



TMS-Evoked Responses Vary With Underlying Brain State

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Introduction

TMS influences behavior:

- Repetitive TMS (10Hz) to SPL modulates alpha-band power and influences memory performance - perhaps through biasing endogenous cortical oscillations. (Hamidi et al., 2009).

Underlying oscillations also influence behavior:

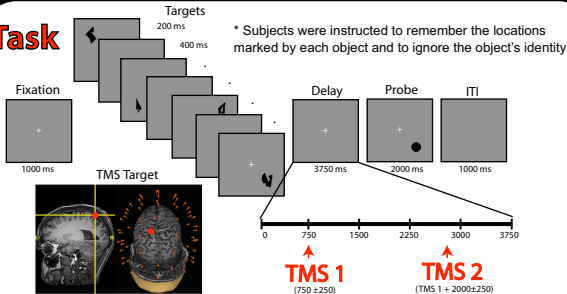
- Prestimulus alpha band power predicts phosphene perception (Romei et al., 2008)
- Prestimulus alpha band phase and power predicts perception (Busch et al., 2009; Mathewson et al., 2009; van Dijk et al., 2008).

Parameters that modulate the TMS-evoked response (ER):

- TMS-ER is modulated non-linearly by stimulation intensity (Komssi et al. 2004) and coil orientation (Bonato et al., 2006)
- TMS-ER (the "natural frequency") varies with brain region stimulated. Power correlates with stimulation intensity (Rosanova et al., 2009).
- TMS evoked natural frequency does not vary between task and rest states (unpublished data, see Jeffrey S. Johnson, poster # E116)

Does the power or phase of ongoing task-related oscillations modulate the TMS-evoked response?

Task



EEG

Approach: Perturb SPL with TMS during the delay period of a spatial delayed recognition task. 160 delayed recognition trials per subject (n=16), with two TMS pulses delivered during the delay period on half of trials (randomized).

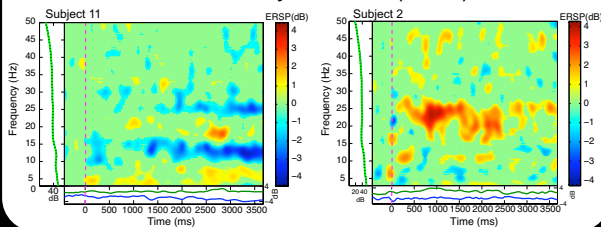
TMS

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

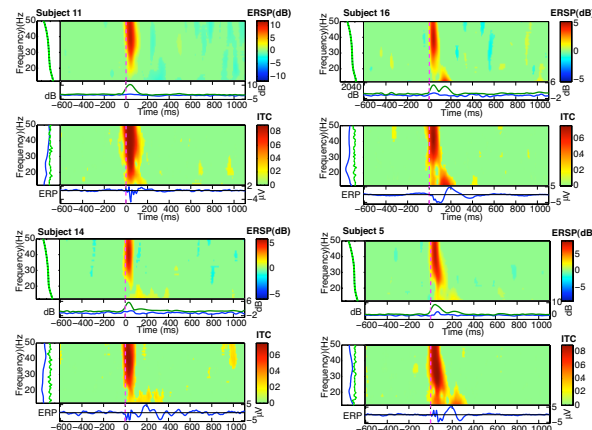
EEG

- Recorded with a 60-channel TMS-compatible amplifier (Nexstim, Helsinki, Finland).
- Sample-and-hold circuit holds amplifier output constant from 100 μ s pre- to 2 ms post-stimulus.
- Data were acquired at 1450 Hz, downsampled (500 Hz) and filtered (2-80 Hz) offline.

Sustained Delay Period Power (No TMS)



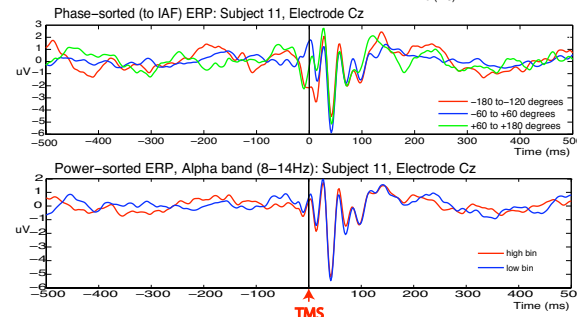
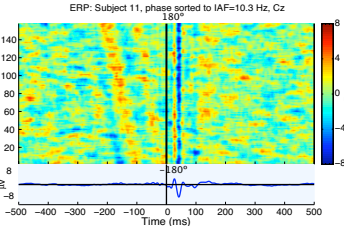
Results



The ERSP (event-related spectral perturbation) and ITC (inter-trial coherence) were consistently elevated over gamma and beta bands, but highly variable in form over alpha and theta bands across subjects (parametric bootstrap; $\alpha=0.05$).

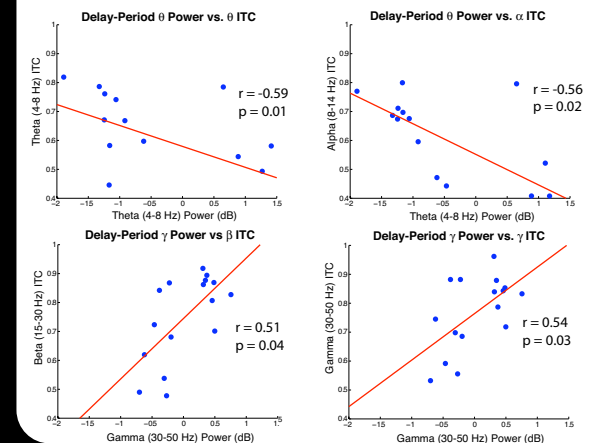
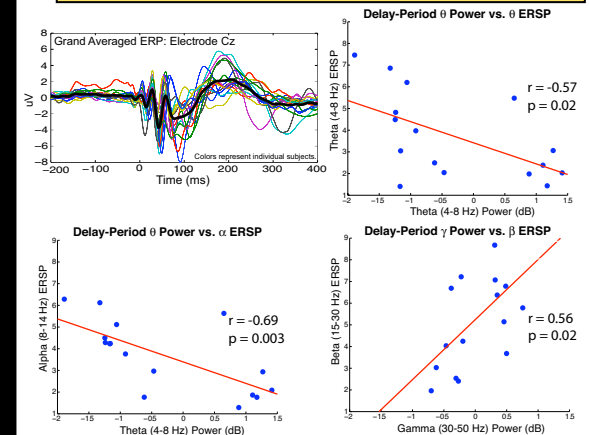
Does variability in the TMS-evoked response relate to underlying cortical oscillations on a trial-by-trial basis?

The TMS-evoked response does not appear to vary with phase across different frequency bands -- theta (4-8 Hz), alpha (8-14 Hz), beta (15-30 Hz), and gamma (30-50 Hz) -- or channels.



Repeated measures ANOVA found no significant relationship between TMS ER (global mean field power from 20-200 ms) and prestimulus phase or prestimulus power.

Does variability in the TMS-evoked response relate to individual differences in sustained delay-period activity in specific frequency bands?



Conclusions

- Neither prestimulus phase nor power of ongoing oscillations were predictive of the TMS-evoked response on a trial-by-trial basis.
- Individual differences in sustained delay-period power during task is predictive of the TMS-evoked ERSP and ITC magnitude.
- Future questions: Does sustained delay-period activity also predict TMS ER when the subject is at rest? Does sustained delay-period activity relate to a stable trait?