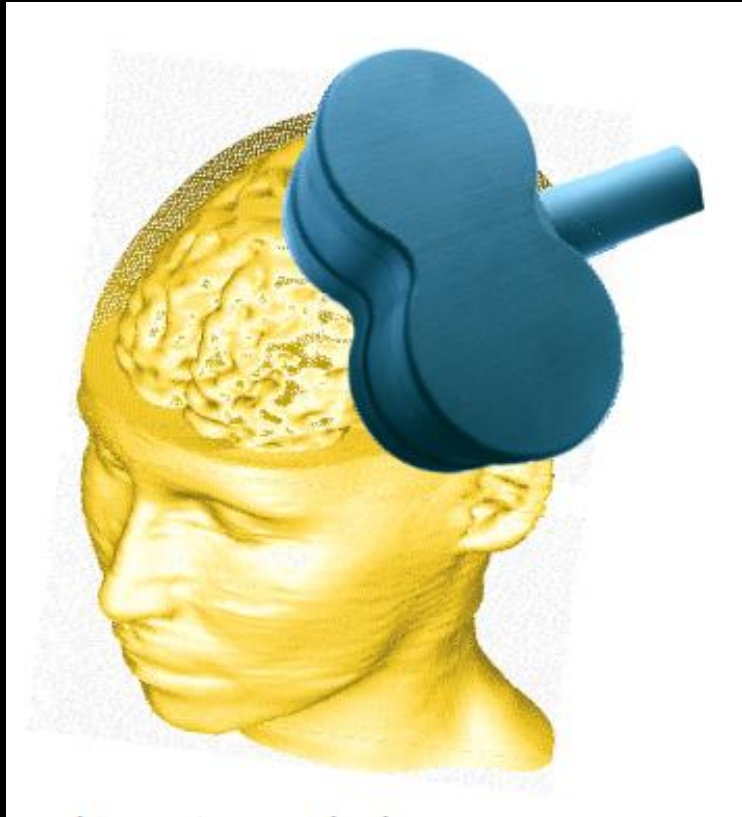


Transcranial Magnetic Stimulation

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Transcranial Magnetic Stimulation (TMS)

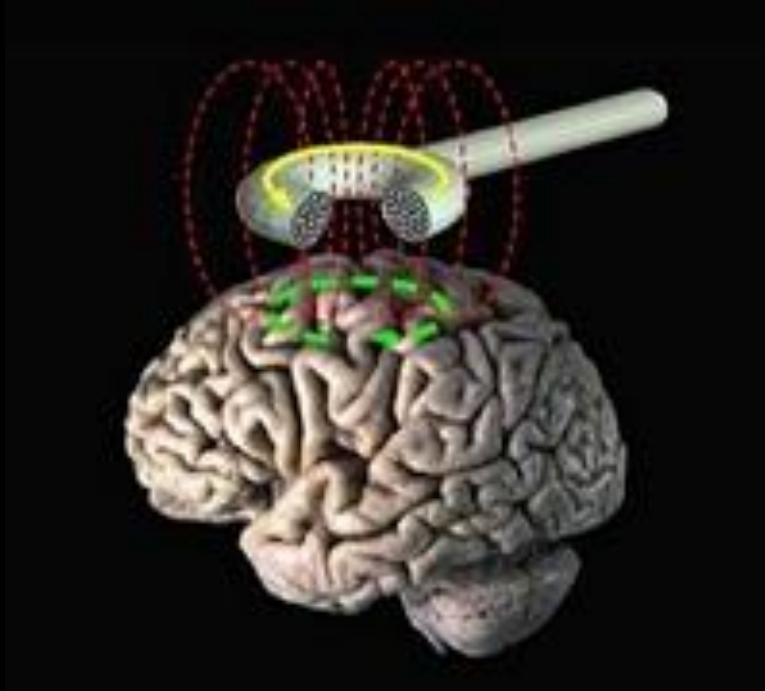


*Magventure

Examples of Applications

- **Treatment**
 - Depression,
 - Pain/migraine
 - Movement Disorders
 - Bipolar Disorder
- **Surgical Planning: Prediction of Response**
 - Pain (rTMS correlates with MCS)
 - Speech and Motor Localization (Nexstim-FDA approved)

Induced Electrical Current



Electrical current
In Coil



Magnetic Field

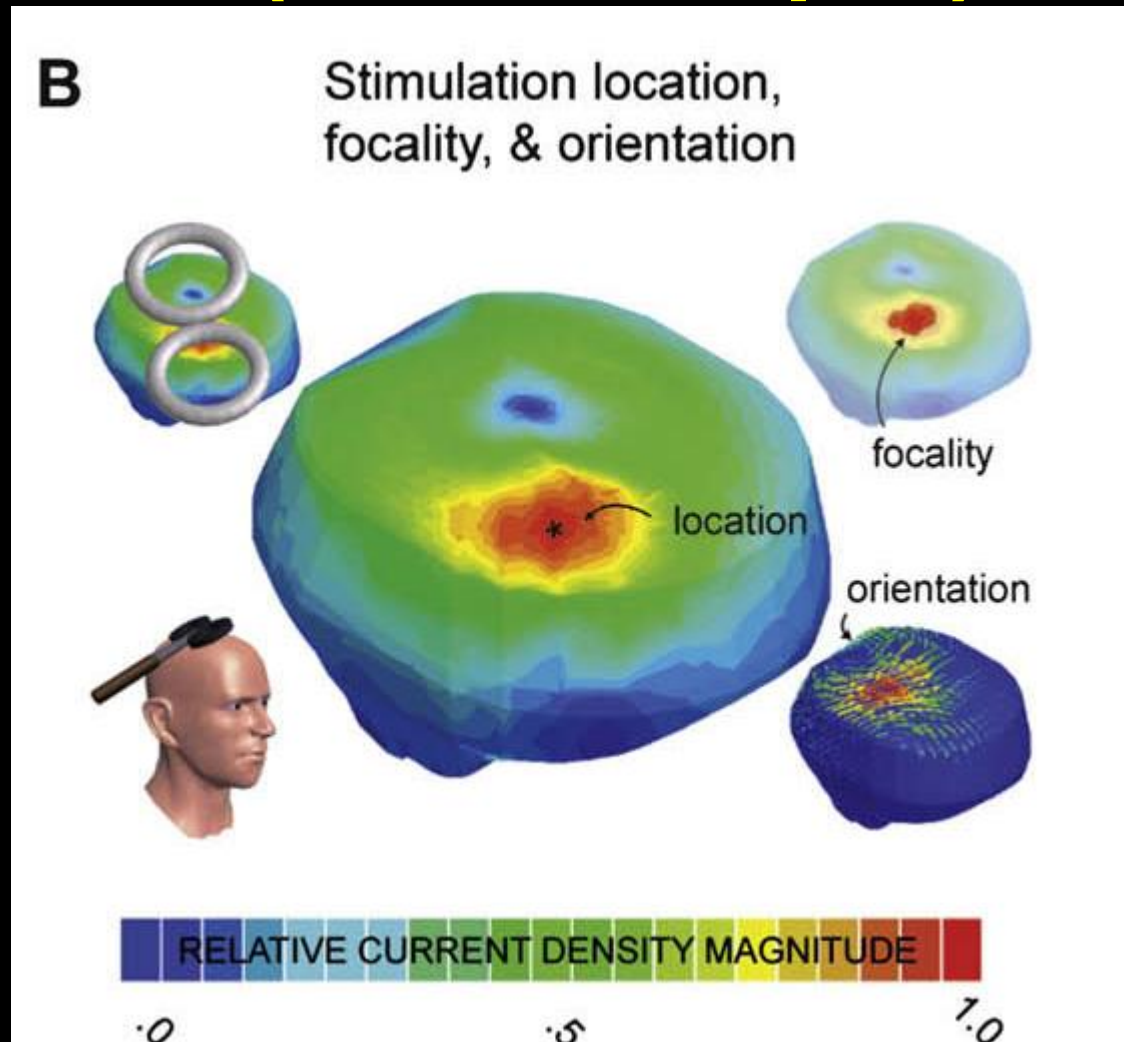


Pass through Scalp



Action Potentials

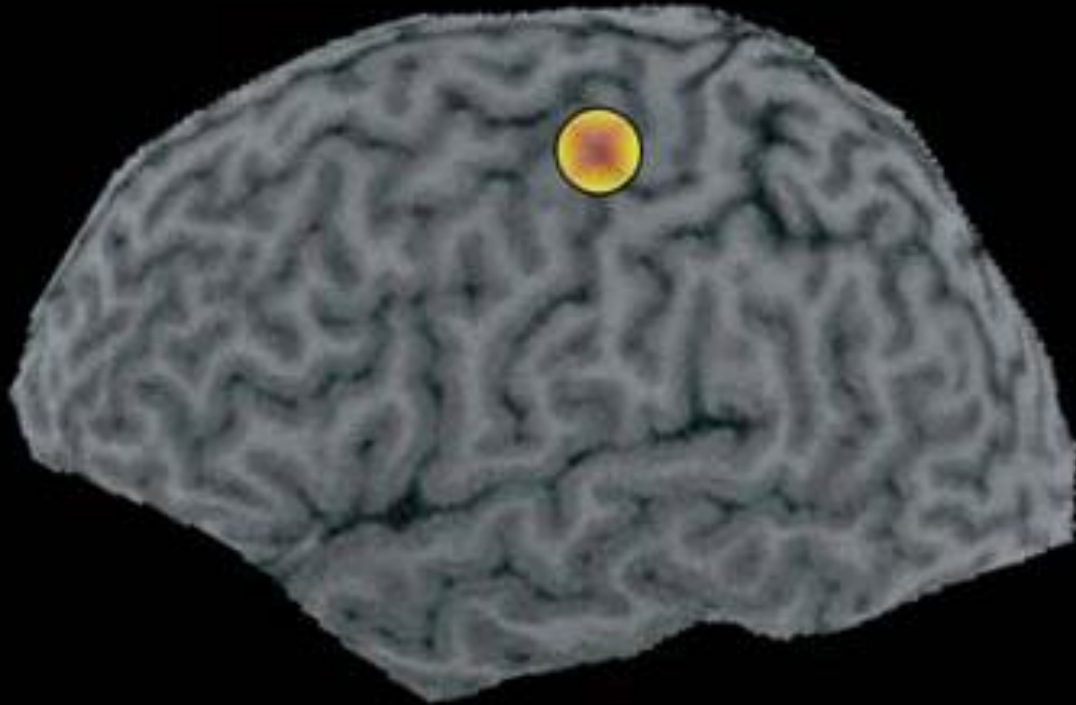
Focal Cortical Stimulation (limited depth)



Parameters

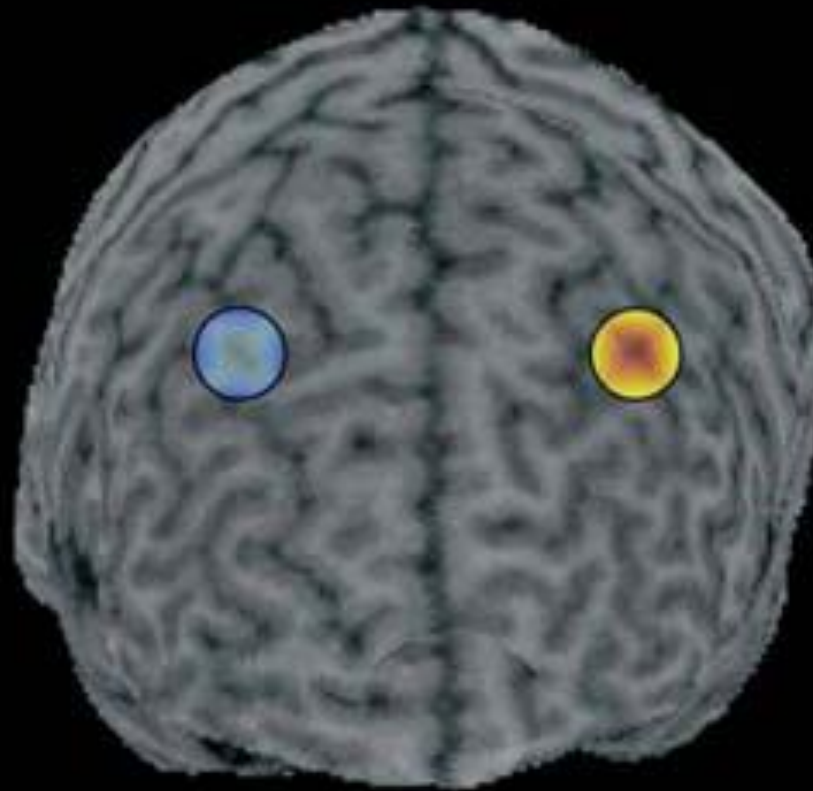
- **Frequency**
 - High (fast->5 Hz.) -> excitatory
 - Low (slow- 1 Hz. or less) -> suppressive
- **Intensity Metrics**
 - % Maximum Device Output
 - % Motor Cortex Threshold
- **Duration**
- **Pattern of Pulses**

Motor Hot Spot



Fregni, Freedman, Pascual-Leone, 2007

Frontal Cortex (Dorsolateral Prefrontal Cortex)

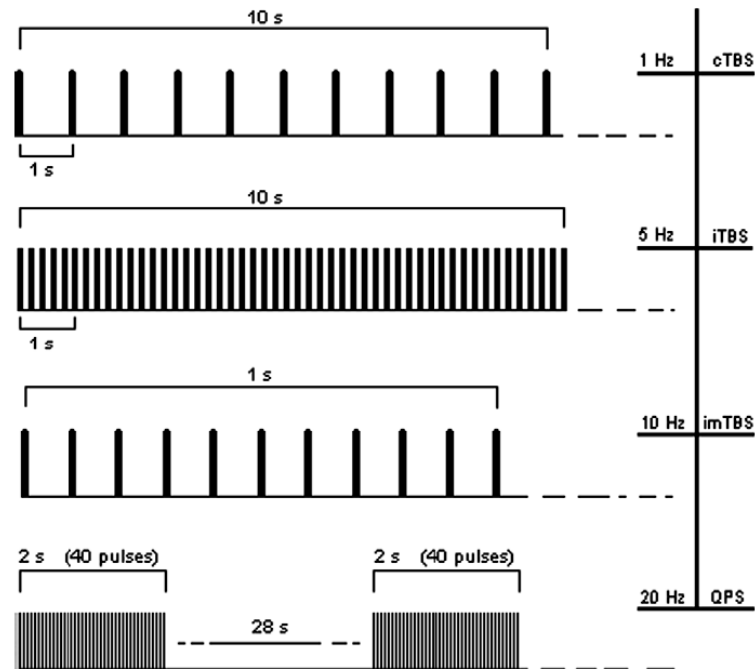


Parameters

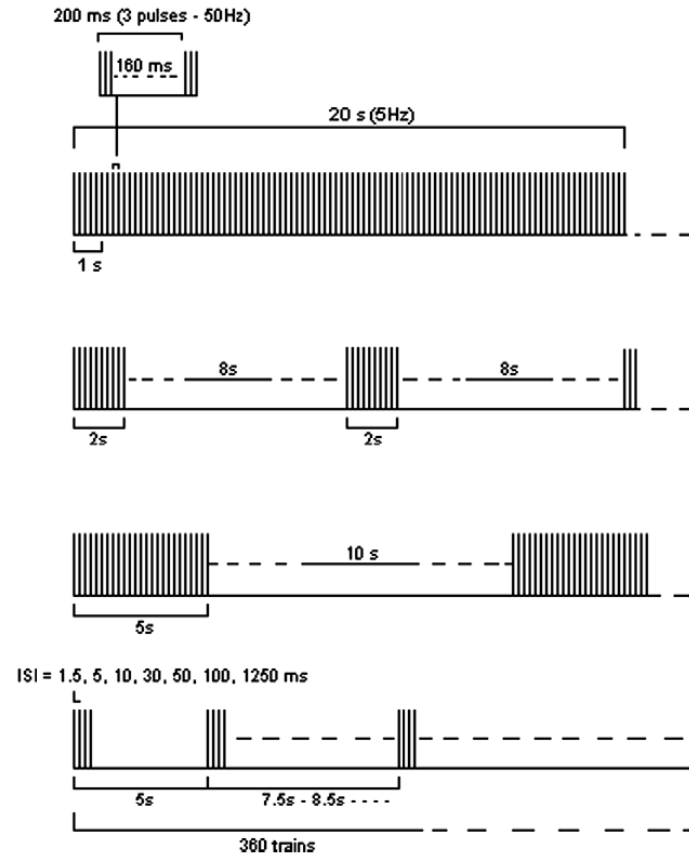
- **Frequency**
 - High (fast->5 Hz.) -> excitatory
 - Low (slow- 1 Hz. or less) -> suppressive
- **Intensity Metrics**
 - % Maximum Device Output
 - % Motor Cortex Threshold
- **Duration**
- **Pattern of Pulses**
 - Single, paired pulse, repetitive, theta burst

Pattern of Pulses

Conventional rTMS

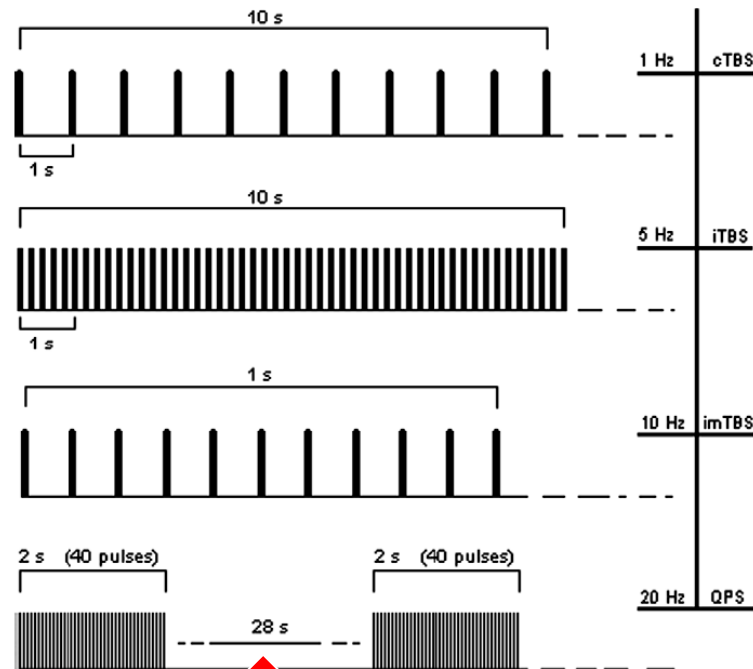


Patterned rTMS

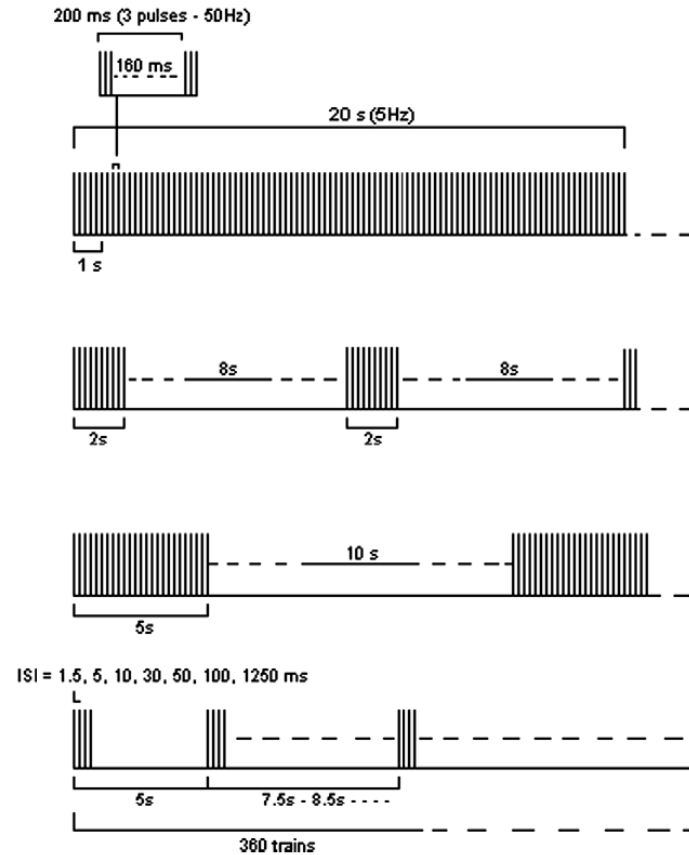


Pattern of Pulses

Conventional rTMS

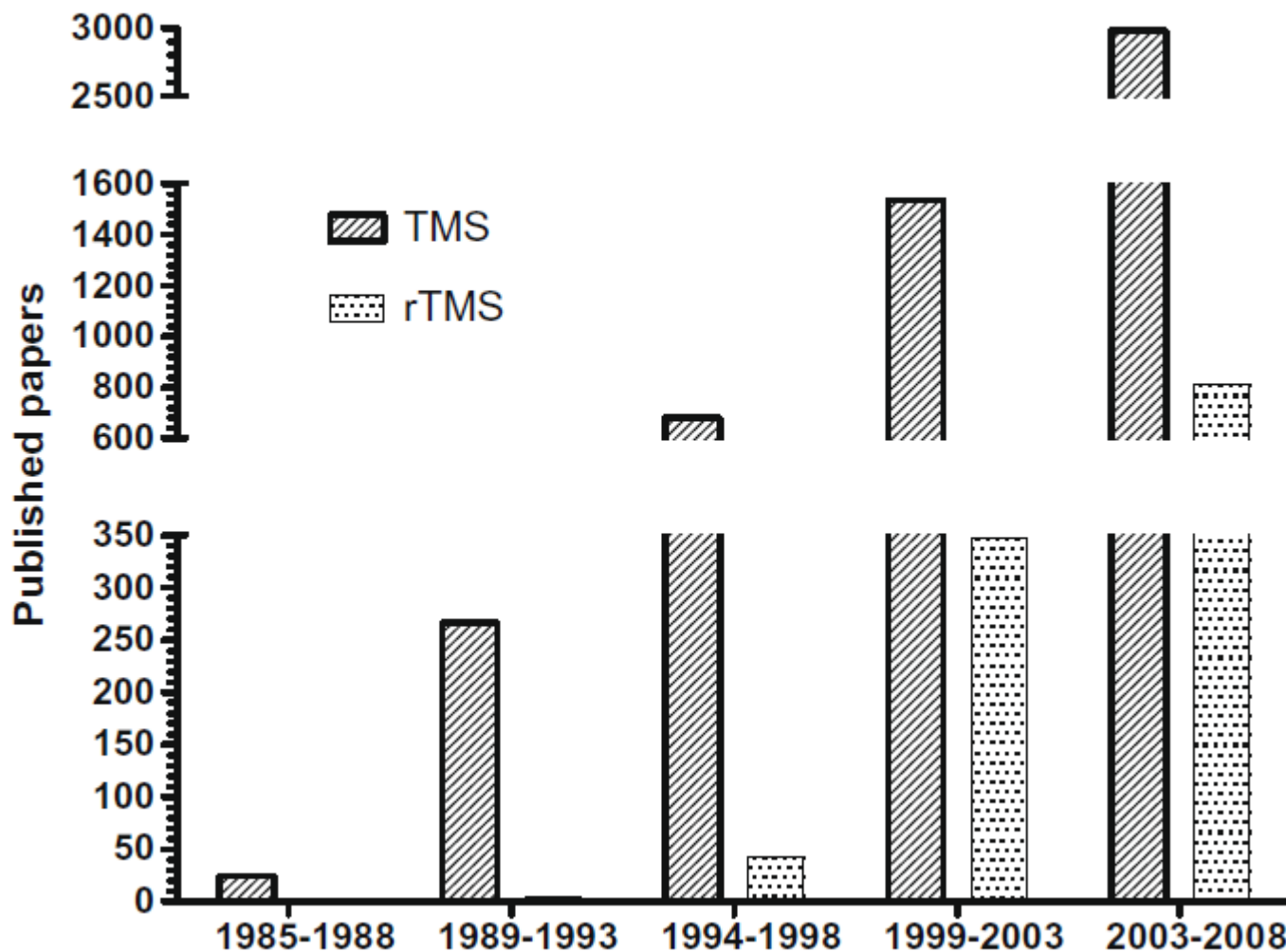


Patterned rTMS



Intertrain Interval

TMS Papers Published



Rossi et al., 2009

Current Guidelines

1. Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research.

Rossi S, Hallett M, Rossini PM, Pascual-Leone A; Safety of TMS Consensus Group.

Clin Neurophysiol. 2009 Dec;120(12):2008-39.

2. Safety of different inter-train intervals for repetitive transcranial magnetic stimulation and recommendations for safe ranges of stimulation parameters.

Chen R, Gerloff C, Classen J, Wassermann EM, Hallett M, Cohen LG.

Electroencephalogr Clin Neurophysiol 1997;105:415–21.

Safety of TMS

Side Effects

Mild Headache

Mild Discomfort at sight of stimulation

**Temporary increase in auditory threshold
(without ear plugs)**

Syncope

Induce Mania (rare)

Induce Seizure (rare)

Safety of TMS

Contraindications

Cochlear implant

Aneurysm clips

Brain electrodes

Ferromagnetic material in their head or neck

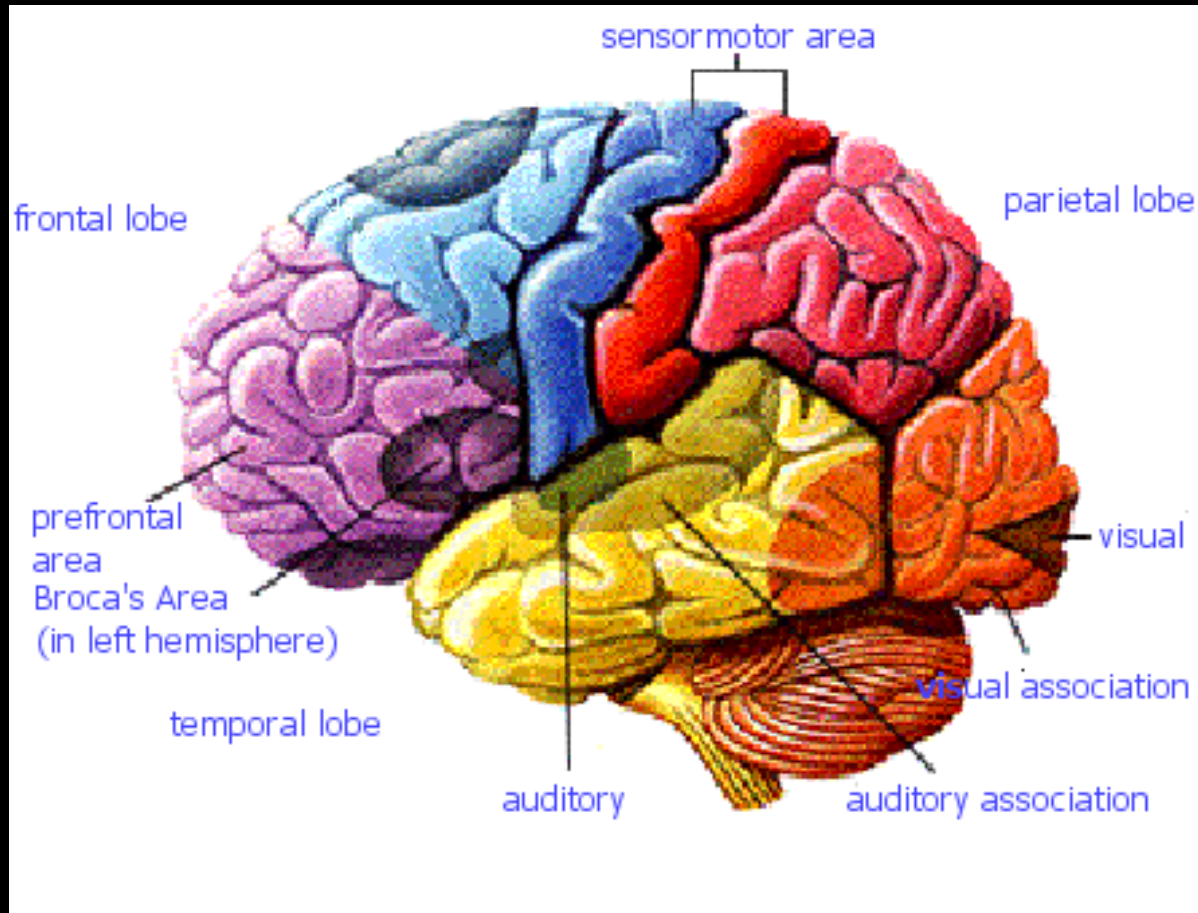
Stroke

Head trauma

Pregnancy

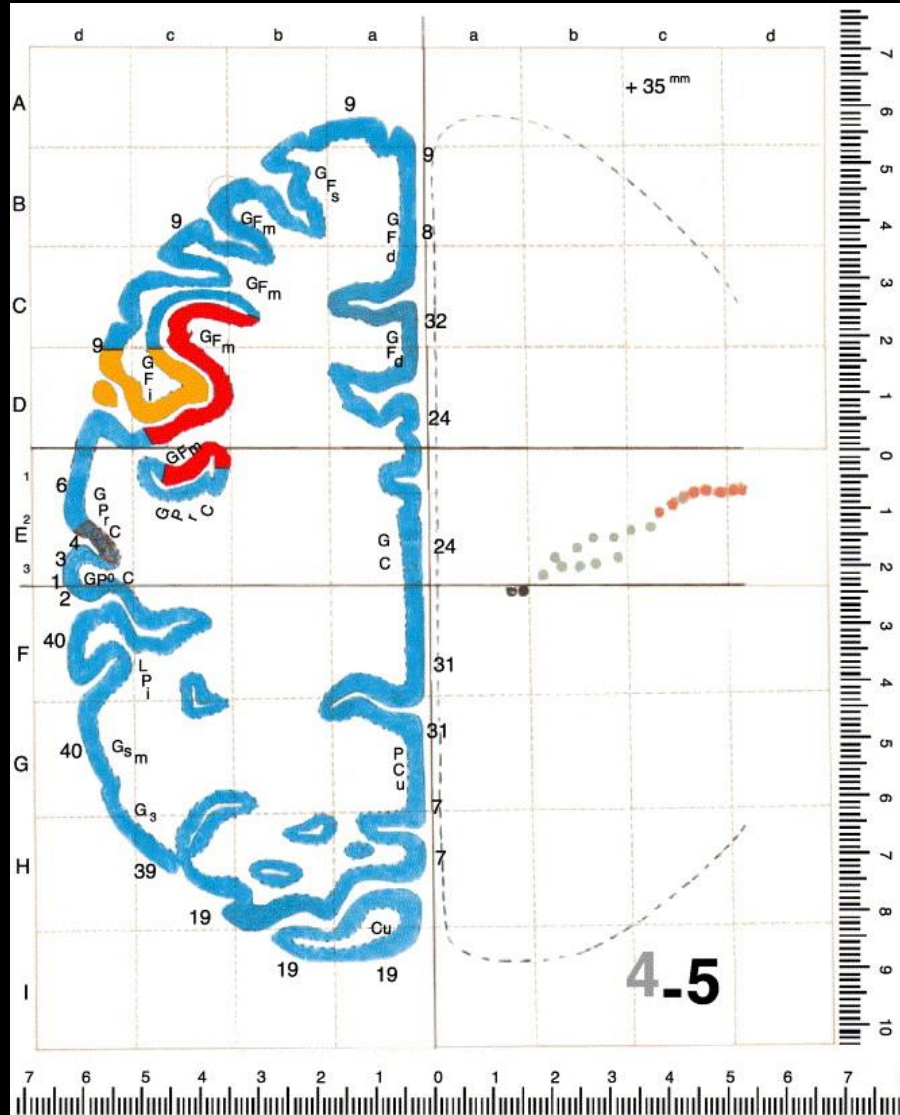
Cardiac pacemaker

Frontal Lobe Target

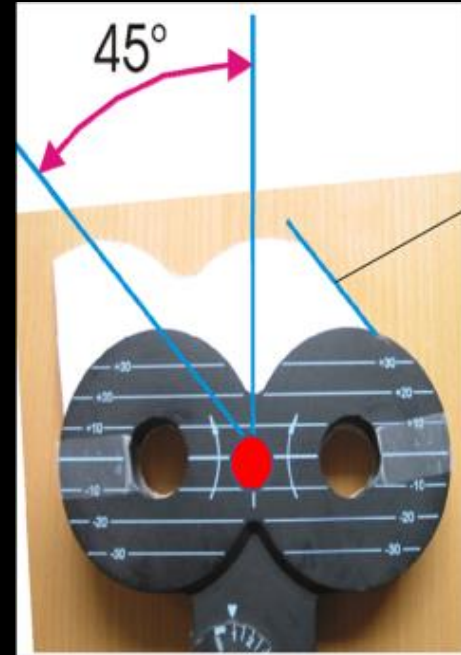


<http://www.mrc-cbu.cam.ac.uk/people/jessica.grahn/neuroanatomy.html>

Talairach Atlas



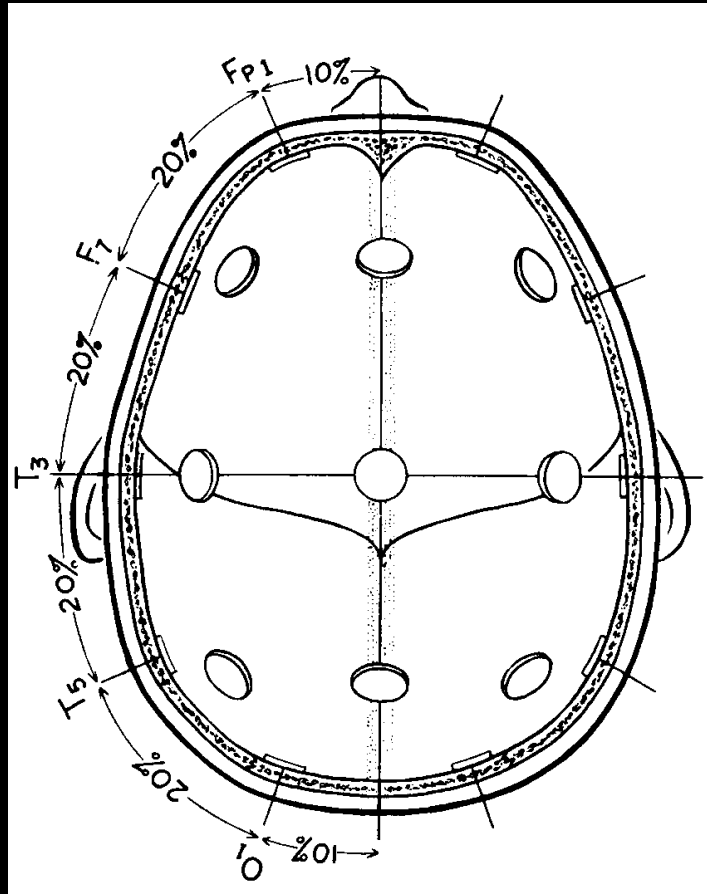
Current Practice: 5 cm Rule



5 cm rule



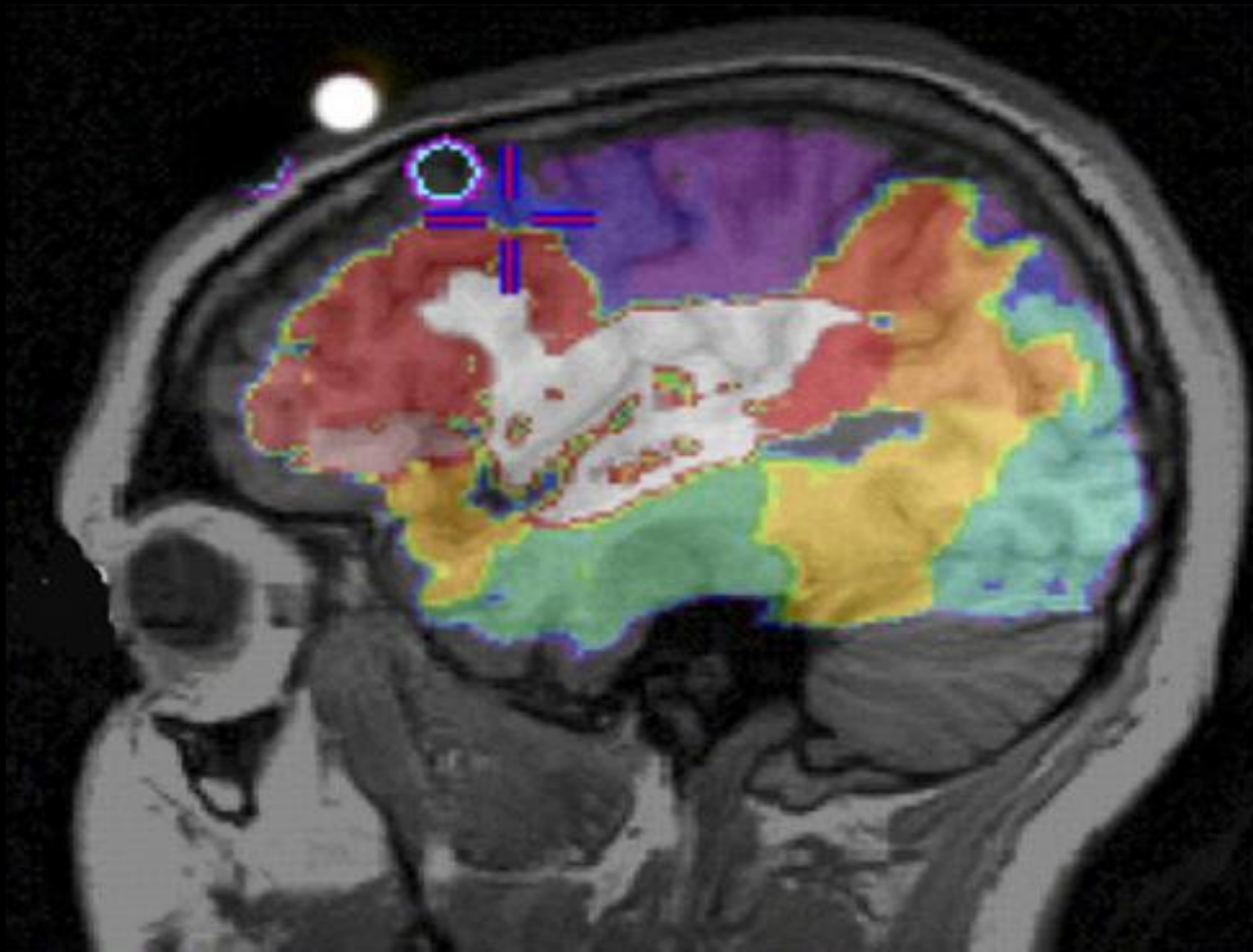
EEG



Beam F3 method is better and more efficient
<http://www.clinicalresearcher.org/software.htm>

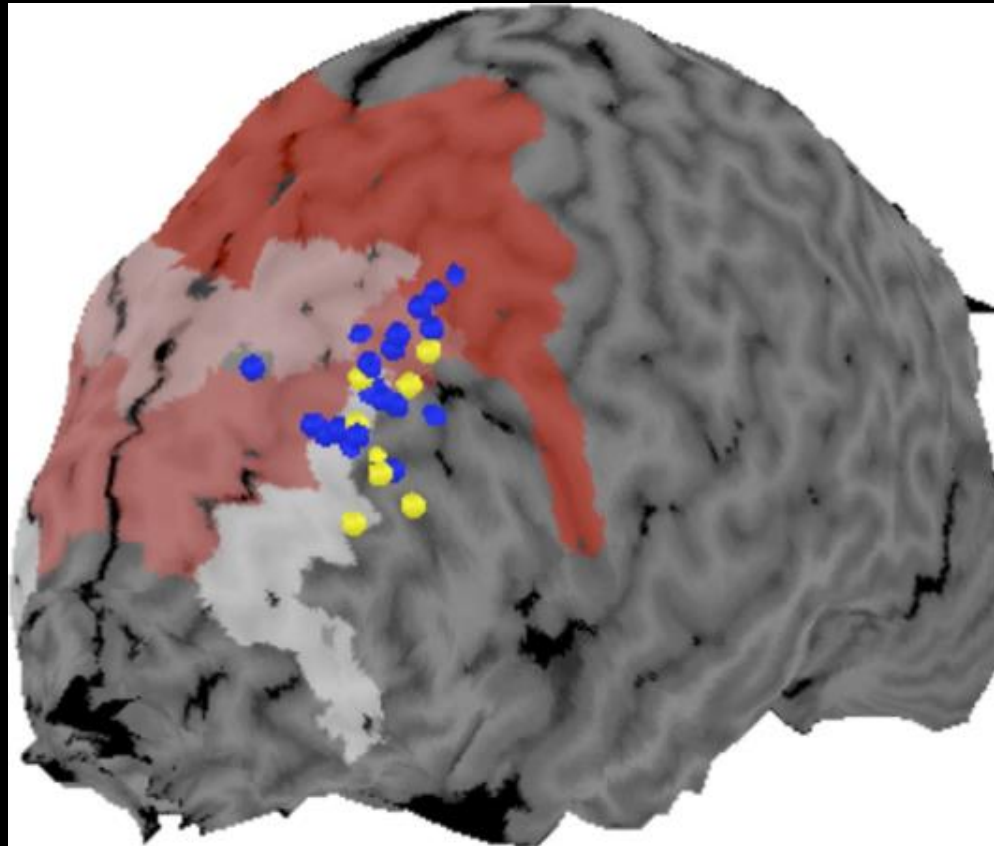
Why Should Do Both Imaging and Stimulation?

Fiducial Marker of TMS



Herbsman et al., 2009

Anterior and Lateral Remitted from Depression



Yellow=remit

Herbsman et al., 2009

Feedback On Location

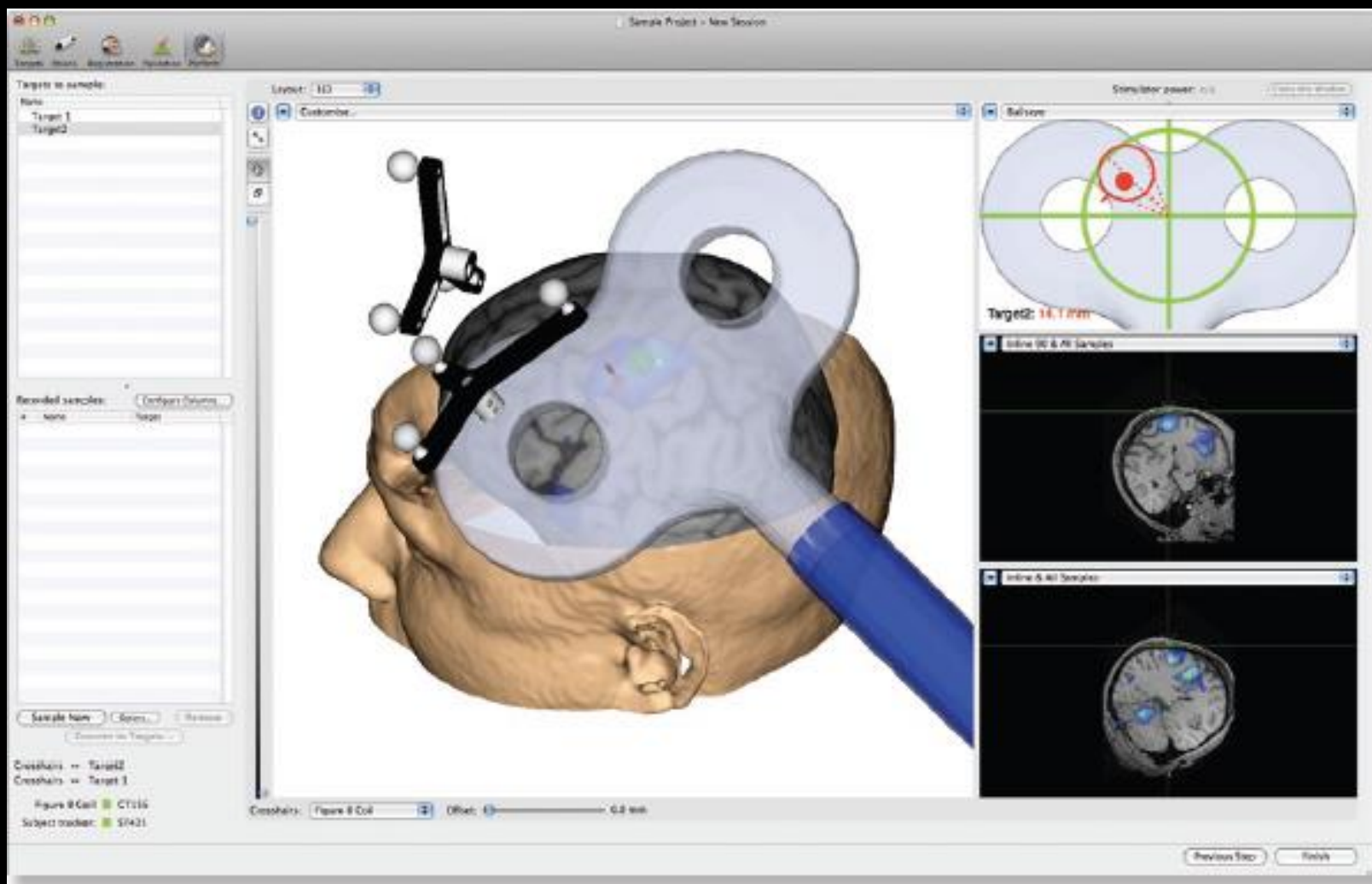
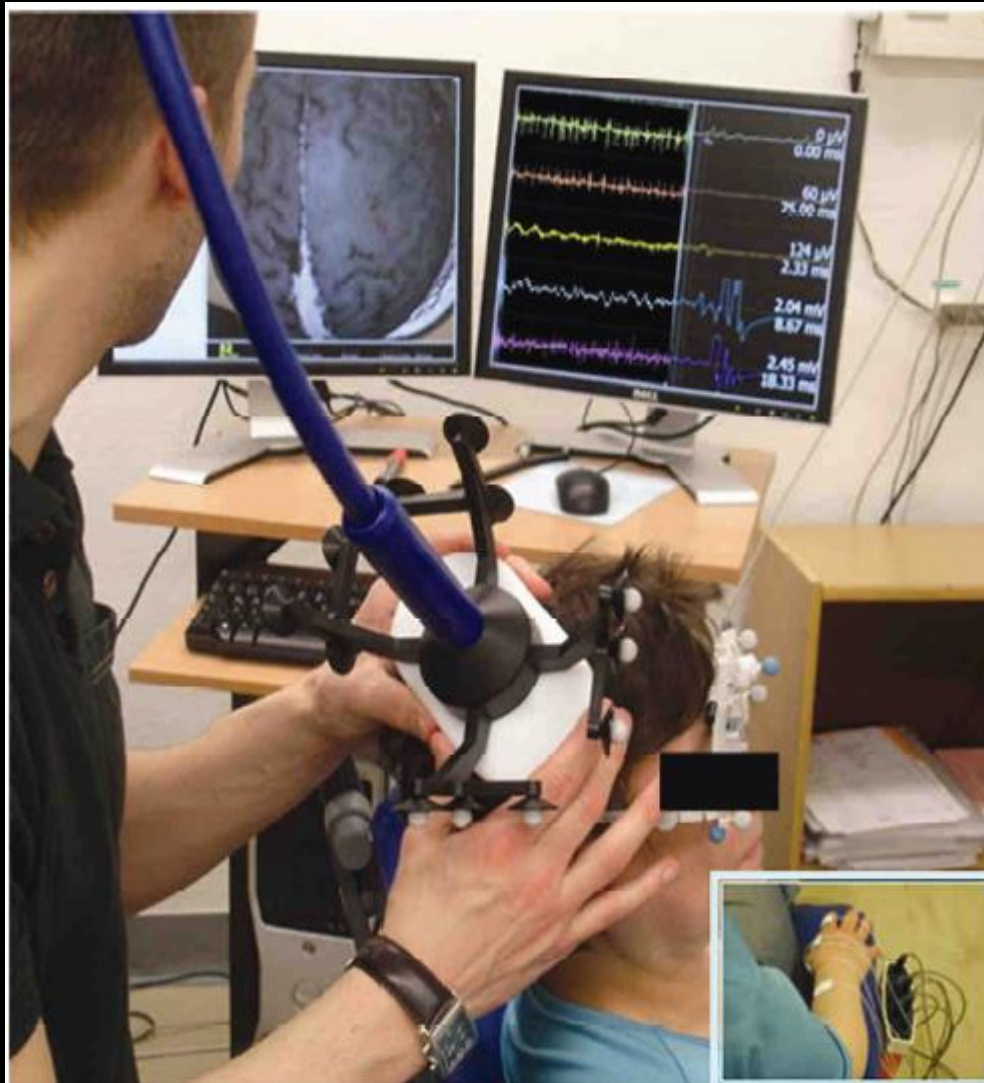


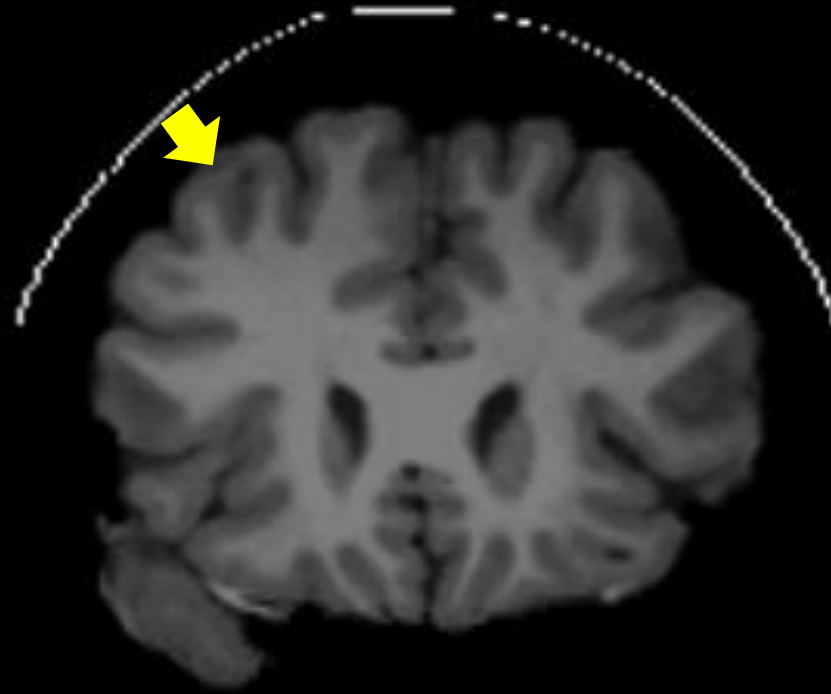
Image Guided TMS



eXimia NBS system

Picht et al., 2011

TMS Distance From Brain



Summary

- **TMS is FDA approved for depression and there are many other off label applications with promise**
- **Know the safety guidelines!!!**
- **The temporal pattern of rTMS is crucially important for the effect on the brain**
- **MRI guided TMS is most accurate for brain targeting and EEG based landmarks are next best but fixed distance is worst (e.g. 5 cm rule)**