Thetaburst TMS to the right posterior superior temporal sulcus disrupts resting state connectivity across the face-processing network as measured with multi-echo fMRI

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INTRODUCTION

Thetaburst transcranial magnetic stimulation (TBS) to the right posterior superior temporal sulcus (rpSTS) or the right occipital face area selectively disrupts BOLD responses within face-selective regions, both local and remote to the initial stimulation site (Pitcher et al., 2014). Given this modulation of task-evoked responses, we hypothesized that TBS delivered over the right posterior superior temporal sulcus would selectively disrupt functional connectivity within face-selective regions, as measured by resting state fMRI. We used multi-echo fMRI (Posse et al. 1999) along with MEICA denoising (Kundu et. al. 2012) to attempt to remove non-BOLD-weighted noise from our data.

METHODS

Data Collection

16 volunteers; 10 Female

3 fMRI sessions on different days

Day 1: High-resolution, T1 weighted anatomical & functional localizer data

Stimulation site 1: Peak voxel for faces > objects contrast in right posterior superior temporal sulcus (rpSTS)

Stimulation site 2: Anatomically defined right hand-knob region (rHk)

Days 2 & 3: A different stimulation site each day, randomized across volunteers

fMRI parameters

2 10-min resting state fMRI runs before & 2 after targeted TBS to rpSTS or rHk
GE 3T MR 750 MRI scanner, GE 32 channel head coil.
GRE EPI, TR=2s, TE=14.8, 27.1, & 39.5ms, FA=77^{O}

TBS parameters

Target sites identified via BrainSight coregistration system (Rogue Research)
MagStim Super Rapid stimulator with figure-eight coil; wing diameter 70 mm
TBS delivered at 30% machine output over rpSTS or rhK
3 pulses at 50 Hz repeated at 200 ms intervals for 60 sec

Preprocessing

Using AFNI, Python, & Matlab

Anatomical scans aligned to common space

Despiked, time-slice corrected

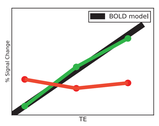
Alignment and motion correction calculated on middle echo time series & applied to 3 echoes as single transform matrix

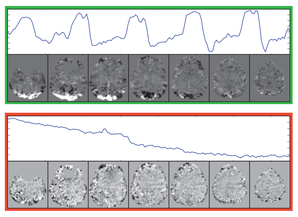
ME-ICA denoising: bitbucket.org/BenGutierrez/mei-ica

Optimally combined time series is weighted average of 3 echoes

Echo 2, TE=27.1 ms, considered standard single echo fMRI run as comparison

Spatial ICA performed on optimally combined time series, removed non-BOLD like components, & recombined remaining components into denoised dataset





This is an example of a component from a visual block design task that was accepted by ME-ICA

This component was rejected by ME-ICA. Based on the time series, it is possible that this component is associated with scanner drift.

Correlational Analysis

3 voxel radius spheres centered on stimulation sites used as ROIs for resting state connectivity analysis

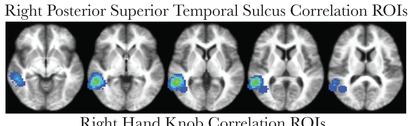
Correlation between each ROI and all other voxels calculated, for each 10-min resting state run

R-values Fischer Z-transformed

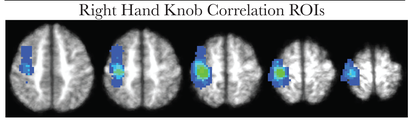
3-way mixed effects ANOVA on Fischer Z values

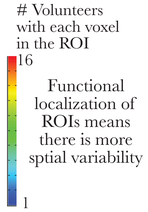
Only results based on first run preTBS and first run postTBS are shown here

Right Posterior Superior Temporal Sulcus Correlation ROIs



Right Hand Knob Correlation ROIs

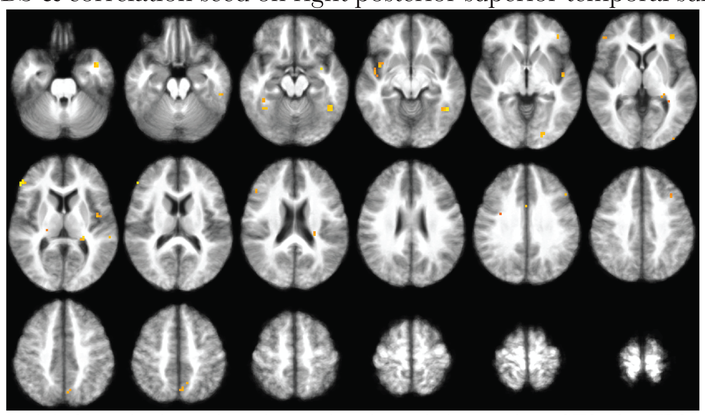




Functional localization of ROIs means there is more sptial variability

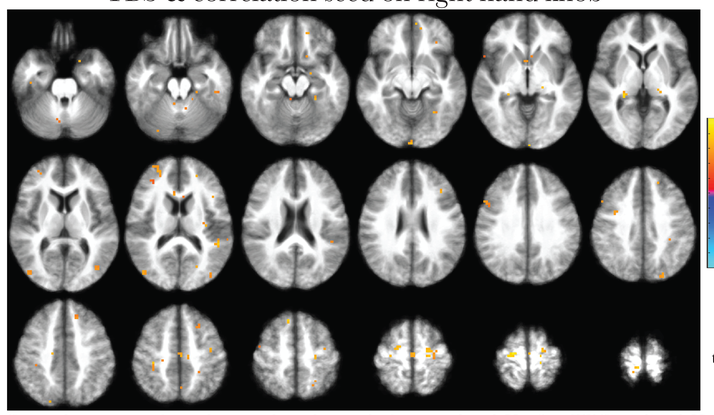
RESULTS

TBS & correlation seed on right posterior superior temporal sulcus



Multiple face-selective regions show reduced correlations to the rpSTS after TBS to the rpSTS. These include bilateral fusiform gyri, inferior frontal gyri, and insula

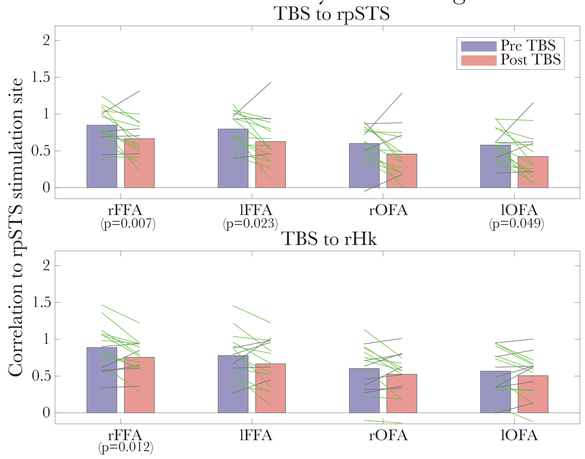
TBS & correlation seed on right hand knob



All maps are thresholded to an **uncorrected** p<0.001

Several motor regions show reduced correlations to the rhK after TBS to the rhK. These include the left precentral gyrus and the supplementary motor area.

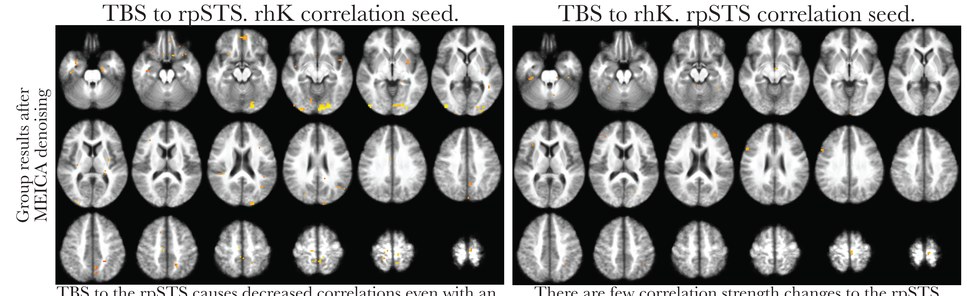
Correlations to functionally defined regions of interest



TBS to the rpSTS disrupted functional connectivity to the rFFA, lFFA, and lOFA, while TBS to a control region, the rHk, did not generate the same pattern or magnitude of disruptions in correlations to the rpSTS.

TBS to rpSTS. rhK correlation seed.

TBS to rhK. rpSTS correlation seed.

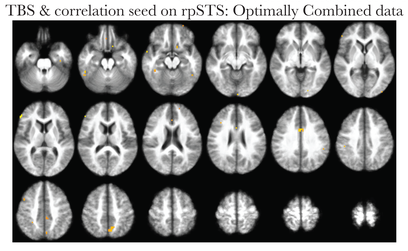


TBS to the rpSTS causes decreased correlations even with an rhK seed, but the decreases are in primary visual rather than motor areas

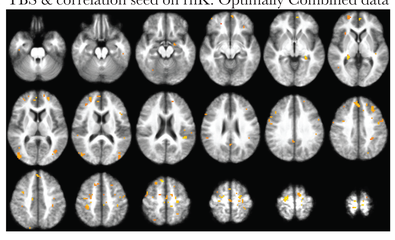
There are few correlation strength changes to the rpSTS when TBS is applied to the rhK

Without MEICA denoising, the maps have fewer voxels that cross the same threshold (rpSTS) or more voxels that aren't in clear spatial clusters (rhK)

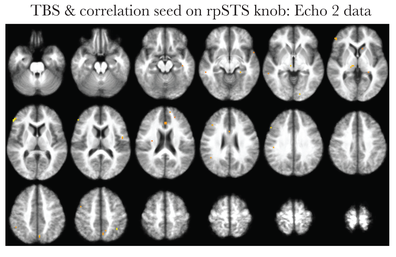
TBS & correlation seed on rpSTS: Optimally Combined data



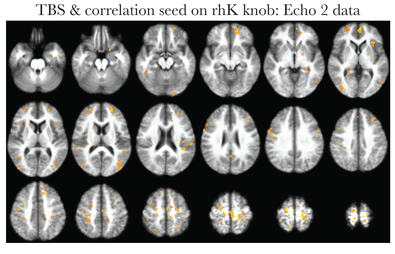
TBS & correlation seed on rhK: Optimally Combined data



TBS & correlation seed on rpSTS knob: Echo 2 data



TBS & correlation seed on rhK knob: Echo 2 data



DISCUSSION

These results show that TBS to the rpSTS selectively decreases functional connections to face-selective regions even in the absence of task-evoked responses.

We observe similar changes in normalized group maps and functionally defined regions of interest.

MEICA denoising qualitatively improves the group activation maps and additional work with quantify the changes.

While these results matched our initial hypothesis, some results use a liberal statistical threshold. We plan to investigate more ways to remove non-neural noise from these data and more precisely compare subject-specific regions of interest to reduce noise due to spatial inaccuracies.

REFERENCES

Kundu, P. (2012), 'Differentiating BOLD and non-BOLD signals in fMRI time series using multi-echo EPI' Neuroimage vol. 60, pp. 1759–70

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