

# Delay-period neuronal oscillations are modulated by 10 Hz rTMS: A Simultaneous rTMS/EEG Study

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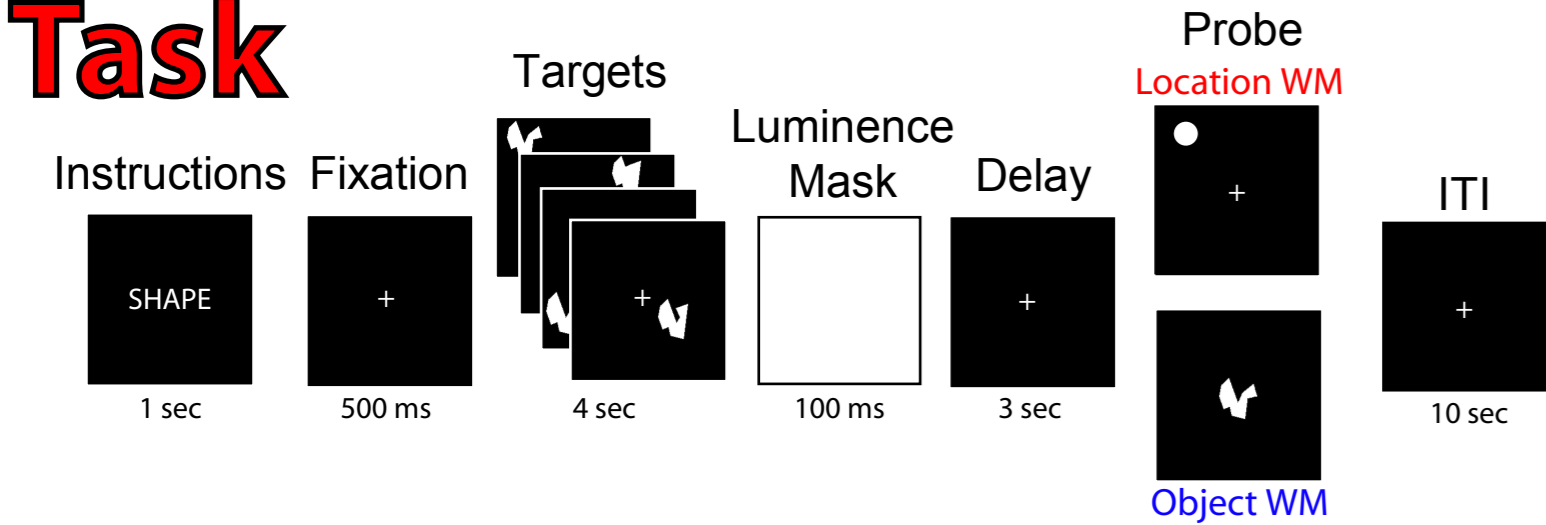


## Introduction

- High-frequency (> 1 Hz) repetitive transcranial magnetic stimulation (rTMS) is used to study cognition - "Virtual Lesion" or Interaction with endogenous activity?
- Previous data have shown that 10-Hz rTMS to dorsal visual stream areas improves spatial working memory performance (Hamidi et al., 2008).
- Behavioral effect of rTMS is sensitive to the frequency of stimulation (Klimesch et al., 2004).
- rTMS is known to alter neuronal oscillations (Brignani et al., 2008; Fuggetta et al., 2008; Fuggetta et al., 2005; Thut et al., 2003).
- Retention of information in working memory has been associated with an increase  $\alpha$ -band (8.5-14 Hz) power (e.g., Jensen et al., 2002).

Is 10-Hz rTMS interacting with working memory-related  $\alpha$ -band oscillations to improve task performance?

## Task



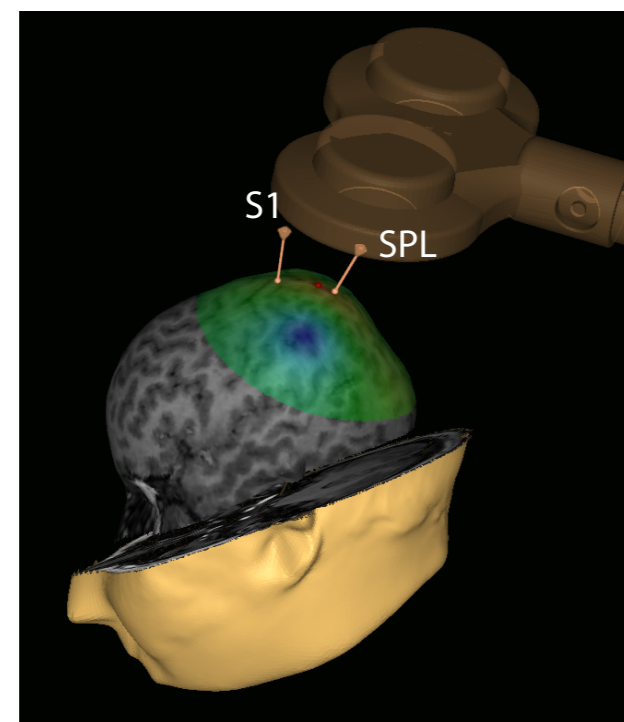
- Target: 4 abstract shapes (Arnoult and Attneave, 1956) presented one at a time (for 1 sec) at random locations, one in each quadrant of the screen.
- Probe: required Y/N recognition decision; matched a target location or shape with  $p=0.5$ .
- Location and object memory trials were randomly interleaved.

## EEG

- Data were recorded with a 60-electrode TMS-compatible cap (Nexstim, Helsinki).
  - sample-and-hold circuit minimizes TMS-induced electrical artifact by holding amplifier output constant from 100  $\mu$ s pre- to 2 ms post-TMS pulse (Virtanen et al., 1999).
  - Data acquired at 1450 Hz, filtered (0.1 to 500 Hz) and down-sampled to 500 Hz.

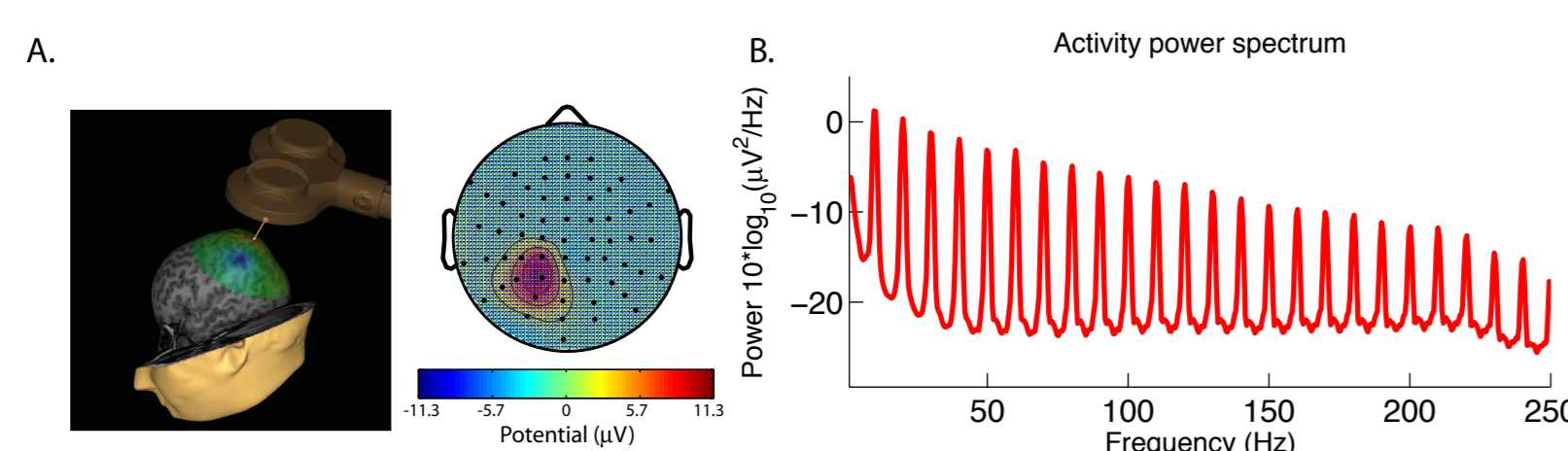
## rTMS

- Each subject's head was coregistered with his/her MRI using eXimia Navigated Brain Stimulation (NBS) frameless stereotaxy navigation system (Nexstim).
- rTMS (10 Hz, 110% MT, 3 sec. - Magstim Standard Rapid, Whitland, UK) coincided with the onset of the delay-period on half the trials (randomly distributed).
- Stimulation intensity was corrected for scalp-to-cortex distance (Stokes et al., 2005).
- Location of targets determined by individual anatomy.
- Somatosensory cortex (S1) served as a stimulation control area



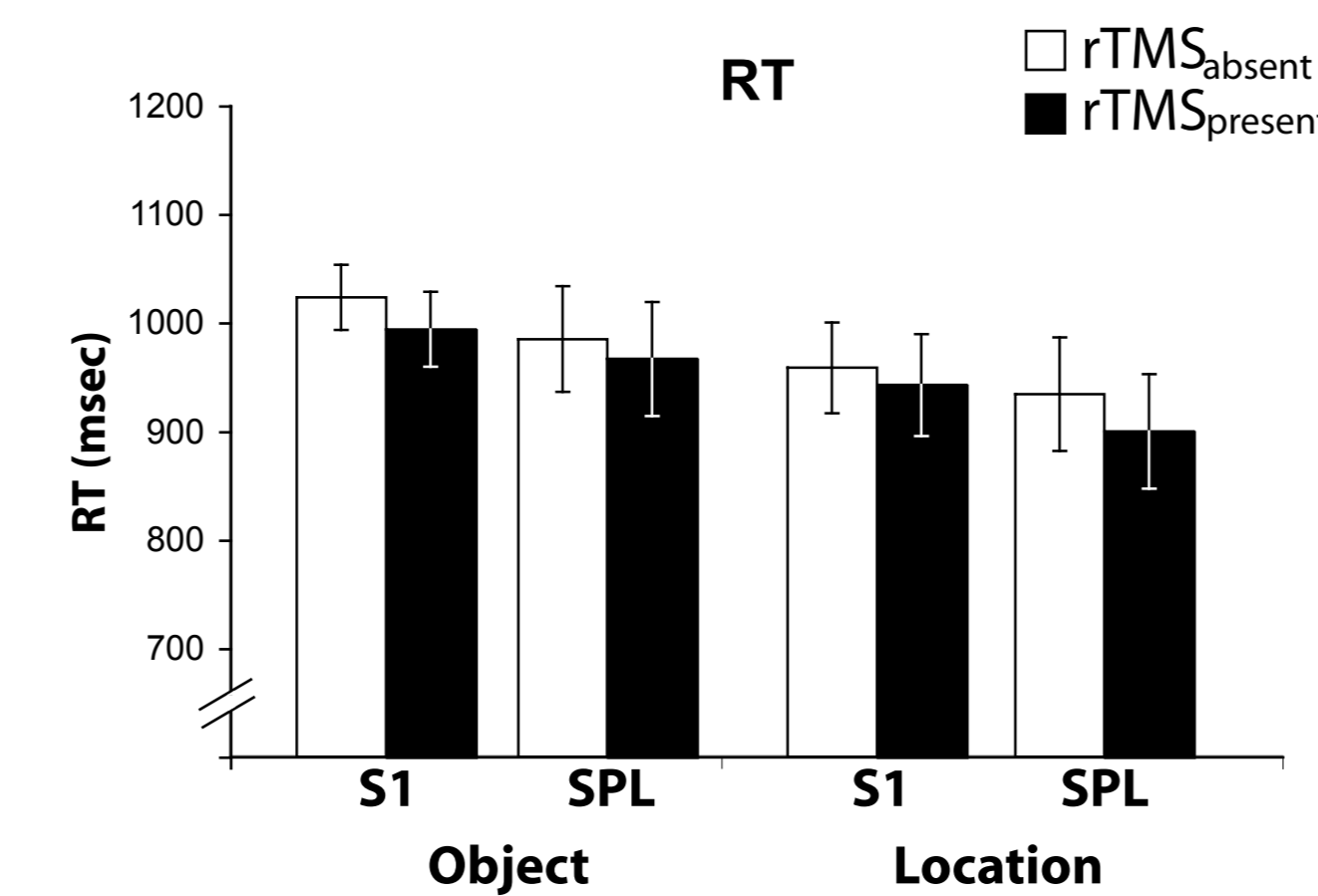
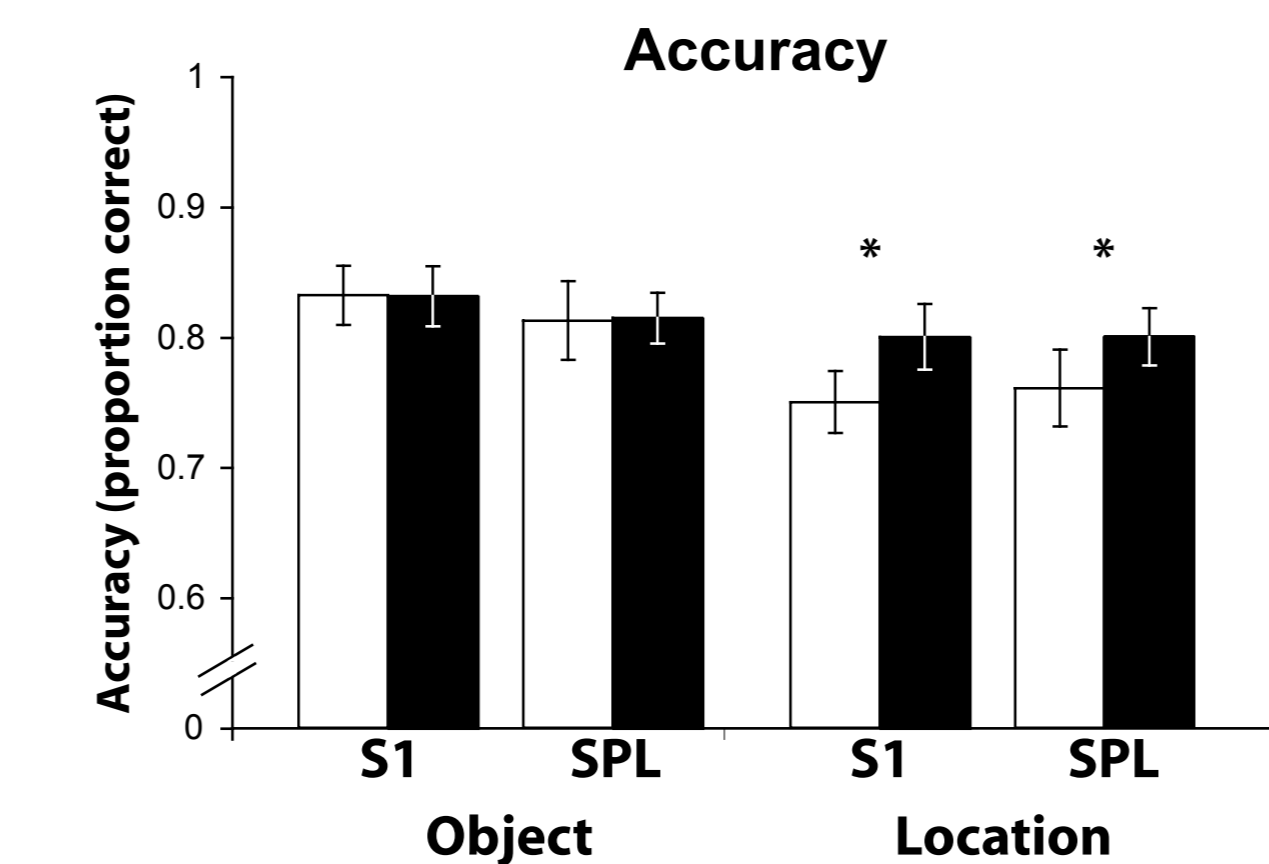
## TMS Artifact Removal

- Artifact removal performed separately for each brain area targeted and for each subject.
- Residual rTMS-related artifact removed through two rounds of ICA.
  - 1st round: ICA performed on entire data set
    - components associated with eye-blinks, channel noise, and rTMS identified and removed.
  - 2nd round of ICA performed on delay-period data only and any components associated with residual rTMS artifacts identified and removed.
- If any channels still contained rTMS artifact, the channel was removed and reconstructed using interpolation of surrounding channel values.

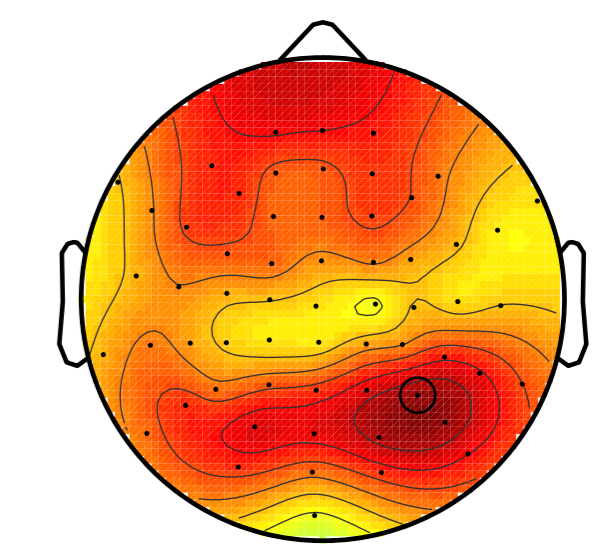
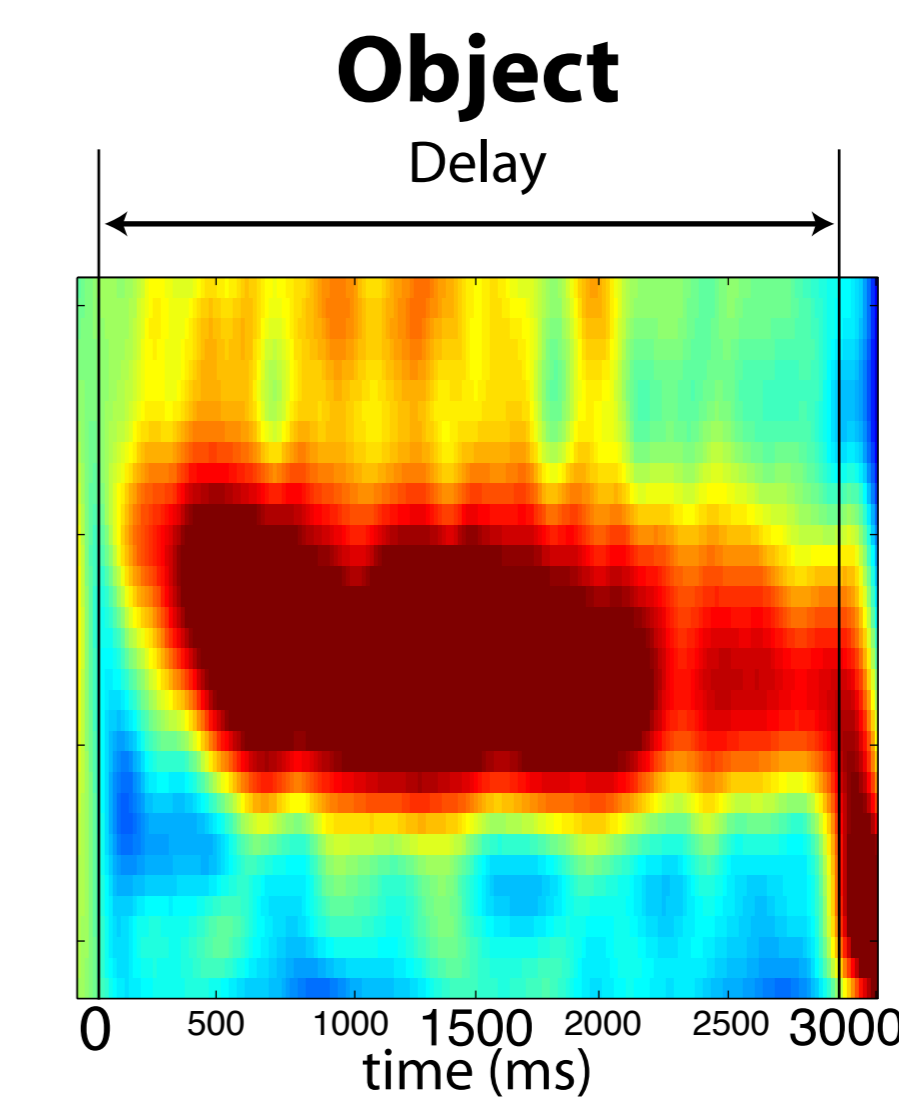
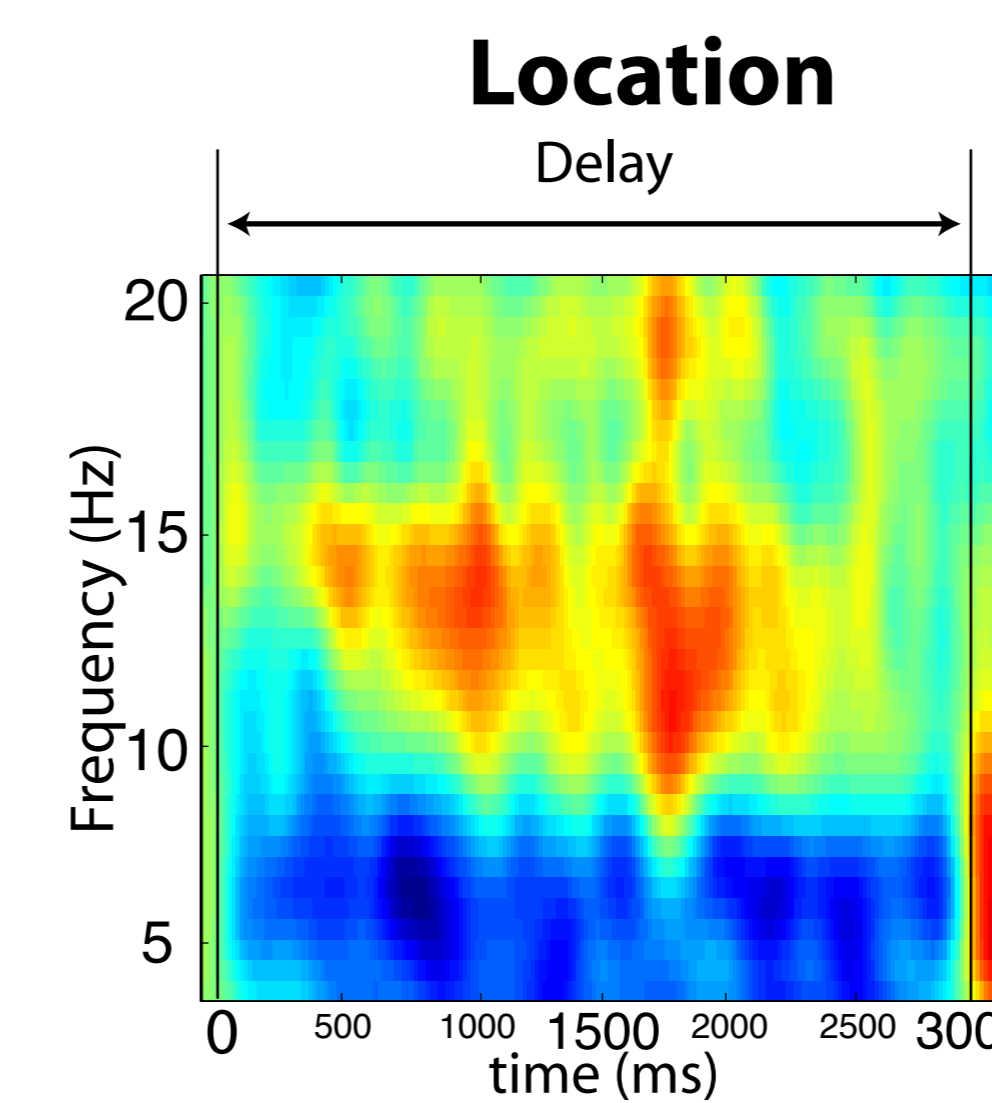
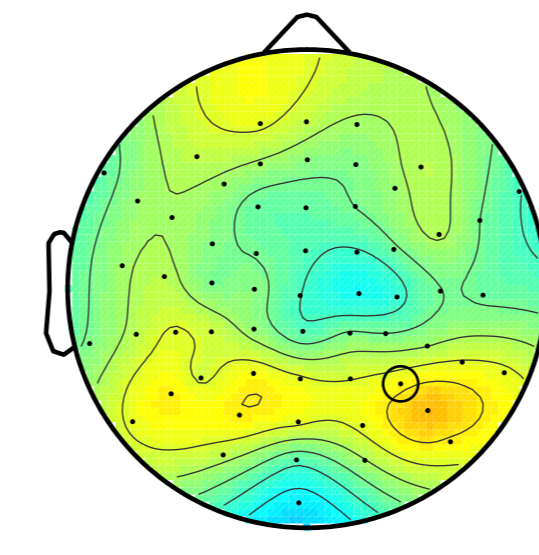


## Results

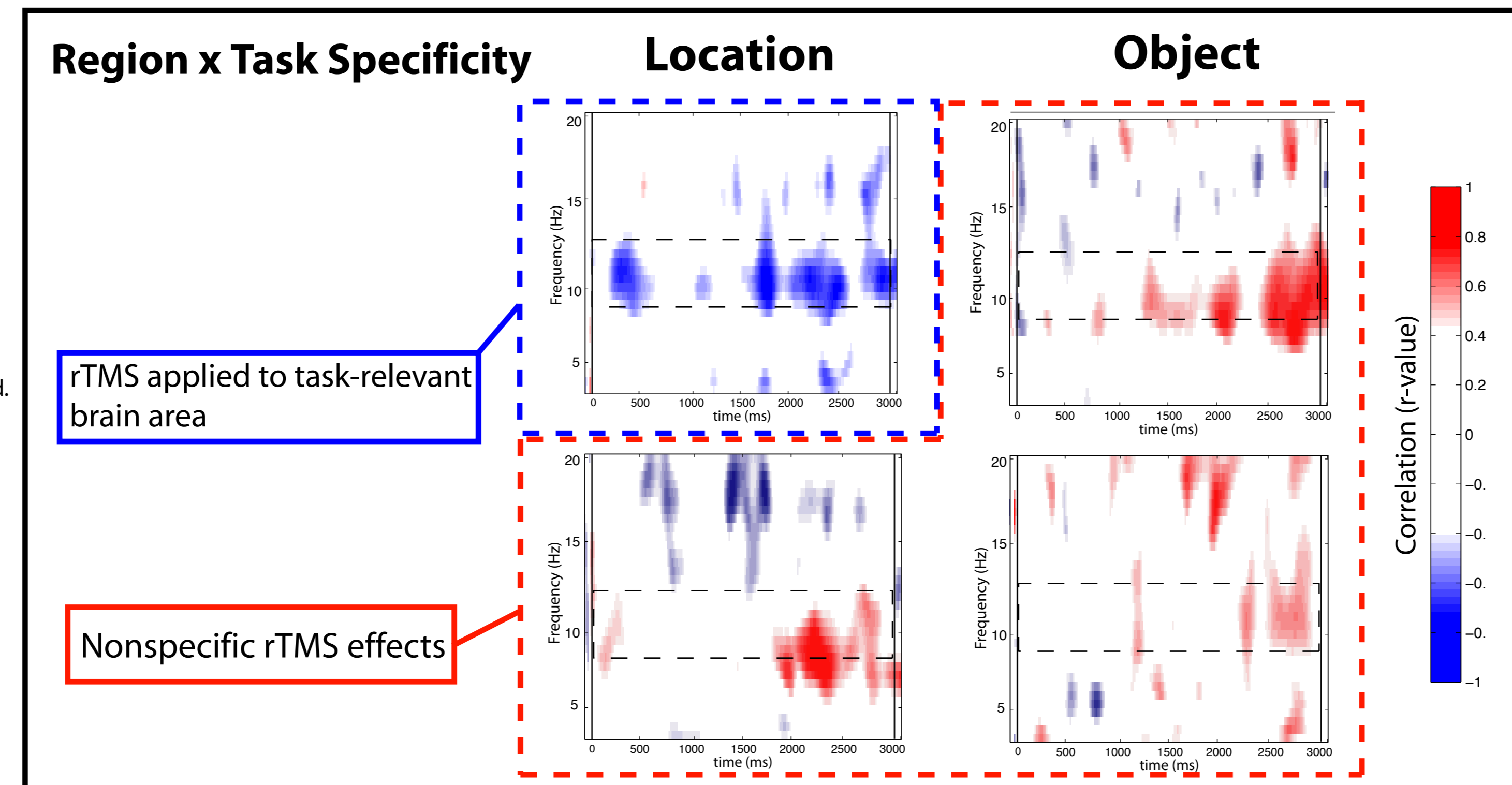
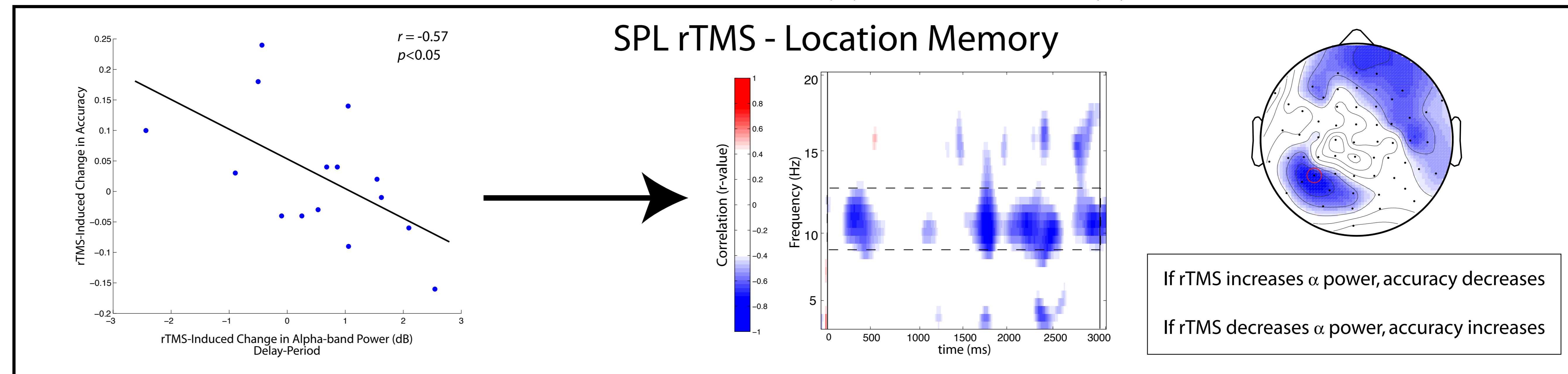
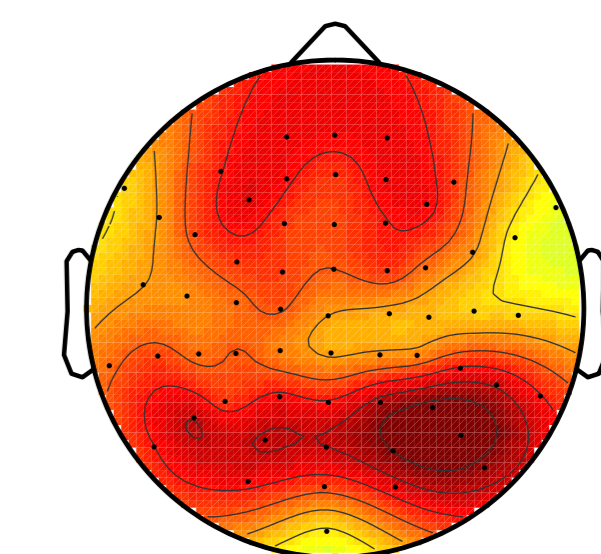
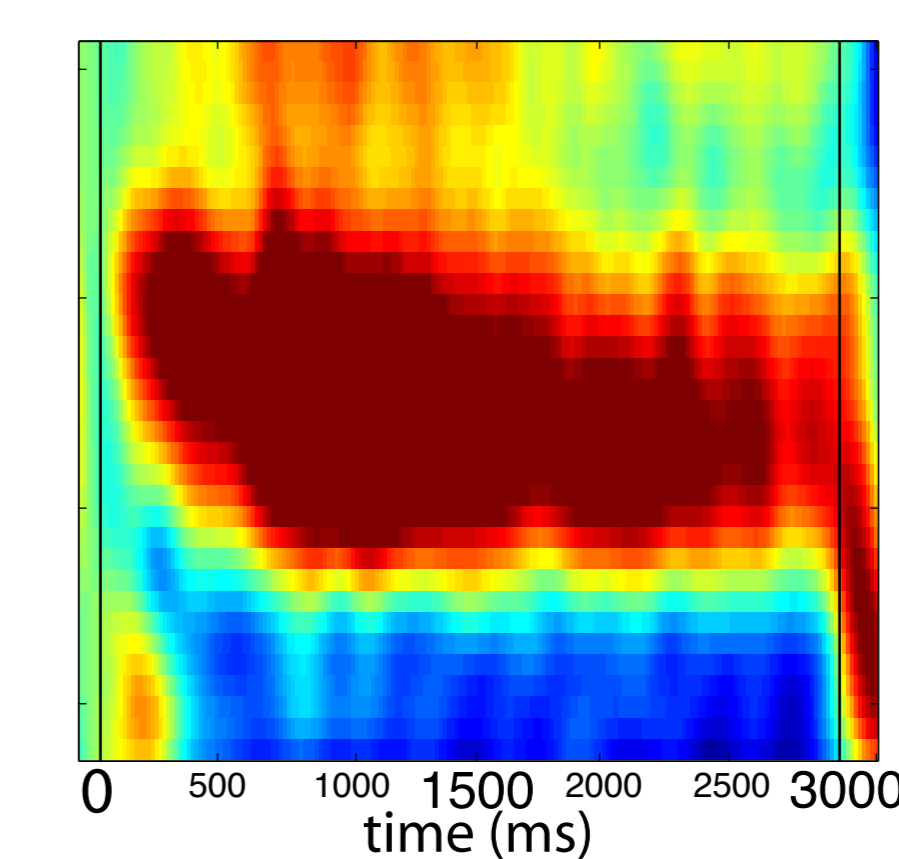
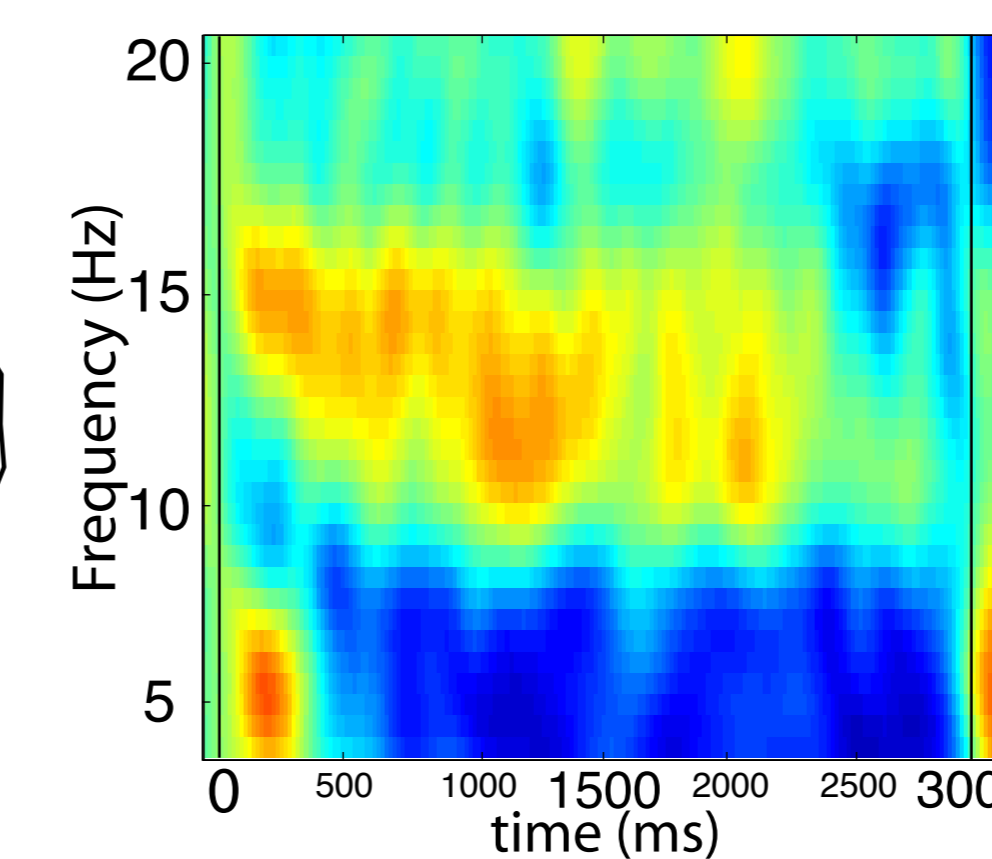
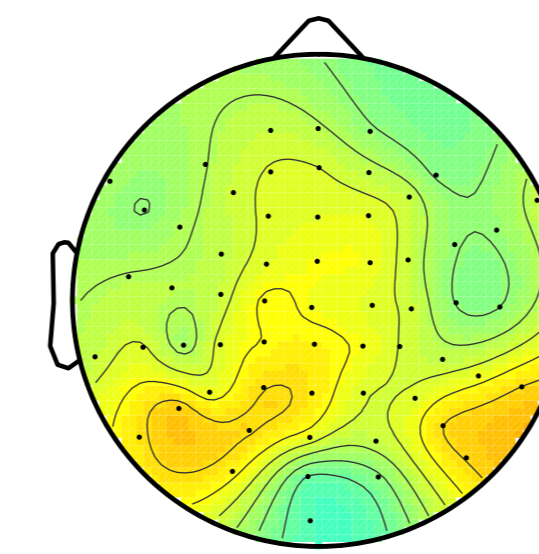
N = 15



rTMS<sub>absent</sub>



rTMS<sub>present</sub>



## Conclusions

- rTMS has region by task-specific effects on cortical oscillations
  - rTMS does not simply induce a "virtual lesion"
- Behavioral improvement is associated with changes in neuronal oscillations
  - rTMS-induced decrease in  $\alpha$ -band power leads to improved spatial working memory performance
  - Supports functional inhibition hypothesis of  $\alpha$ -band oscillations
- Simultaneous EEG/rTMS provides an experimental approach in understanding the role of cortical oscillations in working memory.
  - Results suggest a causal role for  $\alpha$ -band oscillations in working memory.