Title: Modulation of Sensory Acuity With Transcranial Magnetic Stimulation (TMS) (Exp 7)

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Study Protocol

This study consists of three related behavioral paradigms aiming to test sensorimotor adaptation, a correlative analysis investigating the relationship between the outcome measurements from these three experiments, and several experiments seeking to modulate these outcome measures. Here we describe Experiment 7, which used transcranial magnetic stimulation (TMS) to modulate somatosensory acuity of the tongue.

Experiment 7 specific Methods: Participants will complete three TMS sessions (iTBS, cTBS, sham) and a fourth behavioral-only control session. Each session will be separated by at least one week with the order counterbalanced across participants. The target of the stimulation is left primary somatosensory cortex (S1). The duration of tbTMS stimulation is short (40-190s), with effects that begin ~5 minutes following stimulation and persist for up to 30 minutes. In each TMS session, sensory acuity will be tested in two tasks (spatial and temporal) before and after application of theta-burst TMS (tbTMS):

- *Task practice:* Participants first complete a brief training to familiarize them with each acuity task and to ensure they met performance criteria (five consecutive correct responses).
- *Baseline tests:* Participants complete 3 blocks of each task, with the tasks alternating.
- *TMS localization and thresholding:* Single-pulse TMS is used to localize the target stimulation site (S1) and determine the active motor threshold. S1 is localized on each participant's brain surface with Brainsight neural navigation by moving the stimulator 2 cm posterior to a motor hotspot that elicits tongue motor-evoked potentials (MEPs).
- *Rest:* 20-minute break to allow the somatosensory cortex to recover from any potential disruption related to single-pulse TMS.
- *TBS:* Delivery of TBS to S1. Stimulation intensity will be set to 80% of the active motor threshold. Sham stimulation will be applied with the coil rotated away from the head (coil facing downward). This emits the same sound as active stimulation without stimulating the brain.
- *Post tests:* Performed every 5 minutes for 45 minutes following stimulation: participants complete 10 blocks of each task (SDT and TDT), alternating between the tasks with a 1-minute break in between each task.

In the 4th behavioral-only session ("control"), participants' acuity is tested without TMS localization.

- *Somatosensory acuity metrics:* The acuity tasks measure tactile acuity (spatial amplitude and temporal order judgment) with a custom corticalmetrics Brain Gauge vibrotactile stimulator. These measures reliably track the recovery of somatosensory function after neurological damage and can be modified with tbTMS. We use tactile acuity as a proxy for full somatosensation, given the difficulty in measuring proprioception in the oral system. Tactile acuity has been suggested to be important for speech production, as tactile contact is maintained parasagittally during vowel production and tactile deprivation leads to imprecise speech movements.
- *Data analysis and outcome measurements:* Each acuity task (spatial amplitude and temporal order judgment) yields a threshold (spatial amplitude discrimination threshold in µm; temporal discrimination threshold in ms) representing the smallest difference detectable by the participant at a given time point. For each acuity task, we will compare the change in threshold from pre- to post-TMS. Post-TMS values will be normalized by subtracting baseline thresholds for each task on a session-specific basis, then compared across time windows.

- *Sample size with power analysis:* Given previous results in the hand (d = 1.8-3.1), we conservatively anticipate an effect size of Cohen's d = 1. Testing 17 participants gives a power of .82 with α = 0.05.

Statistical Analysis Plan

Experiment 7: We will compare the change in sensory acuity from pre- to post-TMS between sessions using a repeated measures ANOVA. Post-TMS values will be normalized by subtracting baseline thresholds for each task on a session-specific basis, then compared across time windows. To compare changes in thresholds across sessions, a single repeated-measures ANOVA will be conducted for each task with sessions (cTBS, iTBS, control, sham) and time windows as independent variables.