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).

PRELIMINARY RESULTS

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

Phase IPPC

- 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%

Phase rPPC

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

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 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 IPPC 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.
### Group level t-tests on all participants

<table>
<thead>
<tr>
<th></th>
<th>Sham n33</th>
<th>Left PPC n33</th>
<th>Right PPC n33</th>
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<tbody>
<tr>
<td><strong>Interval</strong></td>
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<tr>
<td>Wilcoxon &amp; cohen's d</td>
<td>p = 0.548 &amp; -0.218 (negligible)</td>
<td>p = 0.235 &amp; -0.184 (negligible)</td>
<td>p = 0.548 &amp; -0.037 (negligible)</td>
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<td><strong>Tempo</strong></td>
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<tr>
<td>T-test</td>
<td>p = 0.761 &amp; t = 0.307 &amp; cohen's d = 0.059 (negligible)</td>
<td>p = 0.861 &amp; t = 0.174 &amp; cohen's d = 0.031 (negligible)</td>
<td>p = 0.409 &amp; t = -0.837 &amp; cohen's d = -0.138 (negligible)</td>
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<td><strong>Phase</strong></td>
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<tr>
<td>T-test</td>
<td>p = 0.202 &amp; t = 1.3014 &amp; cohen's d = 0.217 (small)</td>
<td>p = 0.389 &amp; t = -0.874 &amp; cohen's d = -0.116 (negligible)</td>
<td>p = 0.594 &amp; t = 0.5388 &amp; cohen's d = 0.076 (negligible)</td>
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### 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
  - $x^2(3) = 6.1283, p=0.308$

**Tempo**
- Full model, fixed effect of condition * stimulation (assumes interaction)
  - $x^2(5) = 6.1283, p=0.308$
- Full model, fixed effect of condition + stimulation
  - $x^2(3) = 5.3322, p=0.308$

**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
  - $x^2(3) = 6.2425, p=0.671$

**Participants divided by baseline threshold scores**

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*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.

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