

# TMS (Transcranial Magnetic Stimulation)

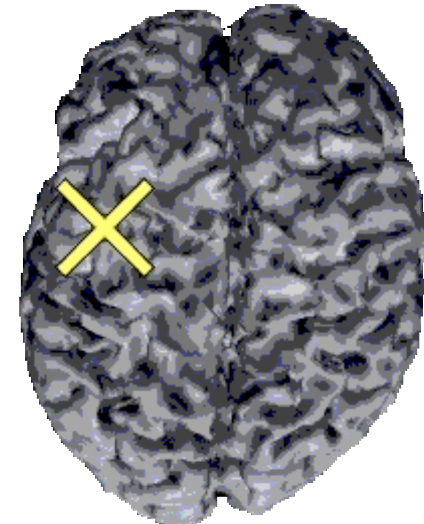
- A changing magnetic field induces electric currents in the brain, causing depolarization of cellular membranes and thereby neuronal activation!



MEG: measure magnetic field



TMS: administer magnetic field.



Neuronal activity caused by TMS and recorded by high resolution EEG.

Ilmoniemi RJ, Virtanen J, [Ruohonen J](#), et al. "Neuronal responses to magnetic stimulation reveal cortical reactivity and connectivity". *NeuroReport* 8: 3537-3540, 1997 1

# TMS (Transcranial Magnetic Stimulation)

- (Cognitive) neuroscience generally involves correlational reasoning: e.g. delay in reaction time correlates with increased activity in an area
- TMS allows for causal reasoning!
- TMS works best for the motor cortex (e.g. it is apparently pretty easy to make a person's thumb twitch..)
- It's usefulness for ***cognitive*** neuroscience is still highly debated.

Sakai K, Noguchi Y, Takeuchi T, Watanabe E. *Selective Priming of Syntactic Processing by Event-Related Transcranial Magnetic Stimulation of Broca's Area*. Neuron. 2002; 35(6): 1177.

- What is the role of Broca's area?
  - Articulatory deficit (remember the early days...)?
  - Lexical access problem?
  - Syntax?
- Administer TMS to Broca's area  
(F3op (pars opercularis, BA 44) / F3t (pars triangularis, BA 45)).
- By “zapping” Broca's area, can we selectively improve syntactic performance?

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- First: determine the position of Broca's area and left middle frontal gyrus for each subject individually.

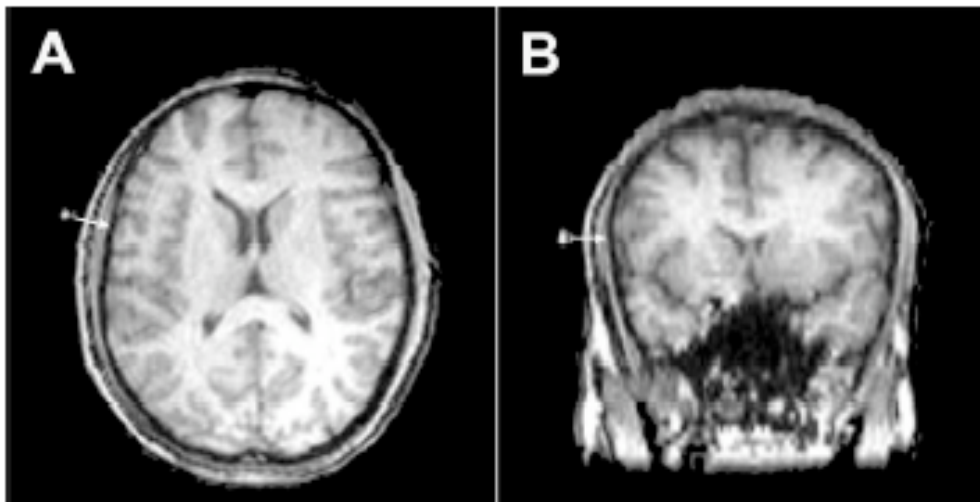


Figure 1. The Targeted Regions in the Left Prefrontal Cortex

Horizontal (A) and coronal (B) MR images indicating the position of the TMS coil for a representative subject. In each panel, the nearest MR marker to the center of the coil, which locates over the center of the left F3op/F3t, is shown (arrow for the stimulated site). The stimulation sites in the left F3op/F3t and in the left F2 are labeled as sites I and II, respectively, on the lateral surface image of the MNI standard brain (C). a, the precentral sulcus; b, the inferior frontal sulcus; c, the superior frontal sulcus.

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• Design

Session 1:

Syntactic decisions with TMS to Broca's area vs. without.

At 0ms  
150ms  
350ms after verb.

Grammatical or not?

Session 2:

Semantic decisions with TMS to Broca's area vs. without.

At 0ms  
150ms  
350ms after verb.

Anomalous or not?

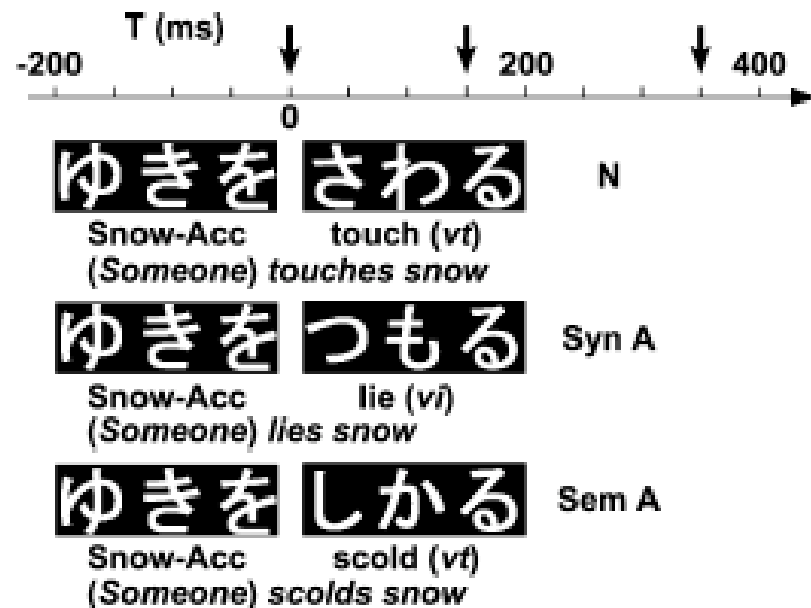


Figure 2. Language Tasks with a Minimal Pair Paradigm  
Normal (N) sentences used in the two tasks were physically identical. In a syntactic decision (Syn) task, syntactically anomalous (Syn A) sentences were intermixed with normal sentences. In a semantic decision (Sem) task, semantically anomalous (Sem A) sentences were intermixed with normal sentences. Arrows on the time scale indicate three time points of TMS: T = 0, 150, and 350 ms from the presentation of a verb. Acc, accusative case particle; vt, transitive verb; vi, intransitive verb.

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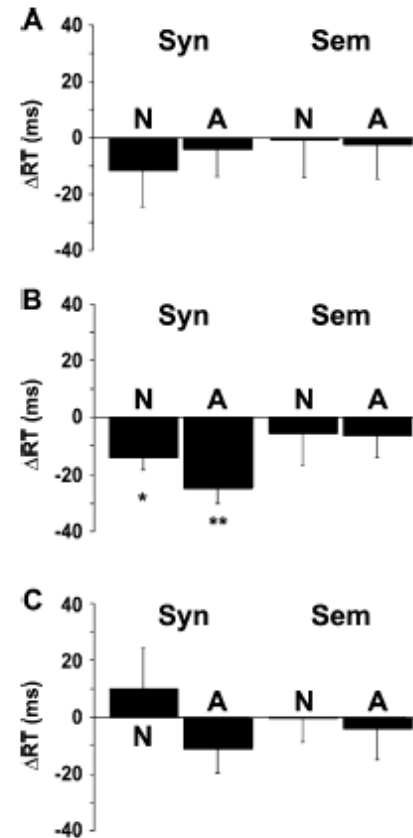
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Anomalous or not?



T = 0 ms

All. n.s.

T = 150 ms

Syntactic priming

T = 350 ms

All n.s.

Figure 3. Selective Priming Effects of TMS on Syntactic Processing at the Left F3cp/F3t

ΔRT (mean and standard error across subjects) indicates the change of RTs (Real - Sham) elicited by the TMS. Each bar denotes ΔRT for either normal (N) or anomalous (A) sentences. TMS was delivered at one of three time points: 0 ms (A), 150 ms (B), and 350 ms (C) from the presentation of a verb. \*p < 0.05, \*\*p < 0.01 (t test, n = 6).

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- Is this caused by zapping Broca's area or just by zapping?
- To determine this, syntactic judgments were made while the left middle frontal gyrus (F2, ~39 mm away from Broca's area) was zapped.
  - TMS was administered only at 150ms.

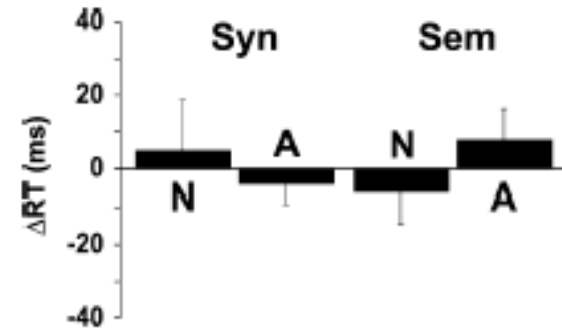


Figure 4. The Absence of TMS Effects on the Language Tasks at the Left F2  
Each bar denotes  $\Delta RT$  for either N or A sentences. TMS was delivered at 150 ms from the presentation of a verb.

## BROCA'S AREA IMPLICATED FOR:

- Center-embedded vs. right-branching structures

*The juice that the child spilled \_ stained the rug.*

*The child spilled the juice that \_ stained the rug.*

- Syntactic transformations

*I helped the girl that Mary saw \_ in the park.*

*I told Mary that the girl ran in the park.*

- Metalinguistic syntactic decisions

# BROCA'S APHASIA

- Only 85 percent of patients with chronic Broca's aphasia have lesions in Broca's area
- Only 50-60 percent of patients with lesions in Broca's area have a persisting Broca's aphasia. (N. Dronkers, *Brain and Language*, 2000)

## Diagnosis

»Following brain injury, an initial bedside assessment is made to determine whether language function has been affected. If the individual experiences difficulty communicating, attempts are made to determine whether this difficulty arises from impaired language comprehension or an impaired ability to speak. A typical examination involves listening to spontaneous speech and evaluating the individual's ability to recognize and name objects, comprehend what is heard, and repeat sample words and phrases. The individual may also be asked to read text aloud and explain what the passage means. In addition, writing ability is evaluated by having the individual copy text, transcribe dictated text, and write something without prompting.

»A speech pathologist or neuropsychologist may be asked to conduct more extensive examinations using in-depth, standardized tests. Commonly used tests include the Boston Diagnostic Aphasia Examination, the Western Aphasia Battery, and possibly, the Porch Index of Speech Ability.

»The results of these tests indicate the severity of the aphasia and may also provide information regarding the exact location of the brain damage. This more extensive testing is also designed to provide the information necessary to design an individualized speech therapy program. Further information about the location of the damage is gained through the use of imaging technology, such as [magnetic resonance imaging](#) (MRI) and [computed tomography scans](#) (CT).

(<http://www.hendrickhealth.org/healthy/000137.htm>)

# BROCA'S APHASIA

- Sharon Thompson-Schill: inferior frontal gyrus involved in semantic selection (say in a verb generation task).