TMS BASICS - PRINCIPLES AND RESEARCH APPLICATIONS

Mgr. Luboš Brabenec

History

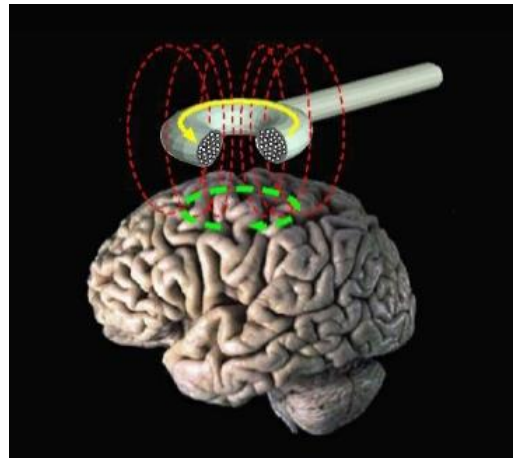
Magnusson & Stevens, 1911

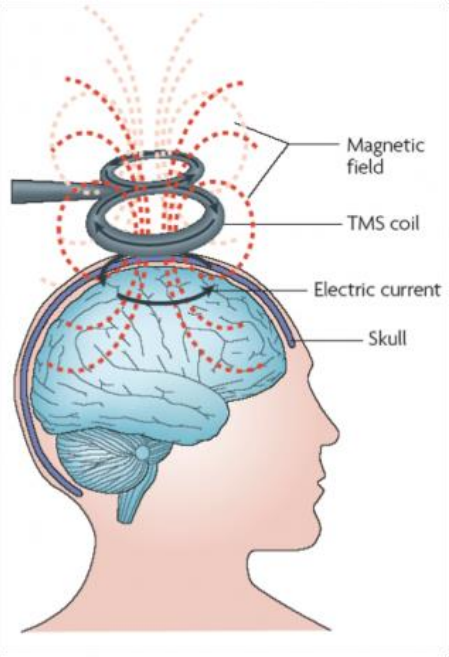
Barker, 1984

Today

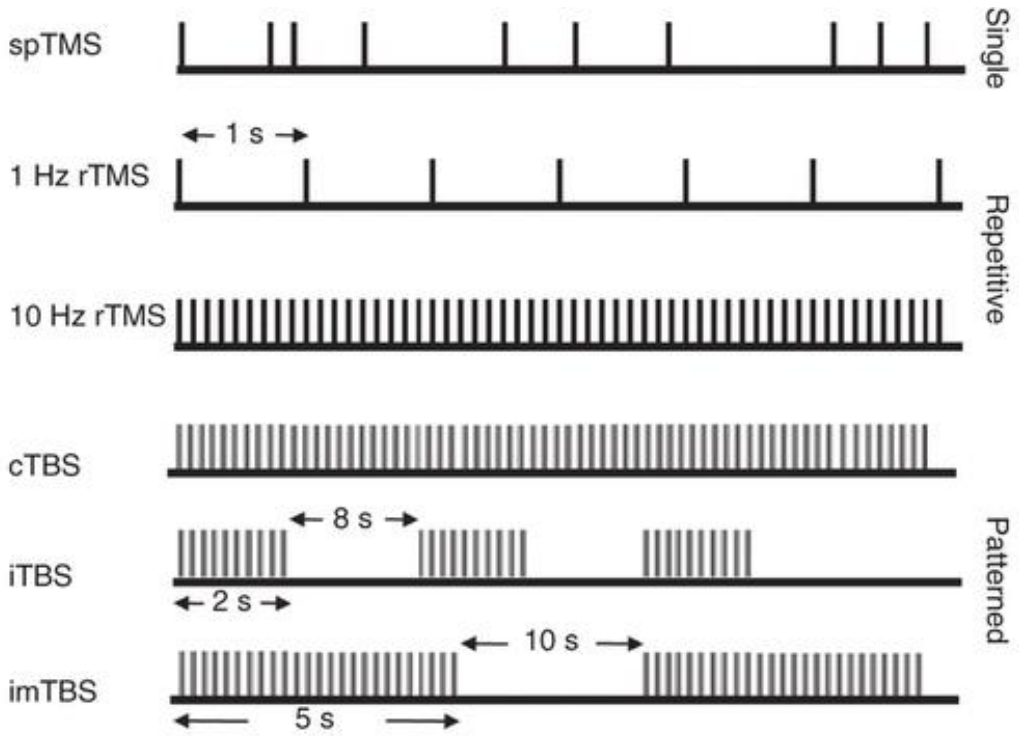
Basic principles

- **Transcranial magnetic stimulation (TMS)**
- TMS is a non-invasive method that is used for modulation of cortical excitability, based on principle of electromagnetic induction.
- **Repetitive transcranial magnetic stimulation (rTMS)**





rTMS- types of stimulation

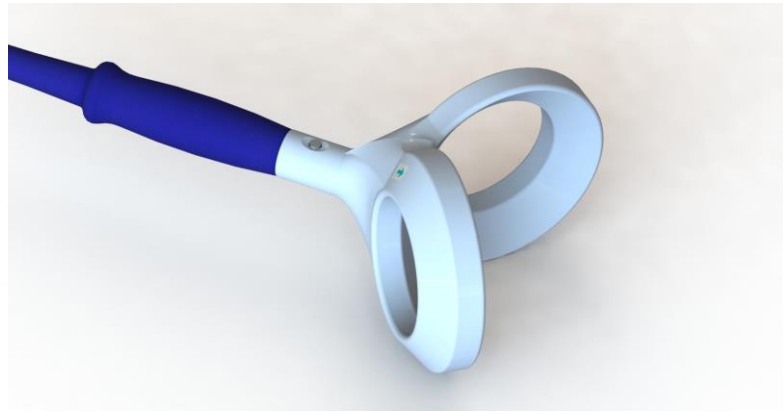


- High frequency (≥5 Hz) rTMS is facilitatory over M1 (Pascual- Leone, Valls-Sole, Wassermann, & Hallett, 1994) .
- Low-frequency (≤5 Hz) rTMS is inhibitory over M1 (R. Chen et al., 1997).
- HF and LF rTMS may have mixed excitatory and inhibitory effects (Houdayer et al., 2008).
- Two new TMS paradigms- continuous theta burst stimulation and intermittent theta burst stimulation

Types of coils

1) round coil

2) figure-eight coil



3) double-cone coil

Types of coils

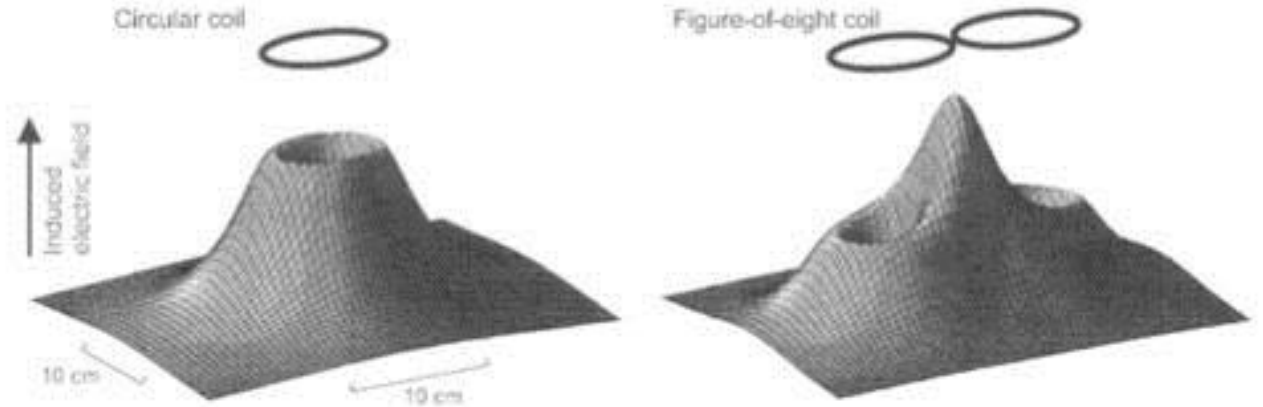
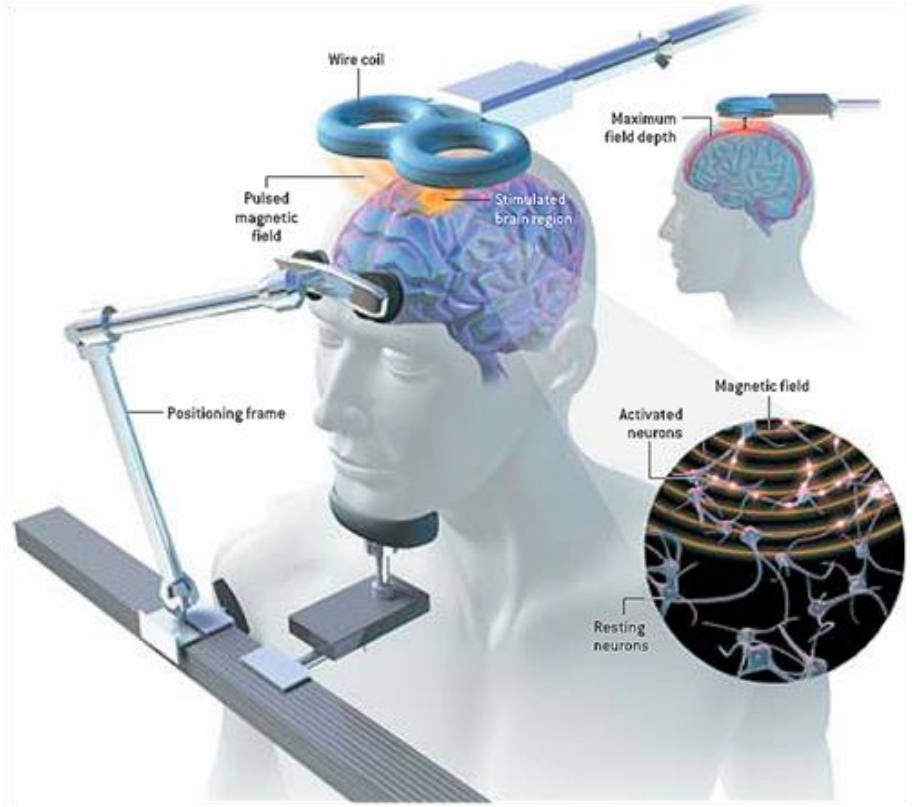


Fig. 2. The strength of the electric field induced in a spherical volume conductor below a circular (*left*) and a figure-of-eight coil (*right*). Reprinted from (Ilmoniemi *et al.*, 1999), with permission of Begell House, Inc.

Coil type influences focality: Round coils induce currents running in directions opposite to primary coil current; Figure-eight (focal) coils induce currents that sums at the intersection. Induced current intensity falls as a function of distance from stimulating coil.

Use of rTMS

- A research tool to study aspects of the human brain physiology
- Therapeutic application:
  - Neurological disorders
  - Psychiatric disorders



rTMS- research tool

- On-line stimulation -person is executing a task while receiving rTMS *(virtual lesions)*.
- Off-line stimulation- stimulation occurs before a task, but some rTMS after-effects may interrelate with the final results.

rTMS-therapeutic potential

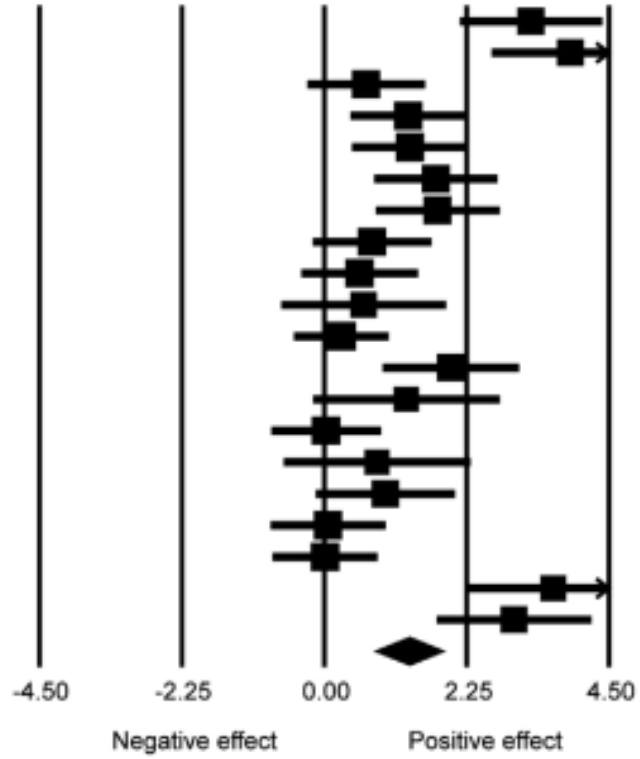
- rTMS may produce changes in the brain, that outlast the period of stimulation for weeks or months.(Ridding and Rothwell,2007).
- rTMS has therapeutic potential in a variety of psychiatric and neurological disorders (Hallet and Chokroverty 2005).

rTMS and Alzheimer's disease

- **Distinct Pattern of Gray Matter Atrophy in Mild Alzheimer's Disease Impacts on Cognitive Outcomes of NoninvasiveBrain Stimulation (Anderkova et al.,2015)**
- 20 MCI/AD patients
- 3 sessions of 10Hz rTMS of the right inferior frontal gyrus (IFG), the right superior temporal gyrus (STG), and the vertex (VTX, a control stimulation site).
- The effect of the stimulated site on the difference in cognitive scores was statistically significant for the Word part of the Stroop test (ST-W, p=0.012)

rTMS and Alzheimer's disease

Study name	Effect size	Lower limit	Upper limit	p-Value	Relative weight
Cotelli et al., 2006 (L DLPFC)	3.27	2.17	4.36	0.00	4.88
Cotelli et al., 2006 (R DLPFC)	3.89	2.67	5.11	0.00	4.62
Ferrucci et al., 2008	0.66	-0.24	1.56	0.15	5.29
Cotelli et al., 2008 (mild/L DLPFC)	1.33	0.44	2.21	0.00	5.33
Cotelli et al., 2008 (mild/R DLPFC)	1.35	0.47	2.24	0.00	5.32
Cotelli et al., 2008 (moderate to severe/L DLPFC)	1.76	0.82	2.71	0.00	5.20
Cotelli et al., 2008 (moderate to severe/R DLPFC)	1.79	0.84	2.74	0.00	5.19
Boggio et al., 2009 (L DLPFC)	0.76	-0.15	1.66	0.10	5.28
Boggio et al., 2009 (L temproal cortex)	0.56	-0.33	1.45	0.22	5.31
Cotelli et al., 2011	0.62	-0.65	1.89	0.34	4.50
Boggio et al., 2012	0.27	-0.45	0.99	0.46	5.65
Ahmed et al., 2012 (20 Hz/mild to moderate)	2.00	0.95	3.05	0.00	4.98
Ahmed et al., 2012 (20 Hz/severe)	1.30	-0.15	2.74	0.08	4.14
Ahmed et al., 2012 (1 Hz/mild to moderate)	0.03	-0.81	0.87	0.94	5.42
Ahmed et al., 2012 (1 Hz/severe)	0.83	-0.61	2.28	0.26	4.14
Rabey et al., 2013	0.96	-0.11	2.04	0.08	4.93
Eliasova et al., 2014	0.06	-0.82	0.94	0.89	5.34
Cotelli et al., 2014	0.01	-0.79	0.81	0.98	5.50
Khedr et al., 2014 (atDCS)	3.62	2.26	4.98	0.00	4.32
Khedr et al., 2014 (ctDCS)	3.00	1.81	4.19	0.00	4.67
Pooled effect size (random effects model)	1.35	0.86	1.84	0.00	



Hsu et al., 2015

rTMS and Parkinson's disease

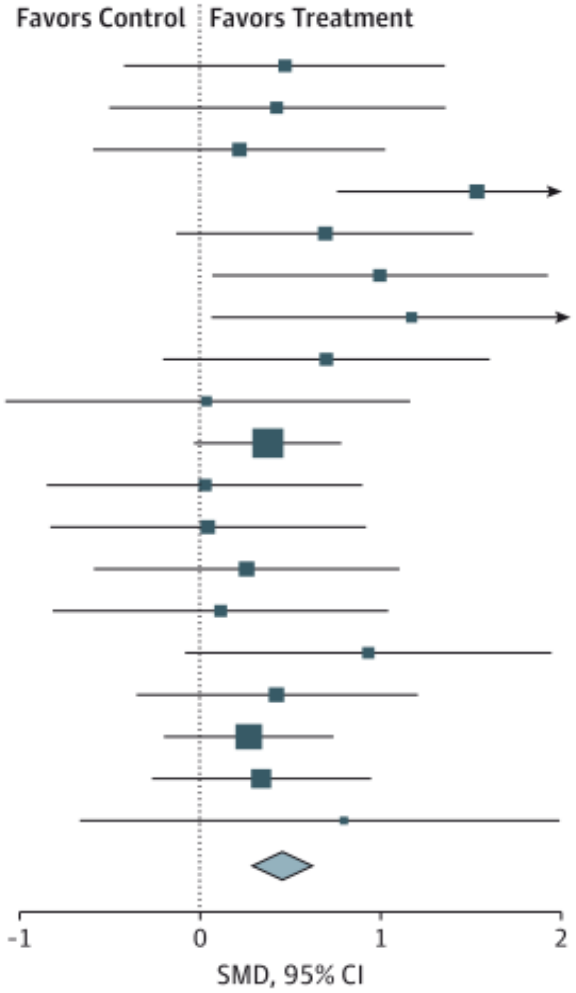
- **Acoustic evaluation of short-term effects of repetitive transcranial magnetic stimulation on motor aspects of speech in Parkinson's disease (Eliasova et al.,2012)**
- 12 PD patients, 21 healthy participants
- 2 sessions of 10 Hz rTMS over left primary orofacial sensorimotor area (SM1) and left dorsolateral prefrontal cortex (DLPFC)
- Stimulation over SM1 lead to improvement in voice quality and intensity and an increase in speech rate of PD patients.

rTMS and Parkinson's disease

Source	SMD, 95% CI
Siebner et al,[42] 2000	0.47 (-0.42 to 1.36)
Shimamoto et al,[28] 2001	0.43 (-0.51 to 1.36)
Boylan et al,[35] 2001	0.22 (-0.58 to 1.02)
Khedr et al,[24] 2003	1.53 (0.76 to 2.31)
Lefaucheur et al,[39] 2004	0.69 (-0.13 to 1.52)
Khedr et al,[33] 2006	1.00 (0.07 to 1.93)
Lomarev et al,[25] 2006	1.18 (0.07 to 2.28)
Brusa et al,[36] 2006	0.70 (-0.20 to 1.61)
del Olmo et al,[31] 2007	0.04 (-1.07 to 1.16)
Hamada et al,[34] 2008	0.38 (-0.02 to 0.78)
Filipović et al,[37,38] 2010, 2009	0.03 (-0.85 to 0.91)
Sedlácková et al,[41] 2009	0.05 (-0.83 to 0.93)
Pal et al,[27] 2010	0.26 (-0.58 to 1.11)
Arias et al,[23] 2010	0.12 (-0.81 to 1.05)
González-García et al,[29] 2011	0.93 (-0.08 to 1.95)
Benninger et al,[32] 2012	0.43 (-0.35 to 1.21)
Shirota et al,[31] 2013	0.27 (-0.20 to 0.74)
Maruo et al,[26] 2013	0.34 (-0.27 to 0.95)
Nardone et al,[40] 2014	0.80 (-0.66 to 2.26)
Overall	0.46 (0.29 to 0.64)

Test for overall effect: $z = 5.18$; $P < .001$

Test for heterogeneity: $Q = 16.22$; $P = .58$; $I^2 = 0.00$



Chou et al. 2015

Thank you for your attention.