Introduction

- Research shows structural and functional neurological differences between people who stutter (PWS) and controls (Ingham, 2001).
- Psycholinguistic theories (e.g., Postma & Kolk, 1991; Vasic & Wijnen, 2005) account for stuttering as a deficit in the phonological-encoding stage of speech planning.
- Our research replicated findings by Sassekaran et al. (2006) that PWS have increased reaction times during phoneme monitoring of the internal speech plan (Garnett & Den Ouden, under review). PWS in our study also made significantly more errors, consistent with a phonological planning problem.
- Functional imaging studies show that LH posterior superior temporal gyrus (pSTG) supports phonological encoding (Indefrey & Fedeschek, 2001) and is involved in monitoring internal speech (Den Ouden et al., 2013).
- Neuroimaging methods alone cannot conclude if specific brain regions are crucial for a task.
- High Definition Transcranial Direct Current Stimulation (HD-tDCS) is a non-invasive, focal method of brain stimulation which provides better information about neural involvement (Omomchok et al., 2011).

This study had two purposes:

- First, can we disrupt or enhance task performance in healthy control participants on a covert phoneme detection task?
- Second, can we ‘normalise’ the performance of PWS on the same task?

Method

Participants

- Presently 11 PWS (6 females, 5 males; mean age 25.5 years) and 14 controls (9 females, 5 males; mean age 23.8 years), all right-handed, have participated. Groups were also matched for years of education.

Stimulation Location, Materials, and Task

- Target location was based on activation found in a cluster of 0.278 cl., with peak in left pSTG (Den Ouden et al., 2013; Figure 1).
- Electrode montages were configured using Soterix software (HD-Targets™ and HD-Explorer™; Figure 2).
- Two stimulation conditions (field orientations of left posterior and right anterior) were modeled for max focality using 4 active electrodes. A sham location was modeled separately to ensure adequate blinding (Figure 2).
- After 20 min of stimulation with total current of 2mA, participants completed the monitoring task.
- Participants monitored for the presence of a target phoneme (e.g., /pa/) during silent picture naming.
- 28 binyal words were used, with the target phoneme occurring in one of four positions, CVC/CVC’ (e.g., “pilght”)’
- Targets: /pl, fl, kl, bl, /l, /dI, /g/, /mo, /n, /lI, /fI, /lI, /fI, /v/, balanced among position within words and across blocks (74 trials/block).

Results

- Stimulation conditions were combined and compared to sham:
  - Unlike sponge tDCS, in which current flows between two oppositely charged electrodes (‘current-controlled stimulation’), HD-tDCS is more local and often uses more than two electrodes, creating a less unidirectional field orientation.
  - Although our two stimulation conditions were of opposite polarity, which condition is stimulating vs. inhibiting for participants is likely dependent on individual gyral structure, due to the focal nature of HD-tDCS.
  - Behavioral results in the sham (no stimulation) condition replicate previous findings: PWS exhibit a trend to be slower (M = 1170 ms; p = 0.076) and are significantly less accurate (M = 91.8%) than controls (M = 96%; p = 0.017) during phoneme monitoring.
  - In controls, there is a strong trend for stimulation to slow RT (M = 1323 ms; p = 0.051) irrespective of field orientation.
  - In PWS, as a group, stimulation decreases RT to 1262ms; however this difference did not approach statistical significance (p = 0.32)
  - Accuracy was nearly identical in sham vs. stimulation in PWS, while controls exhibited a trend to be less accurate following stimulation (p = 0.10).

Discussion, Conclusions, and Future Analyses

- The present study is the first to investigate effects of direct cortical stimulation on monitoring/phonological encoding in healthy speakers and PWS.
- Results from the baseline (sham) condition are consistent with accounts that suggest a phonological encoding/internal speech monitoring deficit in PWS (Postma & Kolk, 1993; Vasic & Wijnen, 2005; Sassekaran et al., 2006) as PWS tend to be slower on a monitoring task designed to tap into this level of speech production.
- Results tentatively suggest that stimulation of left pSTG affects RT in controls, which lends support to studies concluding this area is involved in the phonological encoding stage of speech production.
- However, stimulation of this area does not significantly improve performance in PWS.
- Data collection is ongoing, and future analyses include covarying gender and stuttering severity.
- Order effects will also need to be considered, as performance over time appears to be a factor, although order of presentation of condition was balanced in order to deliberately counter potential order effects.

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