Down-regulation of **Left Posterior Parietal Cortex** Impairs **Musical Phase Shift Detection** in **Subjects with Good Perceptual Acuity** for Phase Timing

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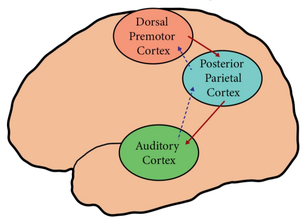
INTRO

Action Simulation for Auditory Prediction (ASAP) hypothesis: Dorsal auditory stream activity is necessary for auditory prediction in beat-based musical timing perception

- Strong Prediction: **Disruption of activity in the dorsal stream should impair timing perception** (Patel & Iversen, 2014)



Transcranial Magnetic Stimulation can be used to causally manipulate cortical activity with measurable effects on behavioral or perceptual processes

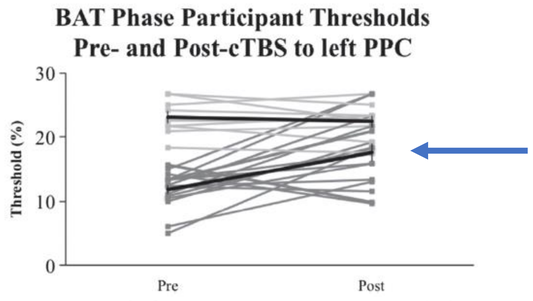
- **Continuous Theta Burst (cTBS)** stimulation down-regulates cortical activity in target areas (Huang et al., 2005). Applied to left/right PPC and sham stimulation.

threshold = performance

Left vs Right Parietal Cortex

cTBS to left posterior parietal cortex (PPC) was shown to impair accurate detection of shifts in beat phase, but not tempo changes or single interval discrimination (Ross et al., 2018).

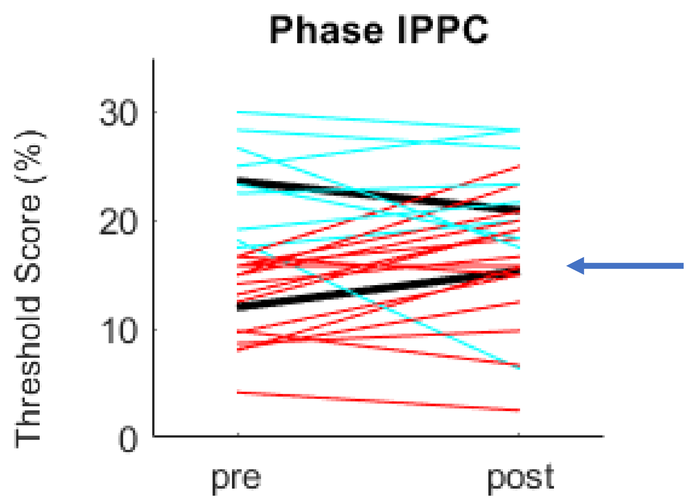
Right and left parietal cortex are implicated in mental reversal of auditory musical stimuli (Zatorre et al., 2010), but the role of the right PPC in beat-based musical timing is unknown.



Following cTBS to left PPC, participants with low baseline threshold were most impaired (Ross et al., 2018).

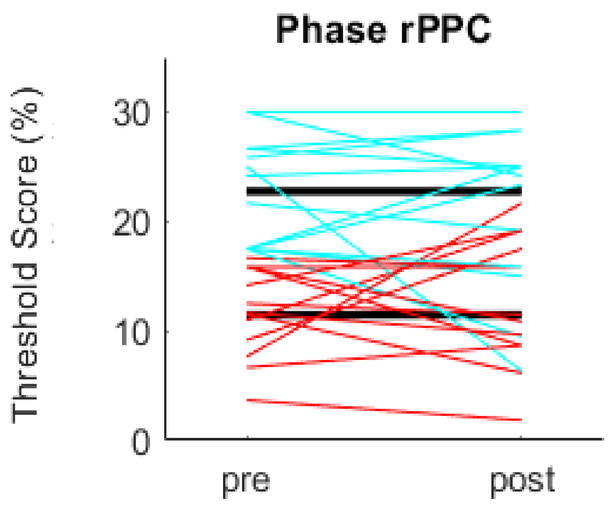
PRELIMINARY RESULTS

Baseline perceptual sensitivity to phase shows decrement after cTBS to lPPC (N=19)



t(19) = -3.810, p = 0.0013

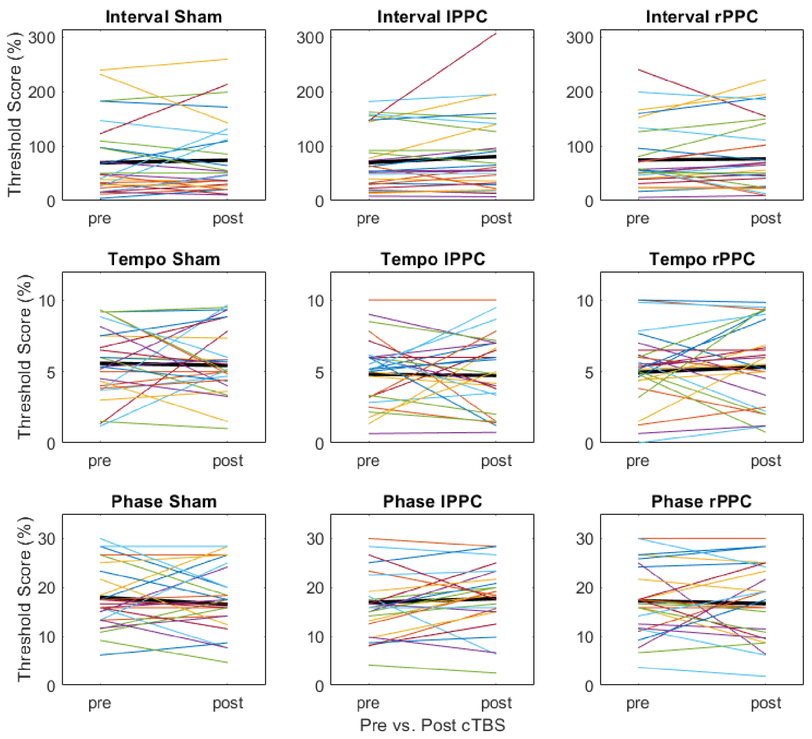
- Replication of Ross et al., 2018
- Impairment in participants with a low baseline threshold (more accurate phase-shift detection) relative to the group mean.
- Remains significant after correction for multiple comparisons with a false discovery rate of 1%



- No change in performance, regardless of participants' baseline threshold

More Results

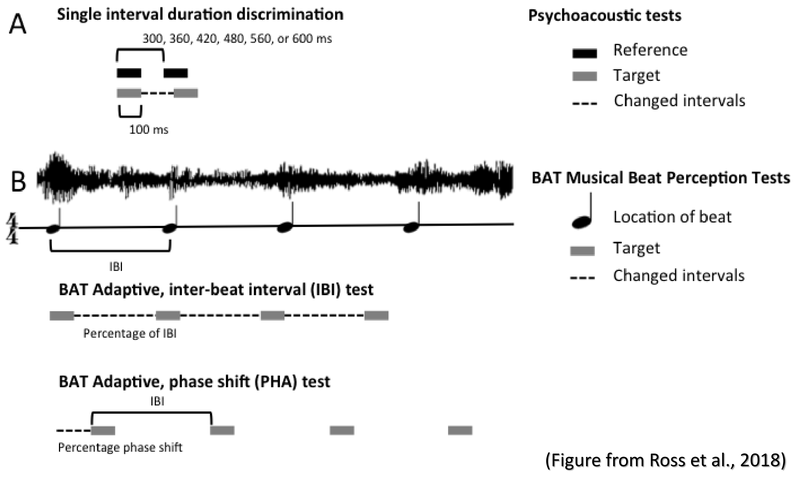
- No change in full group (N= 33)



Demographics

1. N = 33 (19 F)
2. Mean age was 21 years
3. Music experience
   3+ years N = 15
   5+ years N = 8

Perceptual Tests



(Figure from Ross et al., 2018)

METHODS

1. Measured thresholds for musical timing perception (interval, tempo, phase)
2. Paired sample t-tests on pre/post thresholds
   - Divided by baseline performance (above/below group mean- *above group mean indicates less accuracy relative to the group*) and musical training
   - Correction for multiple comparisons using Benjamini-Hochberg procedure
3. Linear mixed effects models
   - Fixed effect for pre/post cTBS
   - Random effects for condition & participant

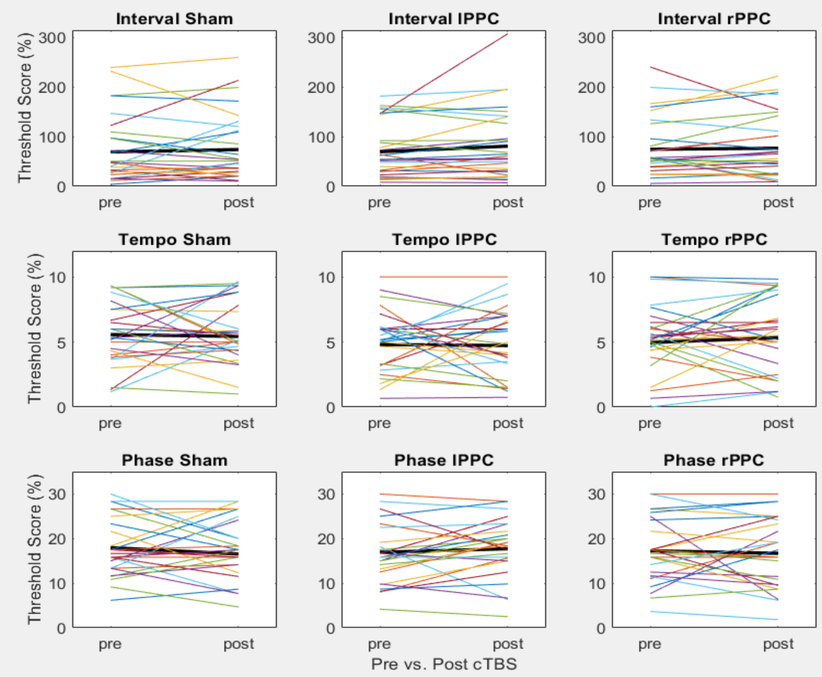
DISCUSSION

- Preliminary results partially replicate Ross et al., 2018 and support the ASAP hypothesis, showing that activity in the dorsal auditory stream is necessary for accurate auditory phase timing perception of music.
- Down-regulation of left PPC impairs accurate detection of beat phase, but in the current study, the effect is observed only in participants with a low baseline threshold.
  → *In Ross et al., 2018, the impairment effect of cTBS to lPPC in phase-shift detection was strongest in participants with a low baseline threshold.*
- No effect was found for down-regulation of right PPC, perhaps indicating left parietal dominance for beat-based timing perception.

For more information and copy of the poster

Group level t-tests on all participants

	Sham n33	Left PPC n33	Right PPC n33
Interval	Wilcoxon p= 0.888 cohens d -0.061 (negligible)	Wilcoxon p= 0.235 cohens d -0.184 (negligible)	T-test p= 0.686 t= -0.408 cohens d -0.037(negligible)
Tempo	T-test p= 0.761 t= 0.307 cohens d 0.059 (negligible)	T-test p= 0.861 t= 0.174 cohens d 0.031 (negligible)	T-test p= 0.409 t= -0.837 cohens d -0.138(negligible)
Phase	T-test p= 0.202 t= 1.3014 cohens d 0.217 (small)	T-test p= 0.389 t= -0.874 cohens d -0.116 (negligible)	T-test p= 0.594 t=0.5388 cohens d 0.076 (negligible)



Linear mixed effects models

Interval

Full model, fixed effect of condition * stimulation (assumes interaction)	x^2(5) = 3.9379, p=0.5584
Full model, fixed effect of condition + stimulation	$x^2(3)$ =2.8905 p=0.4088
Fixed effect of condition(sham/lppc/rppc)	$x^2(2)$ =0.6794 p=0.712
Fixed effect of stimulation (pre/post)	$x^2(1)$ = 2.2068 p=0.1374

Tempo

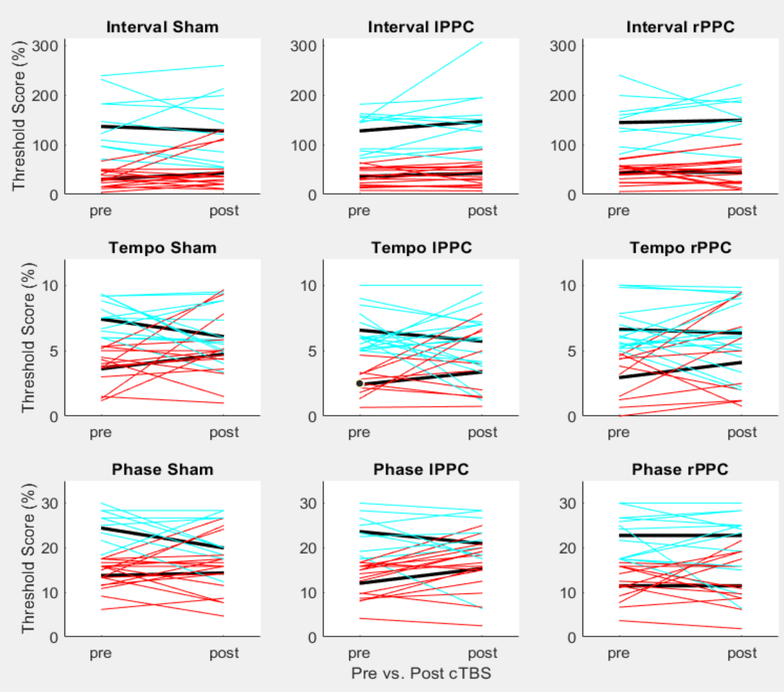
Full model, fixed effect of condition * stimulation (assumes interaction)	x^2(5) = 6.1283, p=0.2939
Full model, fixed effect of condition + stimulation	x^2(3) = 5.3322 p=0.149
Fixed effect of condition(sham/lppc/rppc)	x^2(2)=5.2952 p=0.07082
Fixed effect of stimulation(pre/post)	$x^2(1)$= 0.0366 p=0.8483

Phase

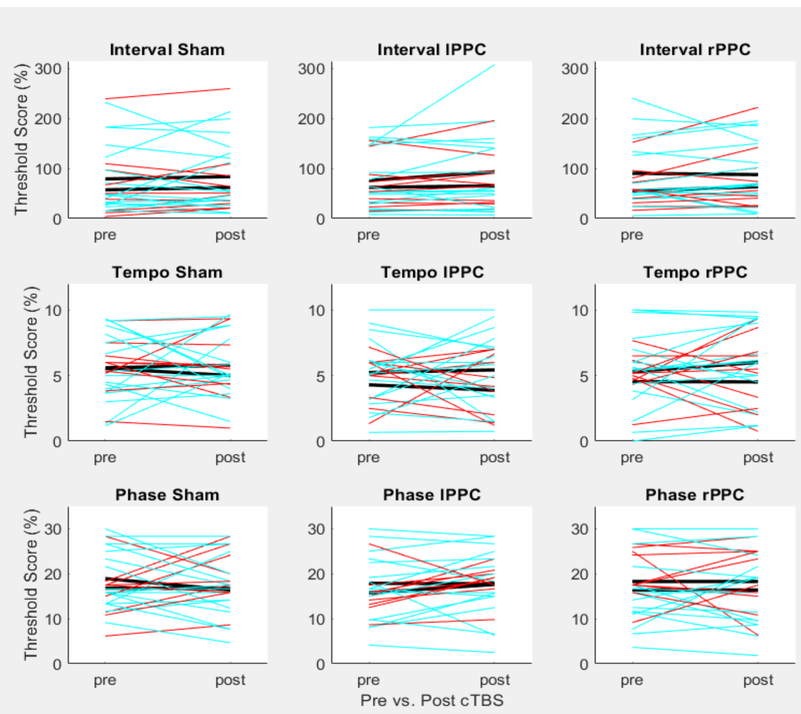
Full model, fixed effect of condition * stimulation (assumes interaction)	$x^2(5)$=2.7059, p=0.7452
Full model, fixed effect of condition + stimulation	$x^2(3)$=0.6259 p =0.8905
Fixed effect of condition(sham/lppc/rppc)	$x^2(2)$ = 0.2181 p= 0.8967
Fixed effect of stimulation(pre/post)	x^2 1) =0.4076 p=0.5232

Participants divided by baseline threshold scores

	Sham		Left PPC		Right PPC	
Interval	Above n12	Below n21	Above n12	Below n21	Above n10	Below n23
	T-Test p=0.487 t= 0.718 Cohens D 0.14 (negligible)	Wilcoxon p= 0.137 Cohen's d -0.487 (small)	Wilcoxon p= 0.380 Cohen's D -0.369 (small)	Wilcoxon p= 0.308 Cohen's D -0.246 (small)	T-Test p= 0.7585 t= -0.317 Cohen's D -0.093 (negligible)	T-test p= 0.8115 t = -0.241 Cohen's d -0.048 (negligible)
Tempo	Above n17	Below n16	Above n19	Below n14	Above n18	Below n15
	T-Test p= 0.02192* t=2.538 Cohen's d = 0.693 (medium)	T-test p= 0.116 t= -1.6692 Cohen's d = -0.533 (medium)	T-Test p= 0.177 t= -1.405 cohen's d 0.4239 (small)	T-Test p= 0.144 t= -1.553 cohen's d -0.521 (medium)	T-test p= 0.557 t = 0.599 cohen's d 0.133 (negligible)	T-test p= 0.151 t= -1.520 cohens d -0.487 (small)
Phase	Above n13	Below n20	Above n14	Below n19	Above n17	Below n16
	Wilcoxon p= 0.068 cohens d 0.842 (large)	T-test p= 0.6685 t= -0.435 cohens d -0.112 (negligible)	T-test p= 0.051 t= 2.153 cohens d 0.524 (medium)	T-test p= 0.0013** t= -3.810 cohens d -0.671 (medium)	T-test p= 0.314 t = 1.040 cohens d 0.264 (small)	T-test p= 0.747 t= -0.329 cohens d -0.0994 (negligible)



*No longer significant after corrections for multiple comparisons following the Benjamini-Hochberg procedure.
**Remained significant after corrections for multiple comparisons following the Benjamini-Hochberg procedure.



Plots for Participants divided by musician (red) vs nonmusician (blue)