Hemispheric differences in parietal contributions to auditory beat perception

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Background

The Action Simulation for Auditory Prediction (ASAP) hypothesis suggests that periodic dorsal auditory stream activity is necessary for auditory prediction in beat-based musical timing perception. ASAP makes the strong prediction that any disruption of activity in the dorsal stream should impair timing perception (Patel & Iversen, 2014).

Transcranial Magnetic Stimulation (TMS) can be used to investigate the causal role of motor activity on behavioral or perceptual processes

- One type of TMS, the Continuous Theta Burst (cTBS) protocol, down-regulates cortical activity in target areas

Left Posterior Parietal Cortex

- cTBS applied to areas in the dorsal auditory stream has demonstrated a causal relationship between the motor-planning cortical network and musical beat perception (Ross et al., 2018)
- Specifically, cTBS of left posterior parietal cortex (lPPC) interfered with accurate detection of shifts of beat-phase, but not absolute interval timing discrimination or changes in musical tempo (Ross et al., 2018)

Right Posterior Parietal Cortex

- It has been suggested that time is represented in spatial terms (Bonato et al., 2012) and lesions in right PPC impair temporal processing of narrative events (Bonato et al., 2016)
- fMRI work suggests that mental reversal of musical stimuli in the auditory-temporal domain, like mental rotation in the visual-spatial domain, recruits both left and right PPC (Zatorre et al., 2010).

Do parietal hemispheres contribute equally, or is there differentiation of function in musical beat-based timing perception?

Hypotheses

1. Down-regulating cortical activity in left PPC will interfere with the ability to detect changes in beat-phase, but not tempo or interval timing, replicating Ross et al., 2018.
2. Because of right PPC’s role in temporal processing, auditory imagery, and dorsal stream auditory-motor interaction, we predict that it will be similarly involved in musical phase perception.

Methods

- Continuous Theta Burst Stimulation (cTBS) was applied to downregulate cortical activity at either the left or right posterior parietal cortex, or in a sham condition over left motor cortex with the coil facing away from the head.
- Participants were tested in three timing perception tasks (see below) both before and after receiving cTBS. Participants received all three cTBS conditions across three separate days in a randomized order.

Discussion

- Preliminary data trends indicate a potential role for lPPC in detecting shifts of beat-phase. A majority of participants, especially those with a low initial threshold (as in Ross et al., 2018), show reduced performance after cTBS to PPC. A subset of participants become less sensitive to phase shifts after cTBS to PPC (also consistent with Ross et al., 2018), which may obscure the trend.
- Trends also indicate a potential increase in single interval duration discrimination threshold with cTBS to either right or left PPC, contrary to previous indication that lPPC is not involved in absolute interval timing (Ross et al., 2018).
- Substantial individual differences are common in perceptual tasks and in response to the cTBS protocol, requiring large samples to determine real statistical effects. Our target sample is N=35, determined by power analysis.
- Causal TMS methods will help to describe the parietal contributions to auditory beat-based musical timing perception, and to discover whether there are any hemispheric differences in the role of the parietal cortex within the dorsal auditory stream.

Preliminary Results

N=18 (target sample of N=35 as per power analysis)

Preliminary data do not show statistically significant effects yet. Below are trends:

Possible increase in threshold for single interval duration discrimination after cTBS to right PPC and left PPC

No increase in threshold for detecting changes in tempo

Potential increase in threshold for detecting changes in phase after cTBS to left PPC

Selected Sources


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