Using TMS and EEG to Probe Task-Dependent Changes in Natural Frequencies

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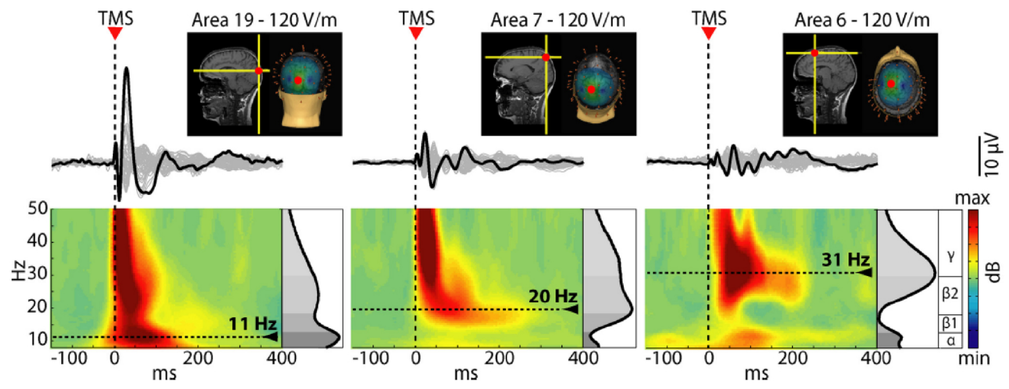
Introduction

- A recent study using TMS to perturb specific corticothalamic circuits (extrastriate, parietal, premotorcortex), and high-density EEG to measure the resultant evoked responses, showed that eachresonated at a unique 'natural frequency' when participants were at rest

(Rosanova, et al., JNeuro 2009)



- What remains unknown, is whether a region's natural frequency varies with behavioral context

Question: Do natural frequency estimates for a given brain area change in systematic ways when that brain area is involved in the performance of a task?

Methods: SPL TMS + hdEEG

Approach: Perturb SPL with TMS 1) While subjects are at Rest, and 2) During the delay period of a spatial delayed recognition task

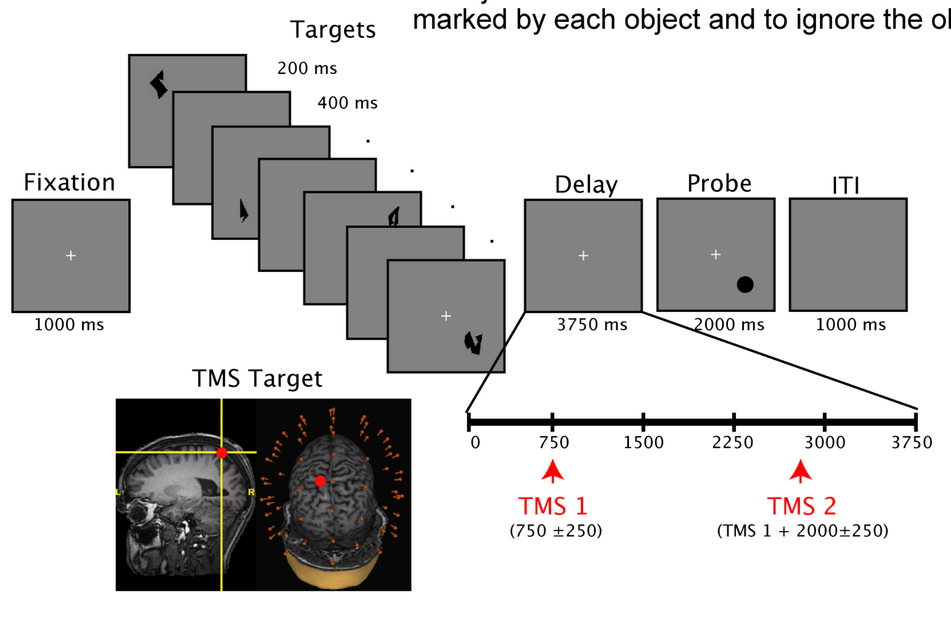
Subjects. 11 Subjects (7 Males) aged 19-30 (Mean=21.82 yrs)

Procedure.

- Single session lasting ~3-3.5 hrs
- Rest and Task blocks counterbalanced across subjects:
  - **Rest block**: 160 TMS pulses delivered at 0.5 Hz (±250 ms) while Ss maintained central fixation (no concurrent task, as in Rosanova, et al. (2009)
  - **Task Block:** 160 delayed recognition trials, with two TMS pulses delivered during the delay period on half of trials (randomized)

Task

* Subjects were instructed to remember the locations marked by each object and to ignore the object's identity



TMS.

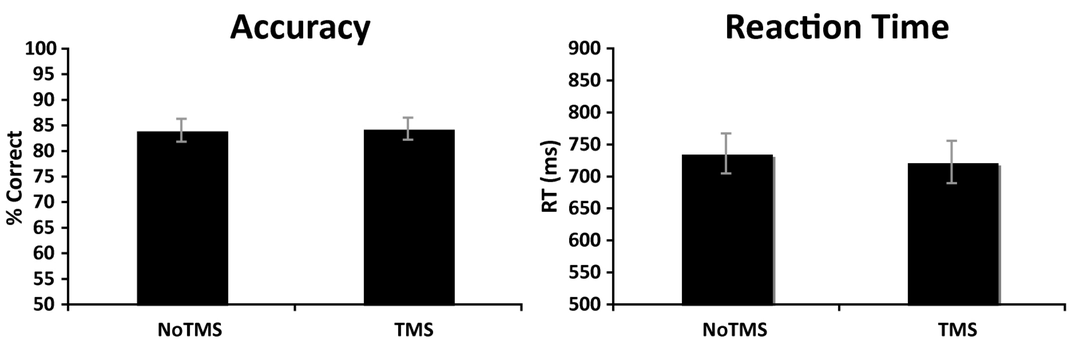
- TMS target location was controlled with a Navigated Brain Stimulation (NBS) system that uses IR-based frameless stereotaxy to map the position of the coil and the subject's head within the reference space of individual high-res sMRI
- TMS intensity varied from 110-140 V/m across Ss (for a given subject, intensity and coil position were held constant across Rest and Task blocks)

EEG.

- EEG was recorded with a 60-channel TMS-compatible amplifier (Nexstim,Helsinki, Finland)
- Amplifier avoids saturation by TMS pulse by employing a sample-and-hold circuit that holds amplifier output constant from 100 µs pre- to 2 ms post-stimulus
- Data were acquired at 1450 Hz, downsampled (500 Hz) and filtered (2-80 Hz)

Results

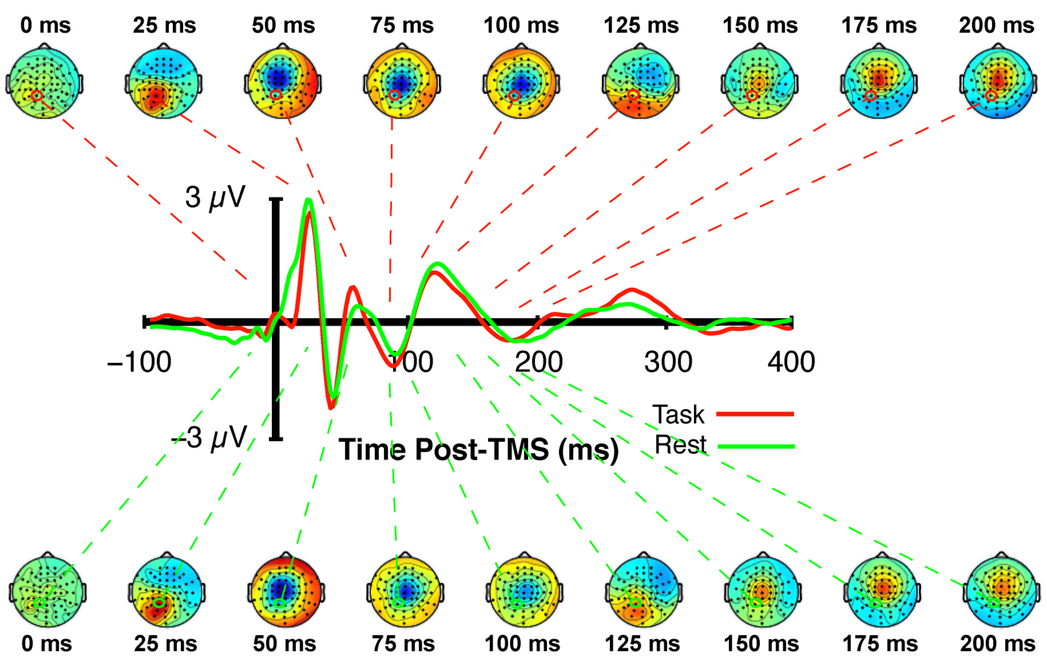
Behavior



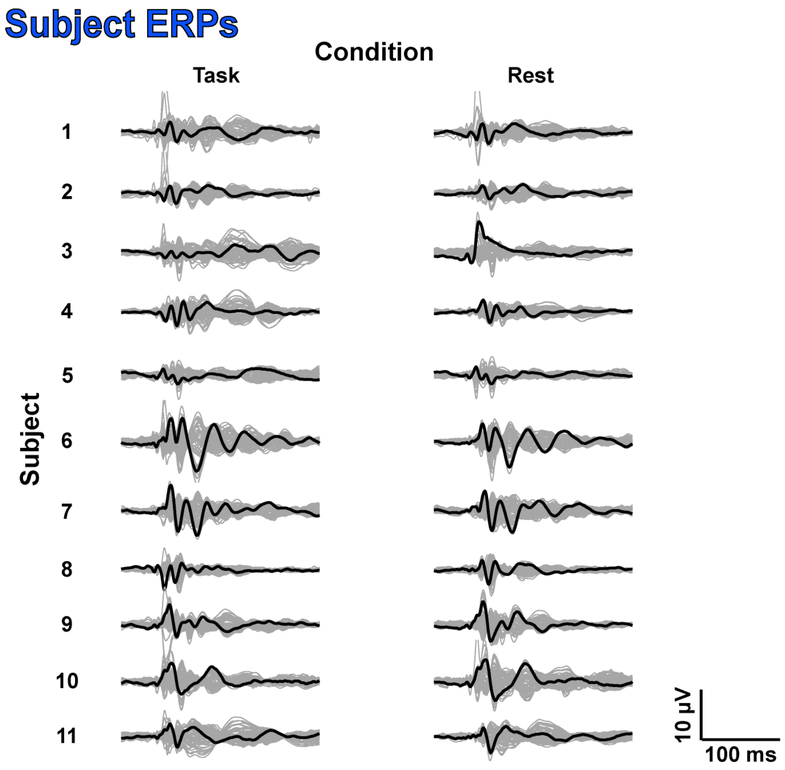
No effect of TMS on accuracy or reaction time measures of performance (all Fs<1)

EEG: Time Domain

Grand Averaged ERPs + topo plots



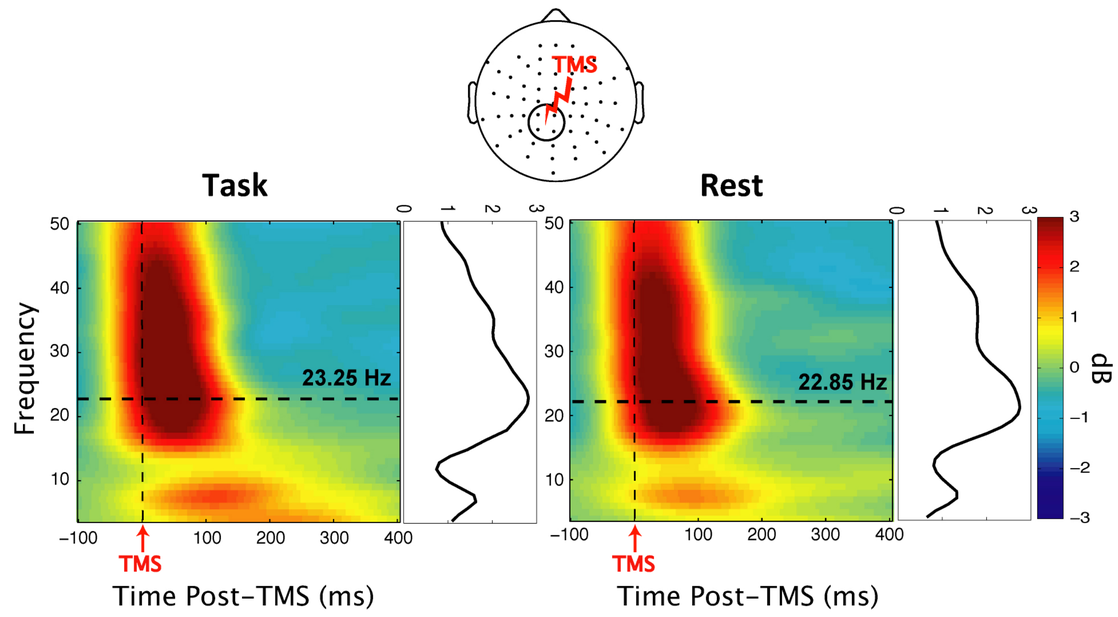
Single Subject ERPs



In each condition, TMS elicited a robust evoked response that was maximal within the first 100 ms, tapering off by ~200-300 ms. The topography and magnitude of the response was comparable across conditions.

EEG: Frequency Domain

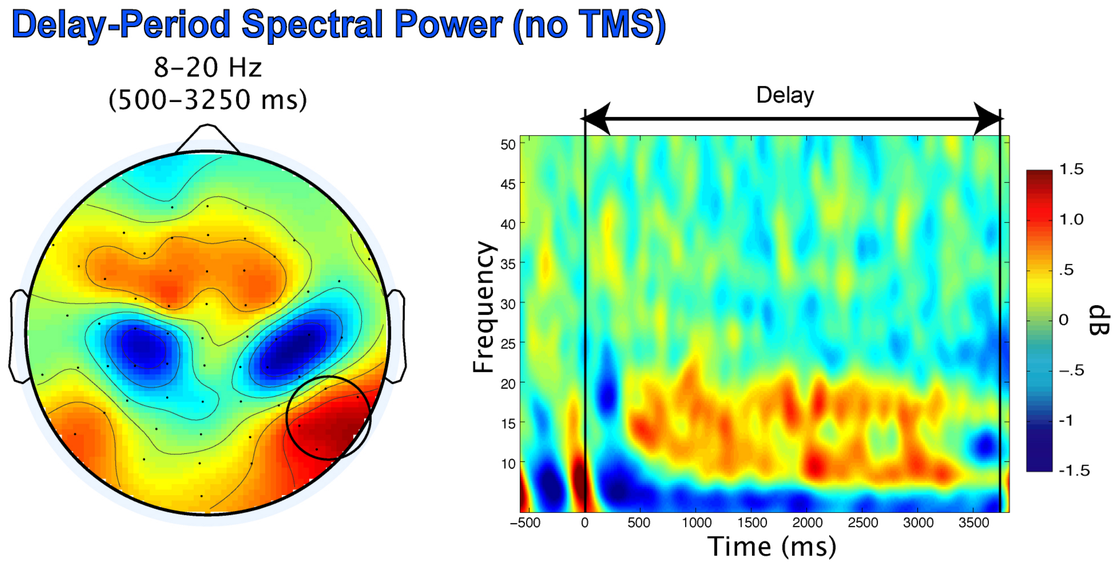
TMS-induced Event Related Spectral Perturbation (ERSP)



- The natural frequency was determined by calculating the average power across electrodes CP1, CPz, P1, and Pz from 20-200 ms post-TMS for each frequency (4-50 Hz) and finding the maximum

The frequency and magnitude of natural frequency estimates did not differ as a function of condition (all Fs<1)

Delay-Period Spectral Power (no TMS)



Sustained delay period power was maximal at posterior electrodes in the alpha and low-beta ranges (~8-20 Hz)

Conclusions

- Single pulses of TMS applied to the SPL produced a robust evoked response that was similar in magnitude and topography in the Rest versus Task conditions
- Similarly, natural frequency estimates were nearly identical in frequency and magnitude across conditions, suggesting that the natural frequency may be a relatively static property of corticothalamic circuits that remains largely intact irrespective of ongoing task-related activity.

References

Rosanova, M. Casali, A., Bellina, V., Resta, F., Mariotti, M., Massimini, M. (2009). Natural frequencies of human coticothalamic circuits. *Journal of Neuroscience*, 29, 7679-7685.

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