rTMS to the Superior Temporal Sulcus Modulates EEG Theta Power in Occipital Cortex in Autism Spectrum Disorder

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Background

- Atypicalities in visual processing, specifically in facial processing, are well-documented in individuals with autism spectrum disorder (ASD)
- Prior work has revealed associations between impairments in facial recognition and evoked power in several electroencephalographic (EEG) spectral bands[1]
- Transcranial magnetic stimulation (TMS) to the dorsolateral prefrontal cortex modulated spectral activity in individuals with ASD in a visual perception paradigm[2]
- Increases in theta power in occipital regions have been observed in response to emotional stimuli in typically developing individuals[3,4]
- Given the relevance of the right posterior superior temporal sulcus (rpSTS) in atypical face and social perception in ASD, the effects of TMS to this region on EEG signatures and visual perception warrant investigation

Objectives: (1) To evaluate modulatory effects of TMS to the rpSTS on EEG theta power in visual areas while viewing social and nonsocial stimuli in adults with and without ASD; (2) to examine potential links to behavioral assessment of facial processing

Methods

Participants

	n (female)**	Age (SD)	Full Scale IQ (SD)
ASD	5 (1)	28.22 (3.37)	113.20 (10.04)
TD	9 (8)	29.22 (5.60)	119.11 (15.47)

Table 1. Participant demographics; age and IQ did not differ across groups.
** Ratio of males and females differed between diagnostic groups, X^2 (1, N = 14) = 7.35, p = .007.

Behavioral Measures

- ASD diagnoses were confirmed with the *Autism Diagnostic Observation Schedule (ADOS-2)* and clinician endorsement of DSM-5 criteria for ASD
- The Benton Face Recognition Test, which measures the ability of participants to match pictures of faces varying in angle and lighting conditions to their targets based on facial features, was given before and after TMS stimulation to index potential changes in facial recognition performance

Trial Structure

- Participants engaged in a 20-minute EEG session, followed by the session of rTMS, and an identical post-TMS EEG session (see Figure 1)
- Participants were randomized to different counterbalance orders of EEG paradigms pre- and post-TMS consisting of houses and faces

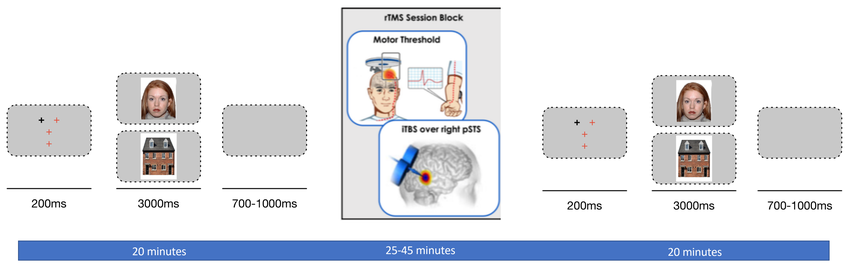

Figure 1. Experiment structure

rTMS Administration

- Intermittent theta burst stimulation (iTBS) was conducted using the Magstim Super Rapid system with four booster modules
- Right pSTS was targeted and stimulation site was determined by anatomical estimates based on the 10-20 EEG coordinate system (see Figure 2)

Methods

EEG Acquisition and ERP Analysis

- EEG was recorded at 1000 Hz with a 128-channel Hydrocel Geodesic sensor net
- Data were segmented from -100 to 500ms relative to stimulus presentation and averaged separately for faces and house conditions
- Power was extracted as the median of activity across frequencies in the theta band (4-8 Hz) and was examined across stimulus types in EEG recordings before and after iTBS administration

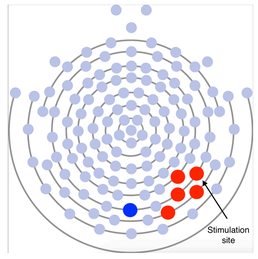

Figure 2. Regions of interest

Statistical Analysis

- Theta power was averaged at two regions of interest (**Figure 2**):
  - Right posterior temporal cortex (red electrodes)
  - Occipital cortex (blue electrode)
- Power data were logarithmically transformed and examined separately for each region of interest via 2X2X2 repeated measures ANOVA with time (pre- and post-TMS) and stimulus type (face/house) as within-subjects factors and diagnosis as a between-subjects factor

Results

- The three-way interaction between diagnosis, time, and stimulus type in the overall model was nonsignificant in all regions of interest, $Fs(1,12) < .18$, $ps > .2$, $\eta^2 < .133$; however, due to the small sample size and limited power in this preliminary analysis, post hoc tests were conducted to explore other possible effects

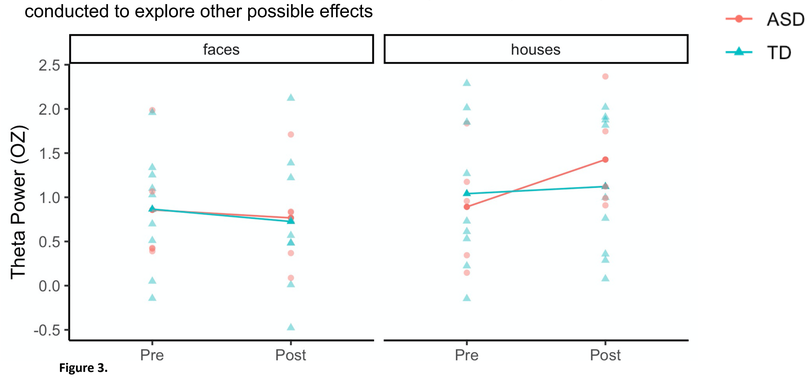

Figure 3.

Figure 3. At OZ, interaction effects emerged for time by stimulus such that theta power to faces decreased and power to houses increased across groups, $F(1,12) = 6.54$, $p = .03$, $\eta^2 = .353$. A time by diagnosis effect was also significant such that theta power increased from pre to post TMS in ASD but decreased slightly in TD, $F(1,12) = 14.14$, $p < .01$, $\eta^2 = .541$

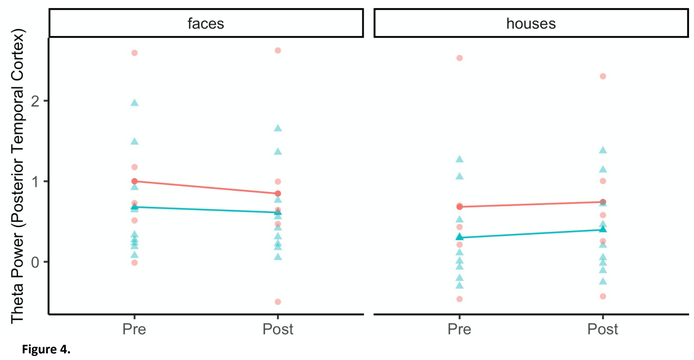

Figure 4.

Figure 4. At the right posterior temporal region, interaction effects emerged for time by stimulus such that theta power to faces decreased and power to houses increased across groups, $F(1,12) = 6.87$, $p = .02$, $\eta^2 = .364$. A time by diagnosis effect was marginally significant such that theta power decreased from pre to post TMS in ASD but not in TD, $F(1,12) = 4.6$, $p = .05$, $\eta^2 = .277$

Results (Continued)

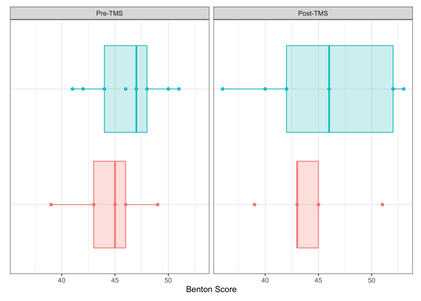

Figure 5. Performance on the Benton and the RMET did not significantly differ between diagnostic groups or within groups between pre-TMS and post-TMS timepoints, $ts(12) < -.19$, $ps > .37$

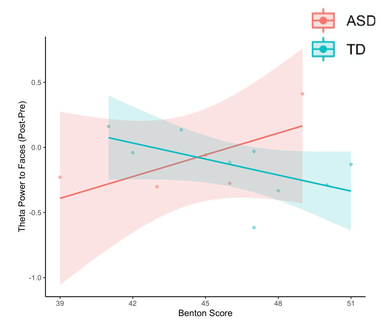

Figure 6. Performance on the Benton prior to TMS administration did not predict changes in theta activity to faces in any of the regions of interest, $F(1, 12) = 0.09$, $p = .77$, $R^2 = .007$

Conclusions

- Results suggest that iTBS impacts theta power differently in ASD vs. TD and to faces vs. houses, but that these differences may be too subtle to translate to observable behavior as measured by changes in Benton Face Recognition task in this small sample
- Although little is known about the functional significance of theta power in occipital regions, Dawson and colleagues[5] found that, in individuals with ASD receiving early intervention, greater theta power to faces was associated with better social communication
- Group-specific theta power increases due to rTMS may index potential improvements in social communication in individuals with ASD; however, more work is necessary to understand the implications of greater theta power to nonsocial stimuli, such as houses
- Given that theta power has been demonstrated to be larger to emotional than to neutral stimuli, use of neutral face stimuli may have attenuated increases in theta power post TMS[4]
- Continued research in larger samples is needed to further investigate theta power in visual regions during visual perception of social and nonsocial targets in ASD and its relationship with social behavior

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