It's Not a 'Virtual Lesion': Evaluating the Effects of rTMS on Neural Activity and Behavior

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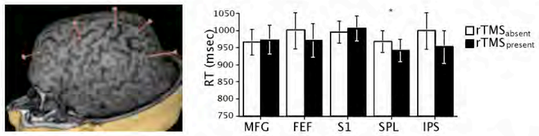
Introduction

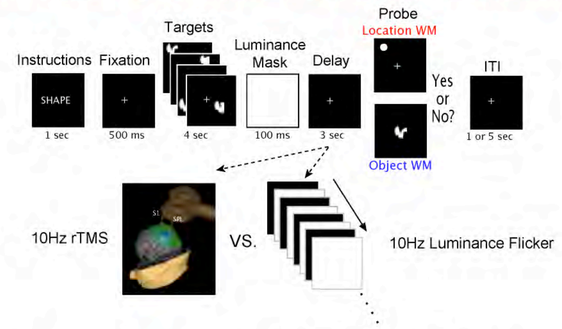
- TMS has become a valuable tool in cognitive neuroscience, but the mechanisms by which it affects brain function remain unclear
  - "Virtual Lesion" or Interaction with endogenous activity?
- Previous data have shown that 10-Hz rTMS to dorsal visual stream areas improves spatial working memory performance (Hamidi et al., 2008).



- Replication with simultaneous EEG found that 10 Hz rTMS affects alpha-band power at parietal electrodes, with individual differences in these effects (rTMS increasing vs. decreasing alpha-band power) predicting whether rTMS impairs or improves behavioral performance (Hamidi, et al., 2009).

Does 10-Hz rTMS produce these effects by imposing an (exogenous) oscillatory rhythm (i.e., by disrupting) or by biasing endogenous task-related oscillations?

Task

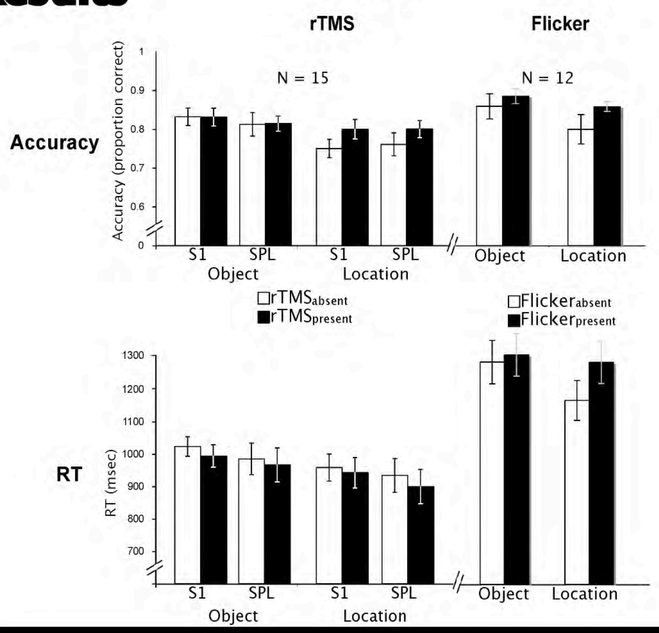


EEG

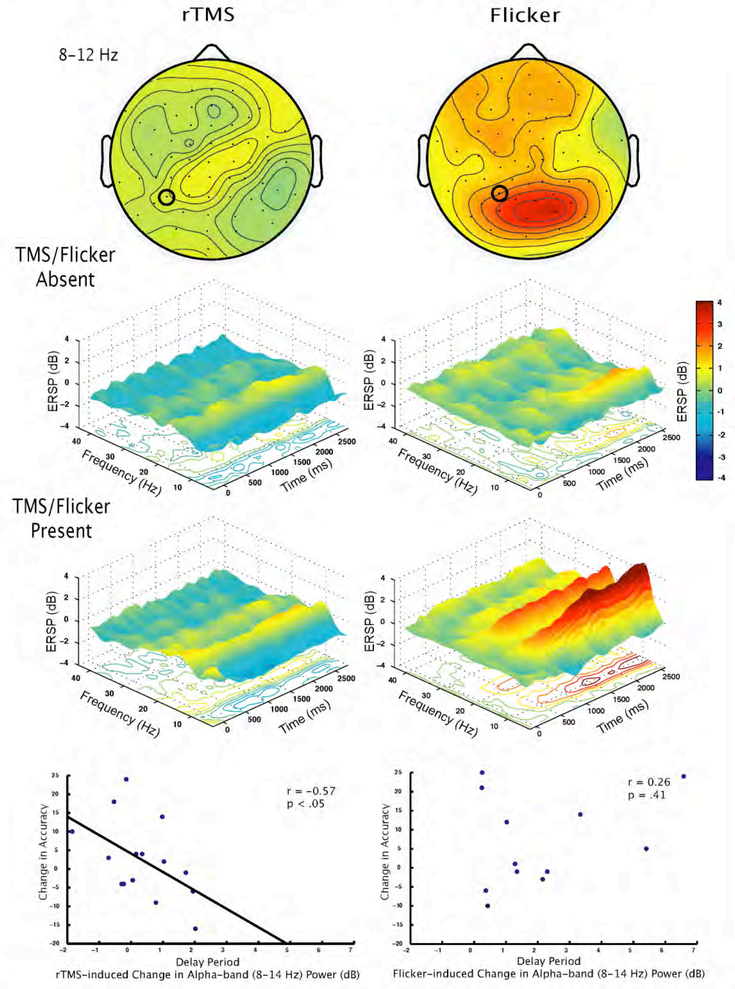
- Data were recorded from 60 electrodes and amplified using a BrainAmp 64-channel amplifier
  - Data was sampled at 250 Hz, and filtered (low cutoff=0.1 high cutoff=500 Hz)
  - Artifacts were removed by visual inspection and through Independent Components Analysis

Results

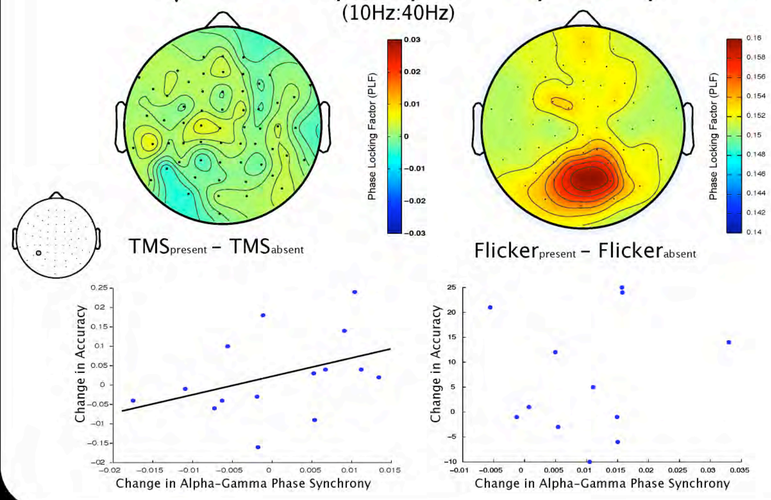
Behavior



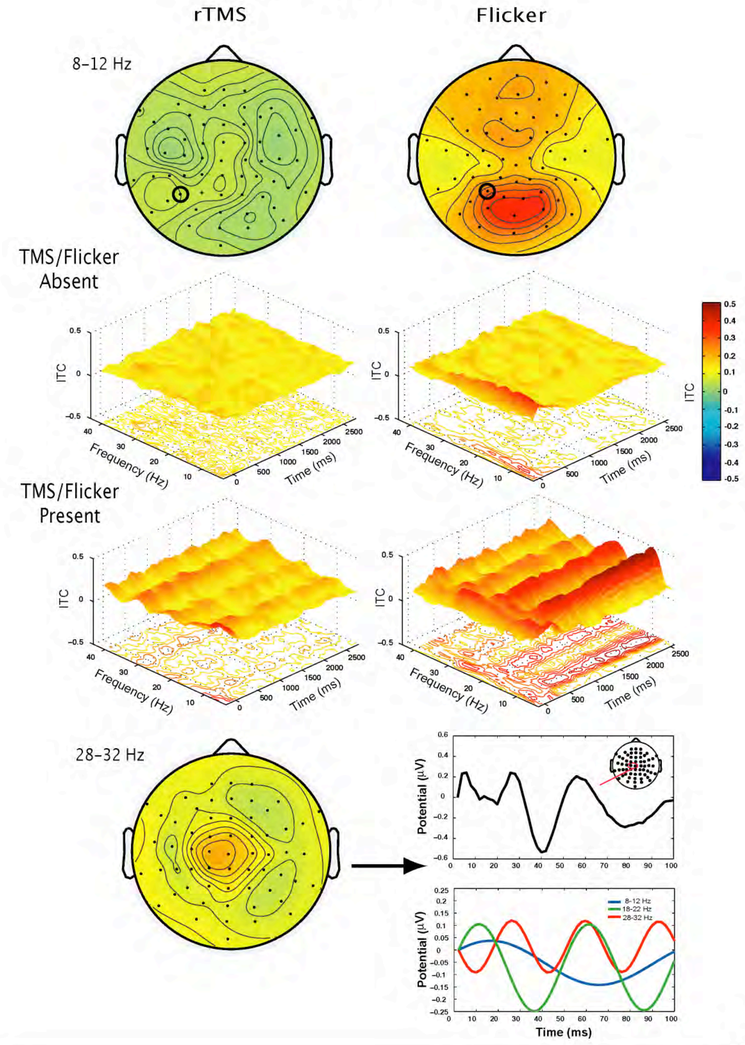
Event-Related Spectral Perturbation (ERSP)



α–γ Cross-Frequency Phase Synchrony



Inter-trial Coherence (ITC)



Conclusions

- 10 Hz visual flicker produced robust and widespread entrainment of neural activity to the flicker frequency, and produced a significant increase in alpha-to-gamma phase synchrony, but was largely uncorrelated with behavioral performance
- In contrast, 10 Hz rTMS had a relatively subtle effect on power in the high alpha-band (10-15 Hz) and produced a non-significant increase in phase synchrony, but these changes were predictive of behavioral performance
  - Changes in alpha-band power were negatively correlated with accuracy
  - Changes in phase synchrony were positively correlated with accuracy
- Importantly, we found no clear evidence suggesting that the functional effects of rTMS resulted from the creation of a "virtual lesion" or an injection of noise into task-related neural areas
- These findings suggest that rTMS exerts its effects through modulations of the power and/or phase of ongoing task-related neural oscillations, rather than through disruption (i.e. entrainment)

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