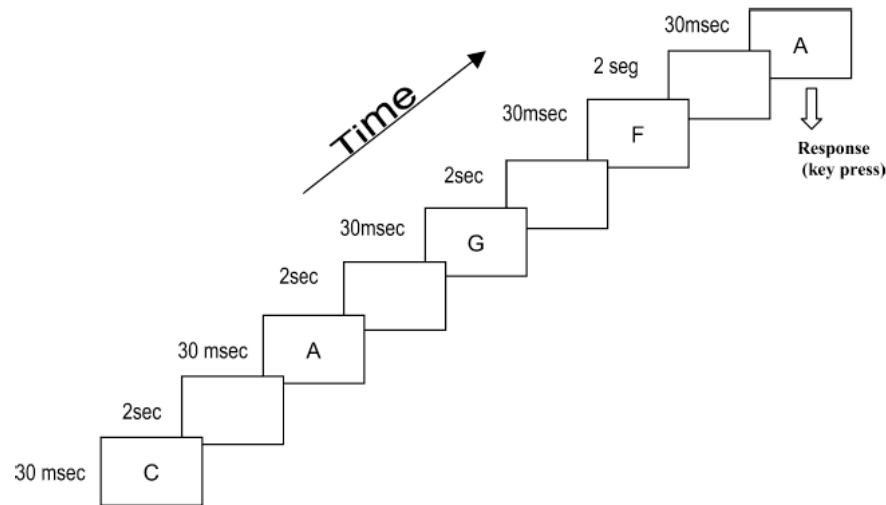
Serial reaction time task (SRTT)



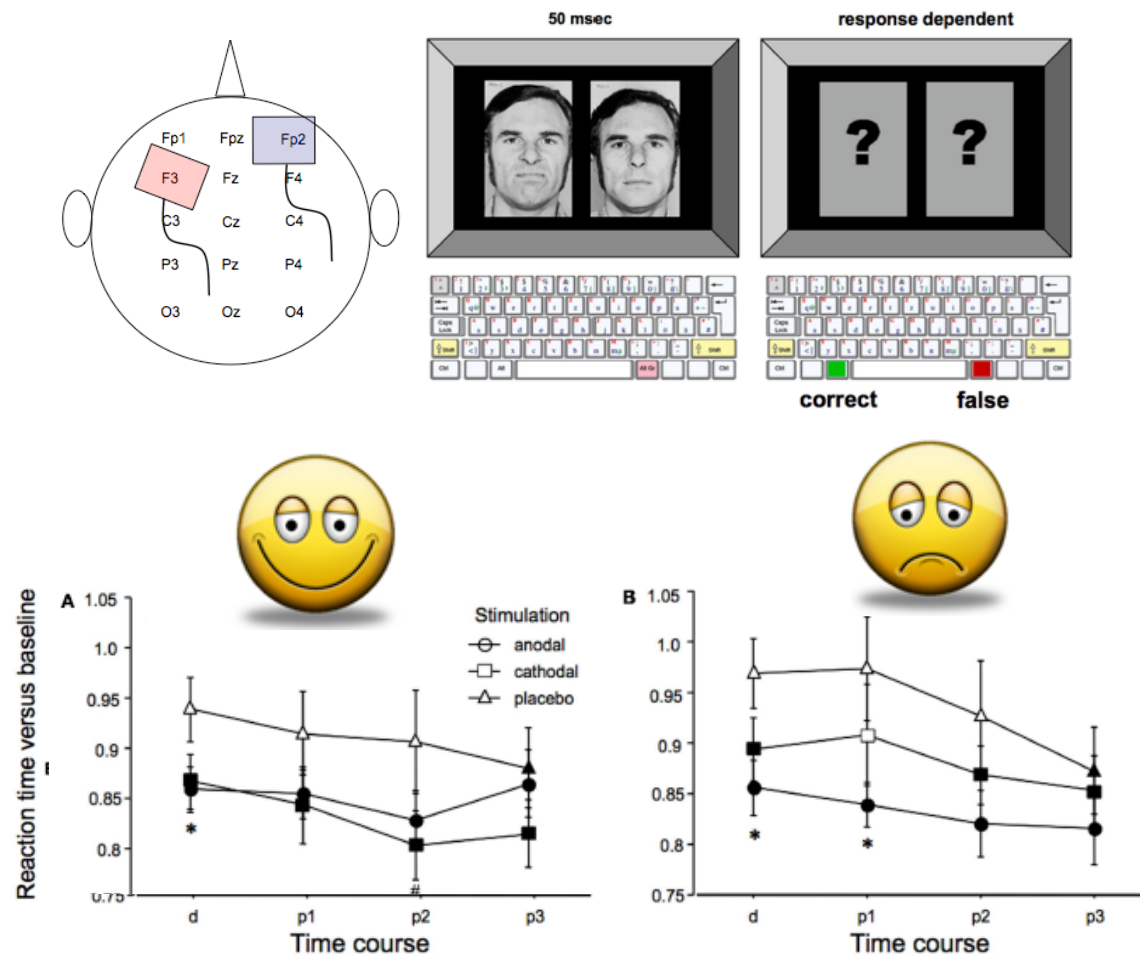
12 stimuli, 10 times repetition per block



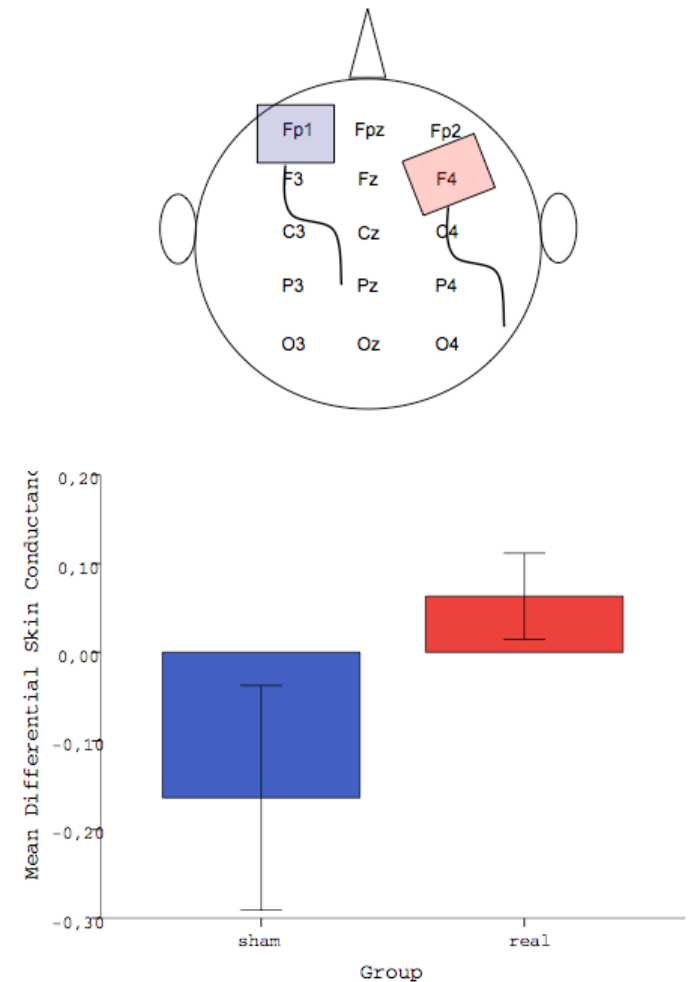
The rationale for behavioural effects – working memory



Modulation of emotional processes via tDCS

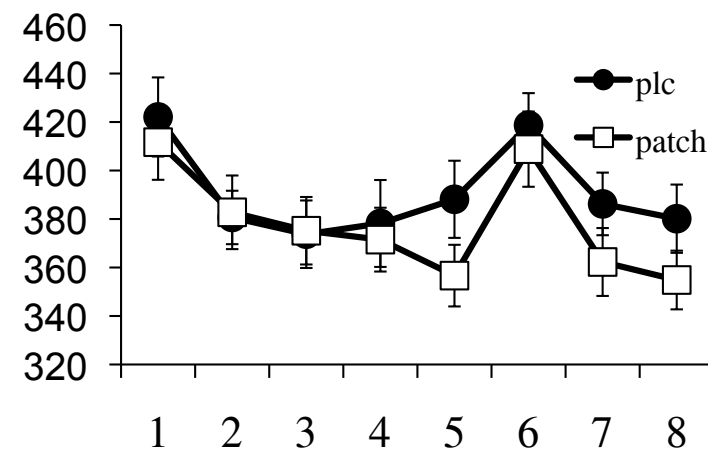
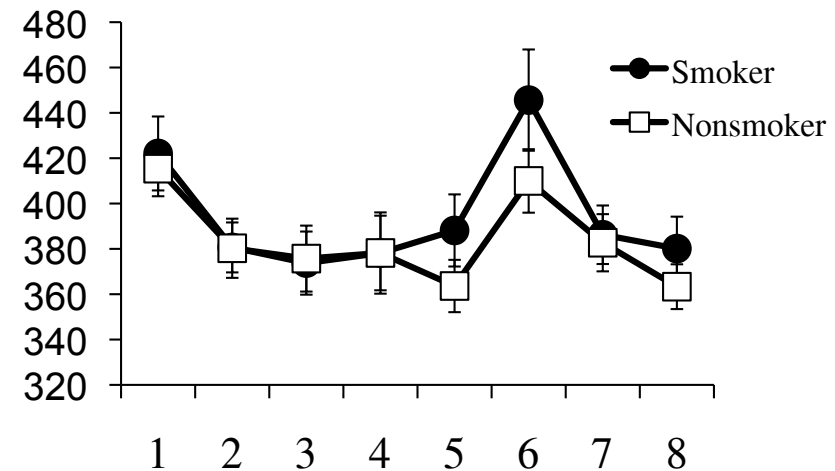
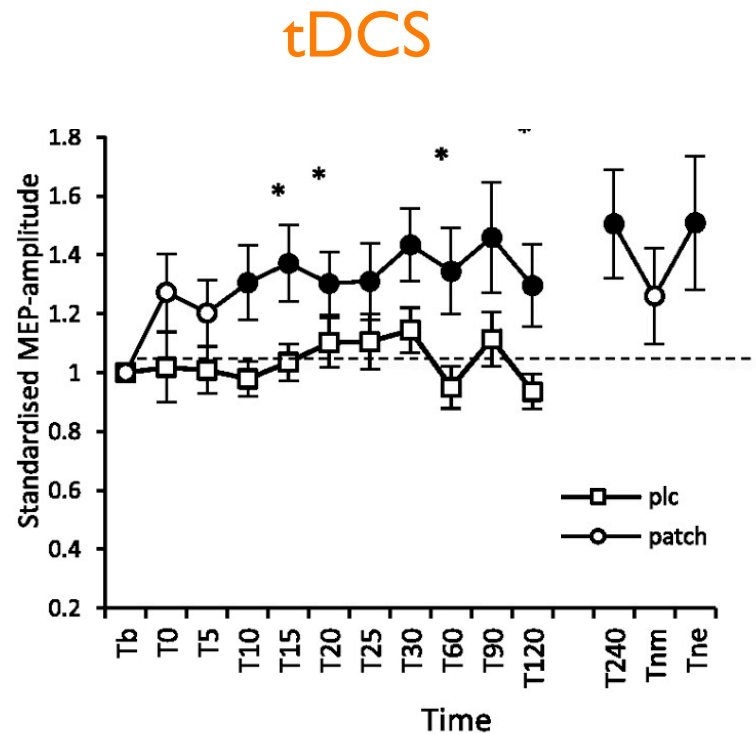


Nitsche et al. Front Psychiatry 2012



Mungee et al. Neuroreport 2014

Association between physiology and behaviour - nicotine

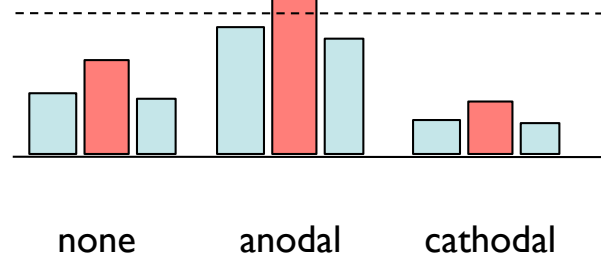
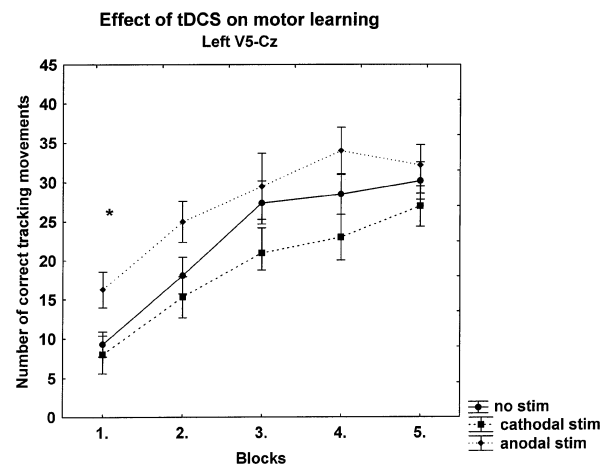
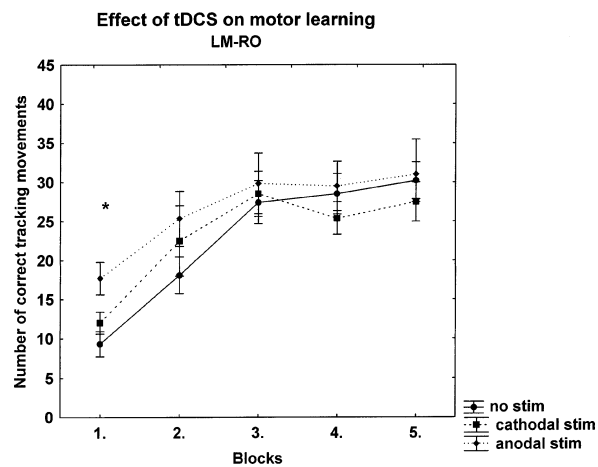
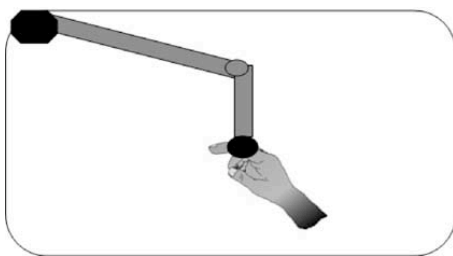
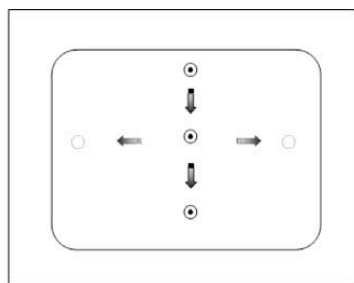


Conclusion I

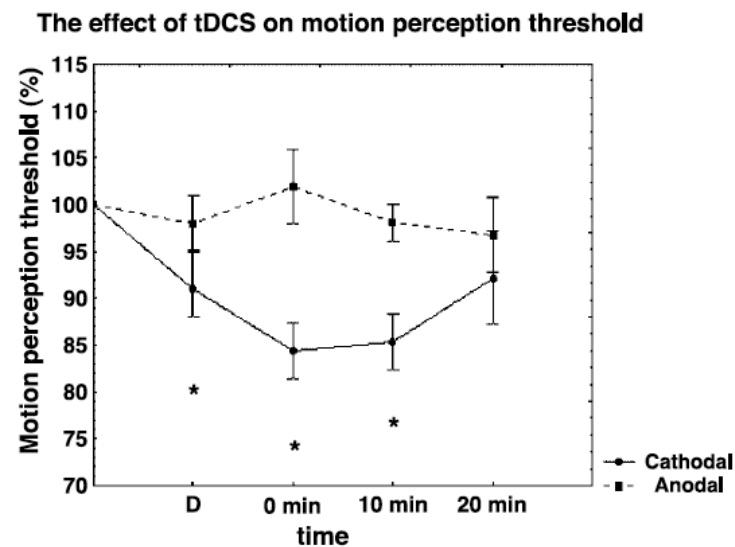
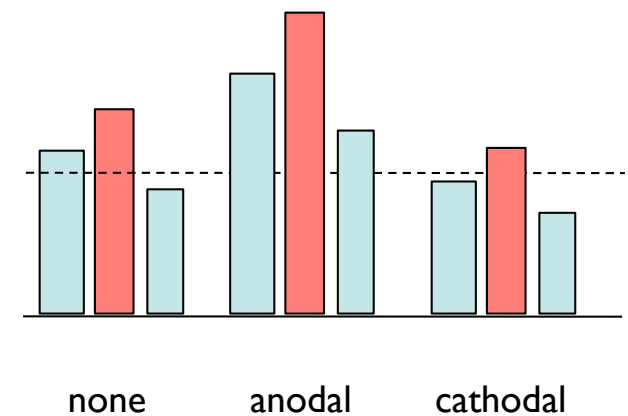
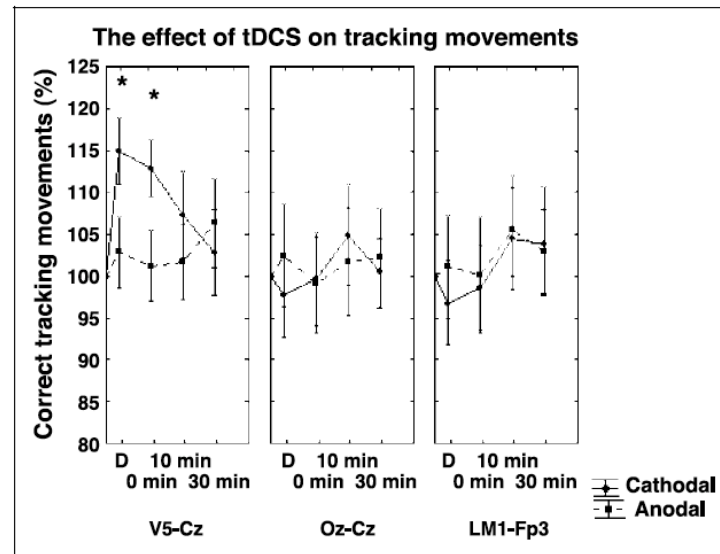
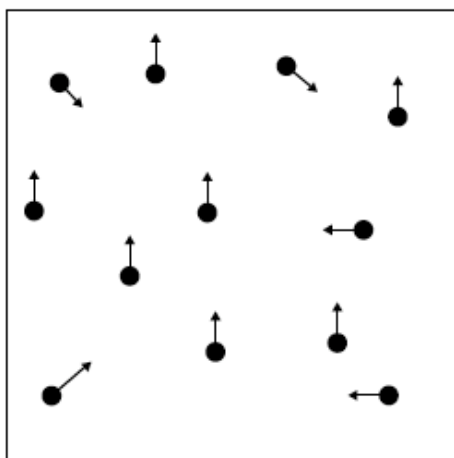
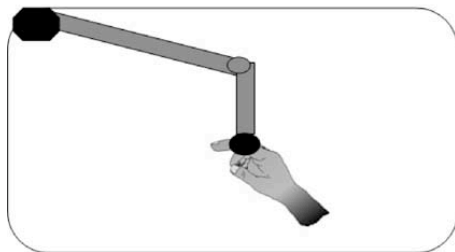
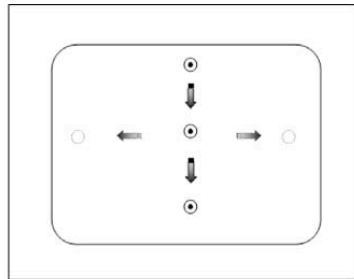
- ✓ Application of tDCS to modulate functions is physiology-based
- ✓ physiological alterations are associated with functional effects
- ✓ So far most extensively explored for anodal tDCS
- ✓ So far most extensively explored for motor cortex

Is this a general rule?

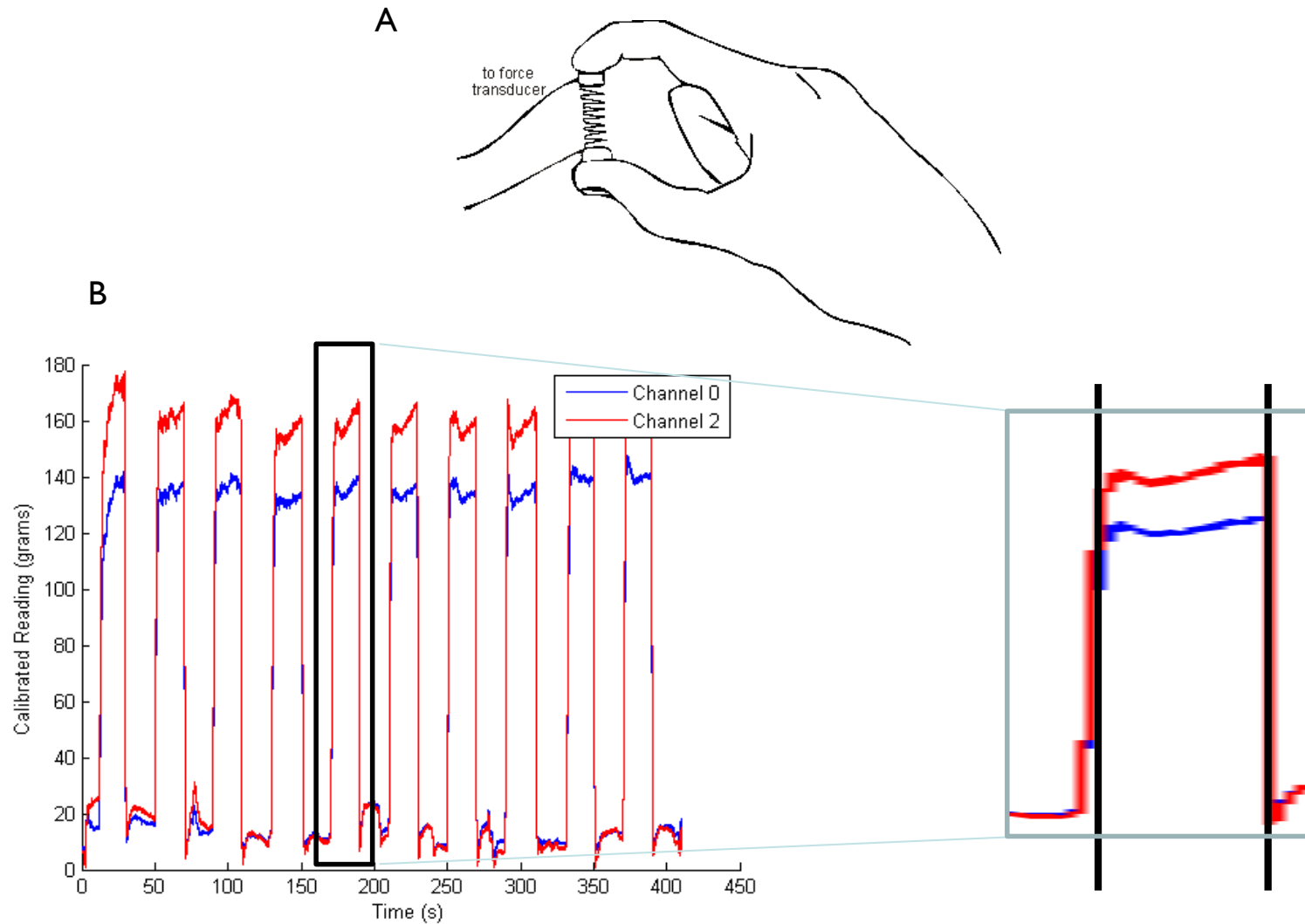
Only anodal tDCS? – task dependency



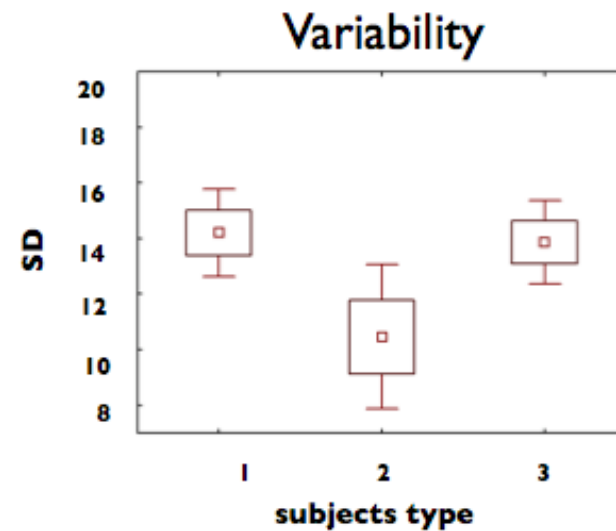
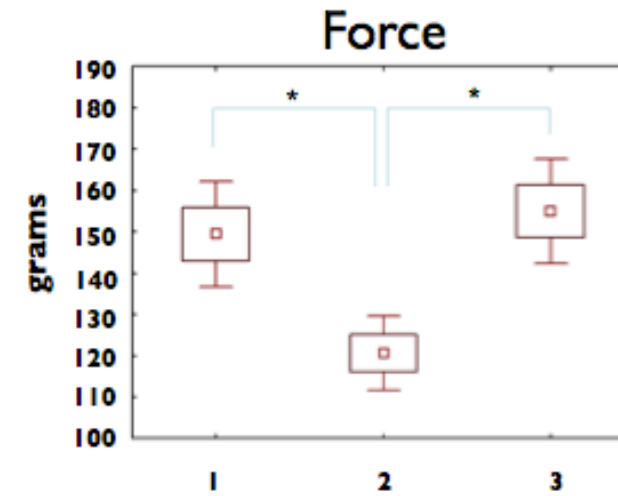
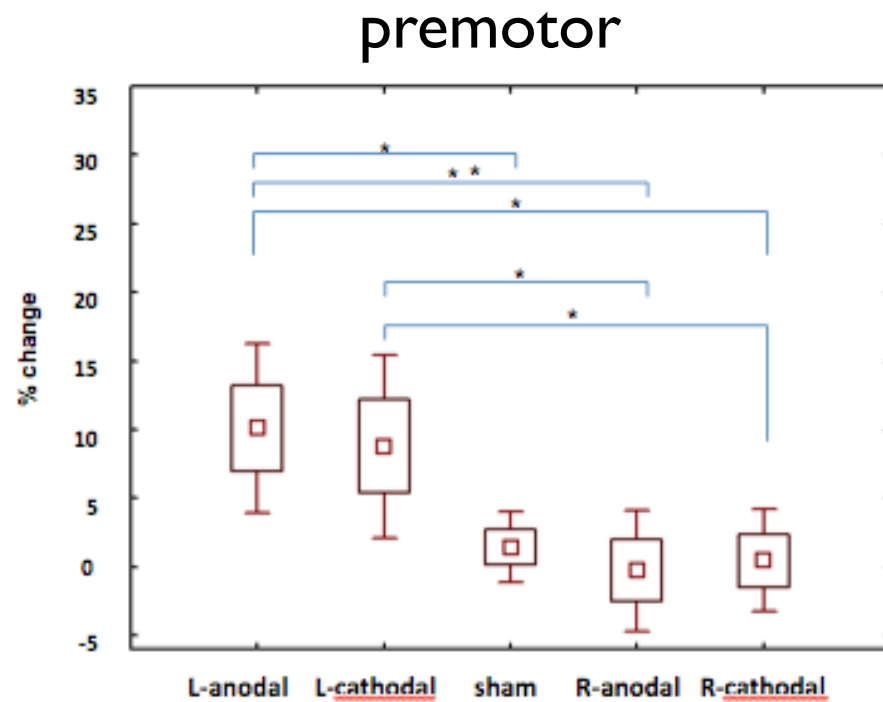
Only anodal tDCS? - task dependency



Everybody the same? – Interindividual differences



Everybody the same? – Interindividual differences



Conclusion II

- ✓ Effect of tDCS on performance depends on task characteristics, e.g. noisy vs not noisy
- ✓ excitability enhancement is not identical with performance improvement
- ✓ interindividual differences might contribute

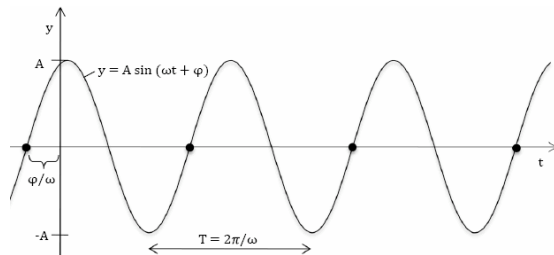
Relevance of oscillatory activity for cognitive processes (tACS)



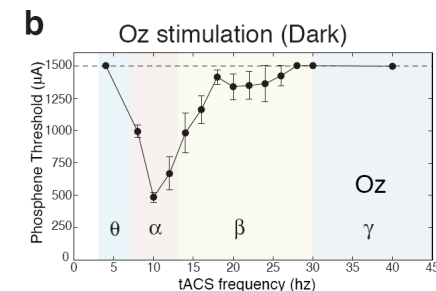
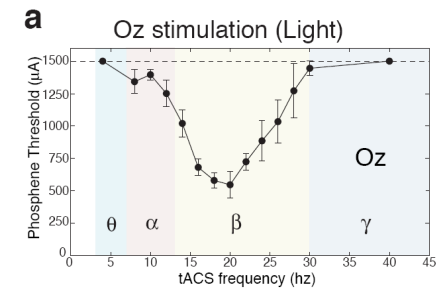
Table 1 Mean MEP amplitudes (SEM) before and after tACS at 1-, 5-, 10-, 15-, and 30-Hz stimulation

	1 Hz	10 Hz	15 Hz	30 Hz	45 Hz	Sham
Before	1.02 ± 0.11	1.03 ± 0.13	1.03 ± 0.09	1.03 ± 0.08	1.04 ± 0.09	1.02 ± 0.11
0 min	1.01 ± 0.30	0.93 ± 0.31	1.15 ± 0.37	1.06 ± 0.33	1.15 ± 0.46	1.19 ± 0.42
2 min	1.04 ± 0.44	0.94 ± 0.31	1.05 ± 0.41	1.11 ± 0.38	1.11 ± 0.47	1.20 ± 0.38
4 min	1.16 ± 0.37	0.91 ± 0.37	1.17 ± 0.34	1.16 ± 0.33	1.30 ± 0.51	1.20 ± 0.31
8 min	1.14 ± 0.35	0.92 ± 0.43	0.98 ± 0.27	1.15 ± 0.29	1.19 ± 0.45	1.20 ± 0.36
10 min	1.20 ± 0.45	0.99 ± 0.36	1.13 ± 0.37	1.14 ± 0.29	1.06 ± 0.51	1.31 ± 0.46
15 min	1.32 ± 0.53	1.08 ± 0.40	1.13 ± 0.27	1.20 ± 0.20	1.09 ± 0.41	1.16 ± 0.41
20 min	1.27 ± 0.52	0.99 ± 0.27	1.21 ± 0.20	1.11 ± 0.33	1.06 ± 0.43	1.04 ± 0.22

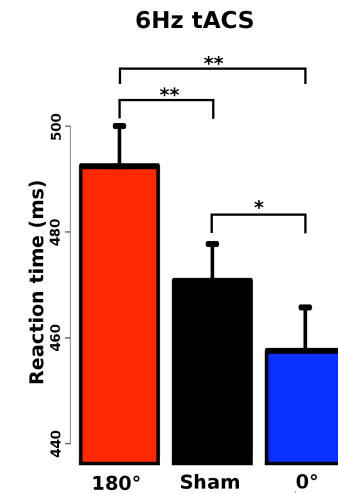
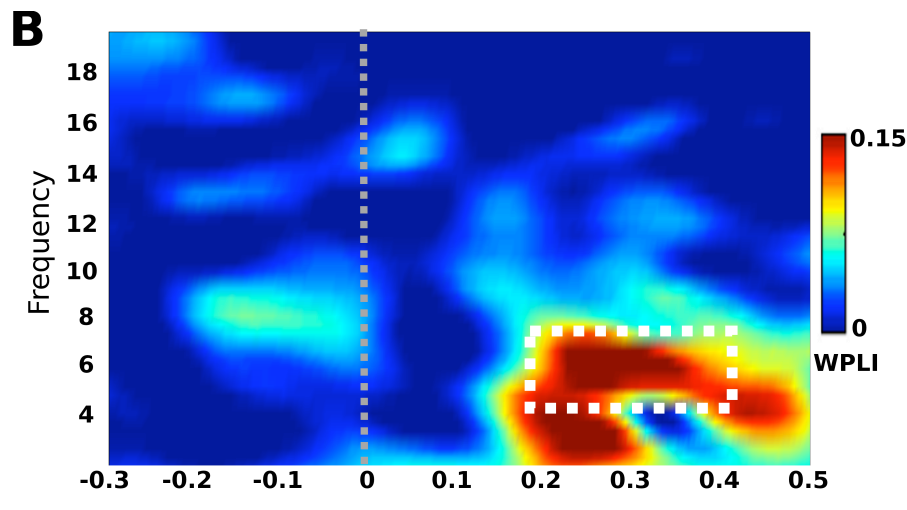
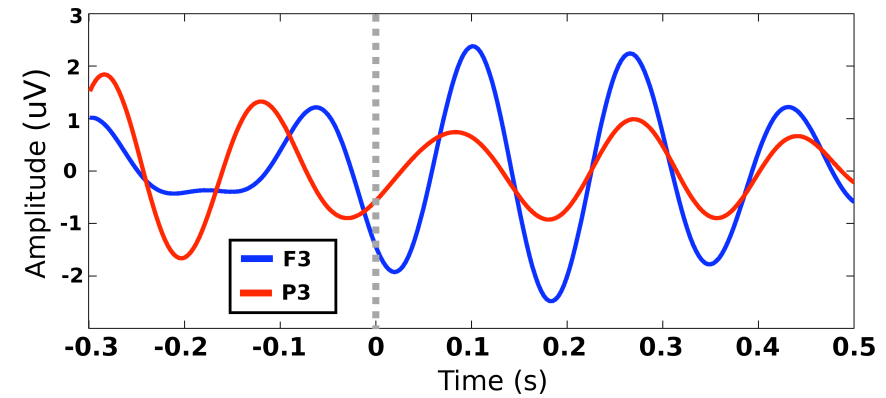
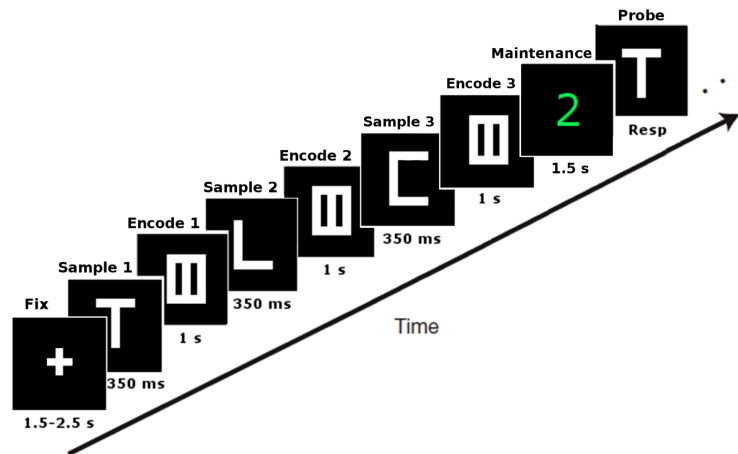
A decrease of the MEP amplitude after 10-Hz stimulation was observed, but was not significant.



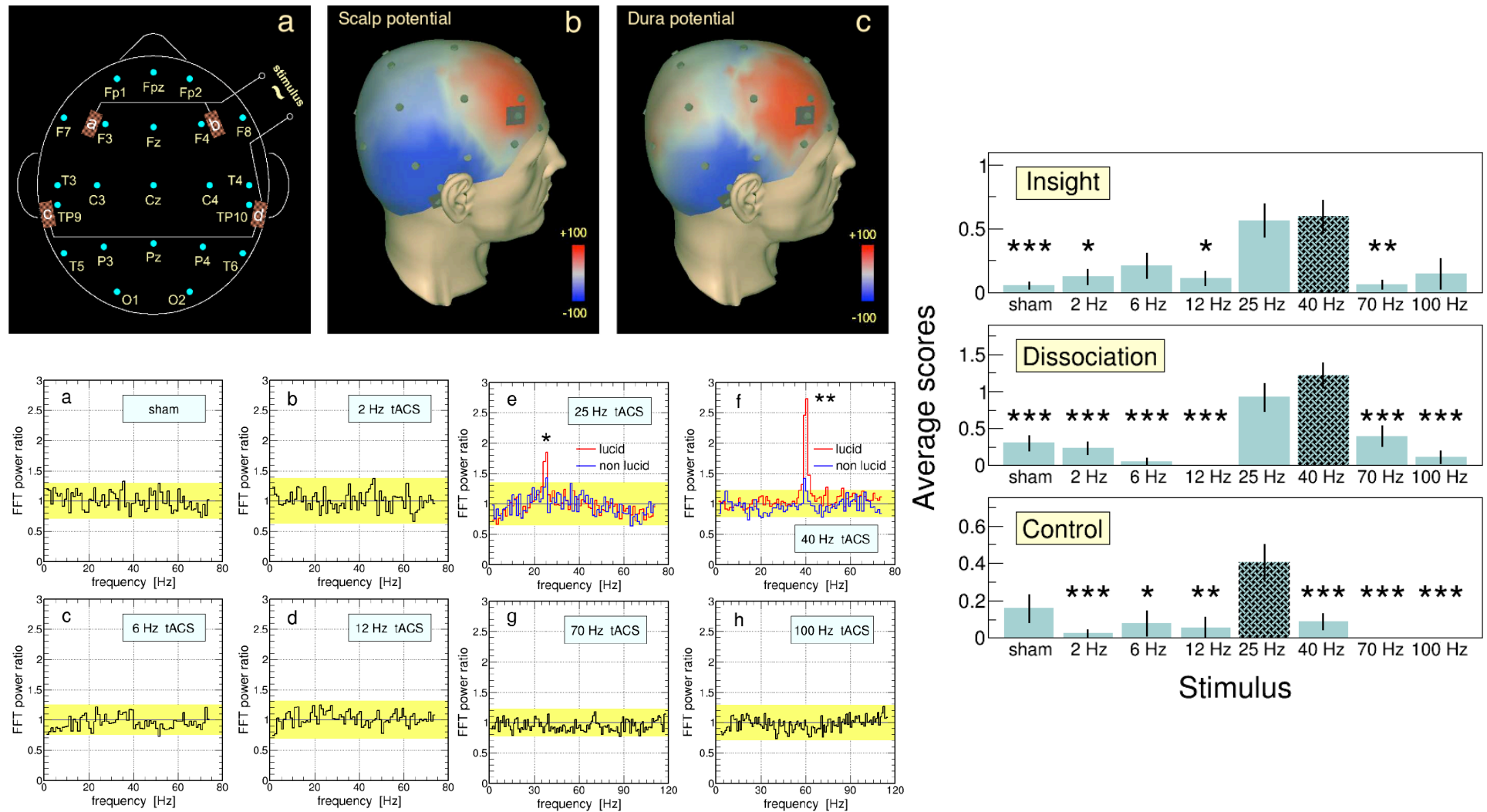
Phosphene thresholds



Oscillatory activity in working memory



Oscillatory activity in dreams



General Remarks

- ✓ physiological processes and behavioural results are not independent from each other
- ✓ the relationship between physiology and behaviour might be more complicated than originally thought
- ✓ state-dependency, task characteristics, individual differences do contribute
- ✓ Nevertheless non-invasive brain stimulation is an important tool to understand the physiological foundation of cognitive processes

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Bundesministerium
für Bildung
und Forschung

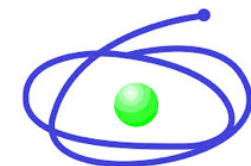


Alexander von Humboldt
Stiftung/Foundation

DAAD



Niedersachsen



C A P E S

Many thanks for your attention!