Effects of HD-tDCS on speech fluency in adults who stutter: a randomized controlled trial

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Background

- **Transcranial direct current stimulation (tDCS)** is a non-invasive brain stimulation technique that may offer new insights into stuttering treatment (Chesters et al., 2017; 2018; Garnett et al., 2019)
- **External** rhythmic pacing (e.g., metronome-timed speech, choral speech) temporarily **eliminates stuttering** (Park & Logan, 2015) and is associated with 'normalized' brain activation patterns in **posterior auditory regions (i.e., pSTG)** similar to that of fluent speakers (e.g., Toyomura et al., 2011; 2015), yet treatment with such techniques is inadequate as improvement is temporary (Kell et al., 2009).
- In this preliminary study, **high-definition (HD)-tDCS** electrodes were used, which increase focality of stimulation compared to conventional methods (Kuo et al., 2013). Stimulation was paired with a rhythmic speech task to augment the effects of this induced fluency task in adults who stutter.
- We expected that active stimulation to left pSTG in conjunction with rhythmic speech would result in decreased stuttering immediately post and at 1 month follow up, relative to sham

Methods

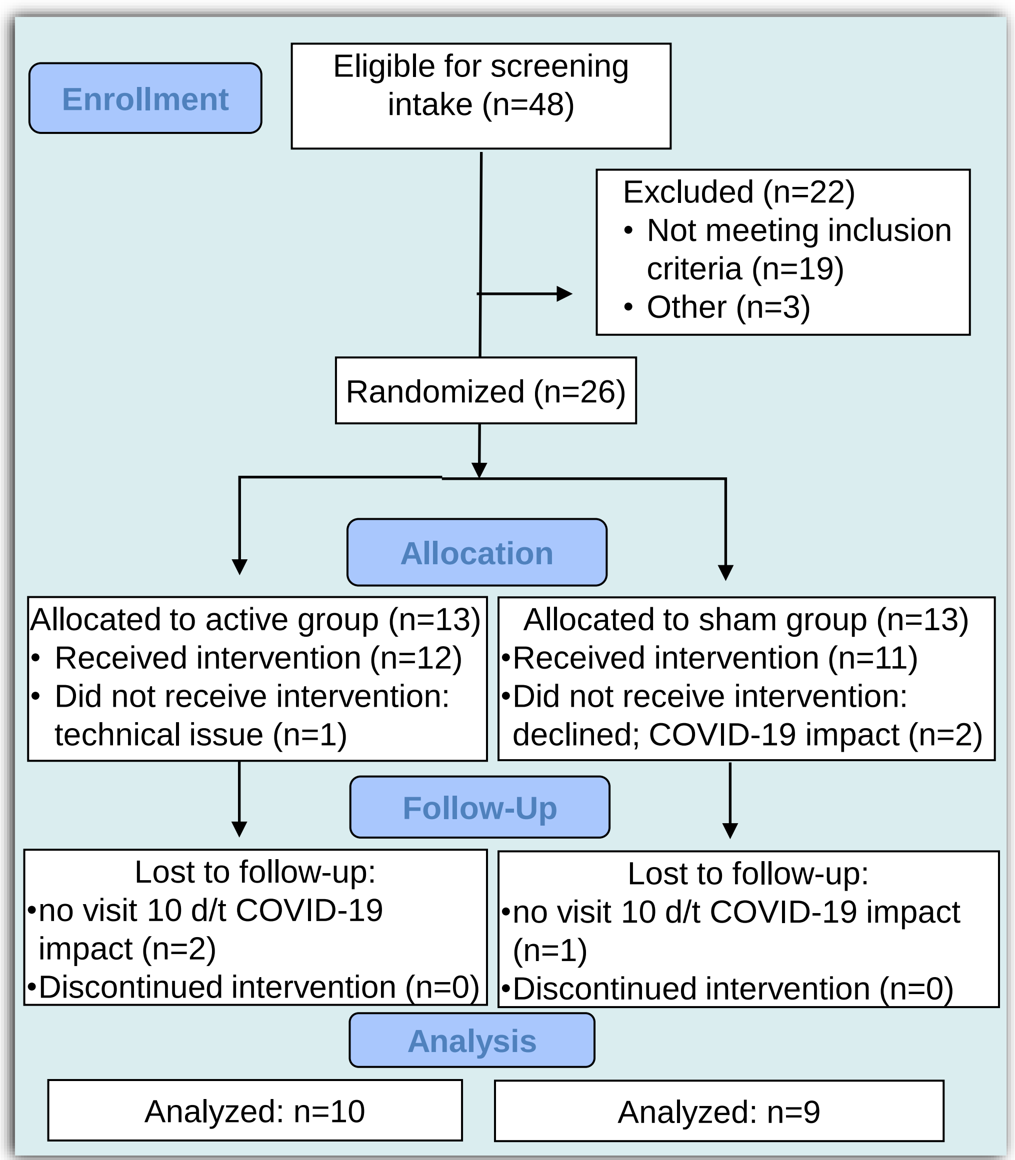

Figure 1. Participant enrollment flowchart.

Baseline characteristics

	active (n=12)	sham (n=10)	
	M *(SD)*		*p*
Age	27.43 *(8.5)*	22.63 *(2.12)*	0.10
%SLD	5.66 *(3.23)*	9.72 *(8.88)*	0.16
SSI-4	23.83 *(7.84)*	27.75 *(7.46)*	0.25
OASES	2.48 *(.61)*	2.53 *(.57)*	0.85
Musical training	19.08 *(13.98)*	18.6 *(11.29)*	0.93
OSPAN	55 *(11.66)*	60.1 *(8.75)*	0.27

Table 1. Participant demographic information. %SLD: percent stuttering-like disfluencies; **SSI-4: Stuttering Severity Instrument 4th edition; OASES: Overall Assessment of the Speaker's Experience Stuttering; OSPAN: operation span (working memory).**

Study Design

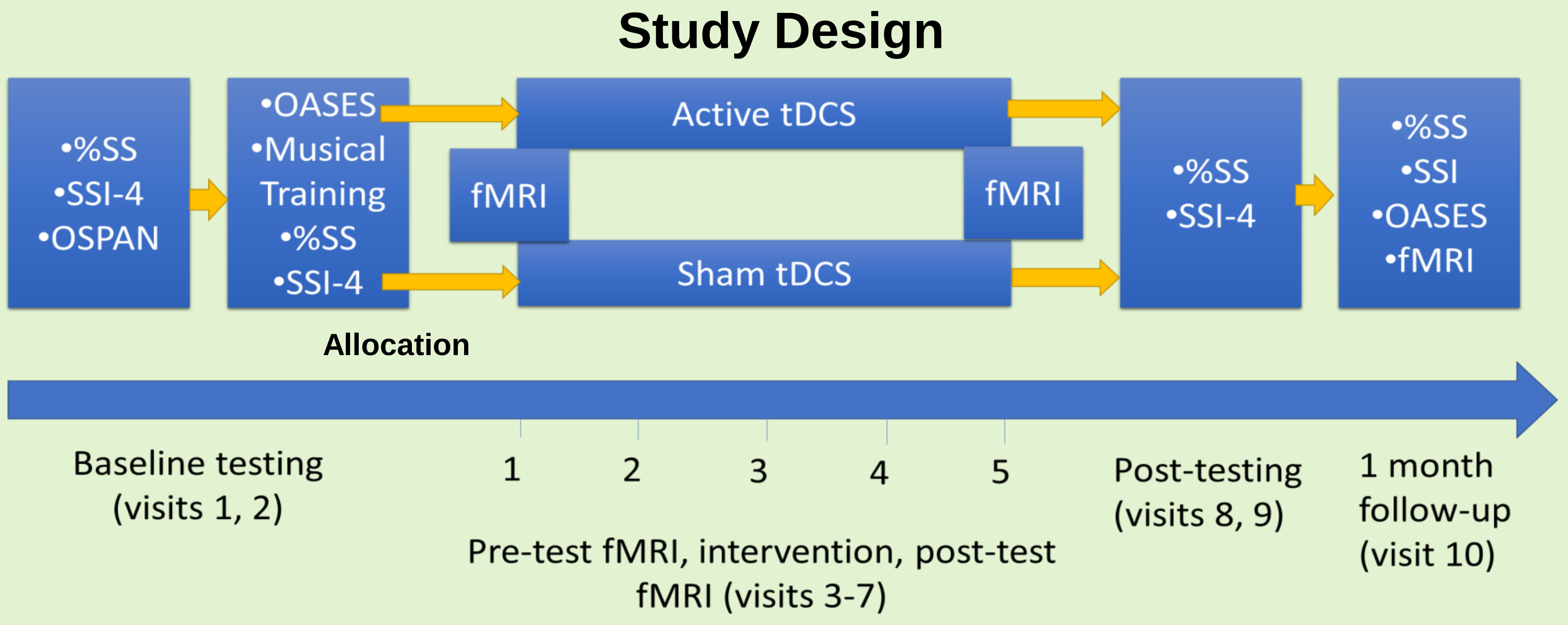

Figure 2. Study design. Following baseline testing, participants are assigned to either active or sham stimulation group via minimization (adaptive randomization). Study procedures/schedule were the same for all participants regardless of group assignment.

fMRI protocol: high resolution anatomical scan, resting state, DTI, and four functional runs during which participants engage in continuous speech. Participants perform 3 speech tasks: 1) read the beginning of a story (short paragraph); 2) continue the story in their own words; 3) recite the alphabet slowly (control task).

tDCS protocol: during stimulation, participants read aloud to the beat of a metronome, with each syllable to a beat. Stimulation was delivered for 20 min at 2mA. Active stimulation: current ramped up over first 30 seconds and continued until ramp down at the end of 20 min. Sham stimulation: current ramped up and back down over 30 sec.

Outcome Measures

Primary outcome measure 1
- Changes in brain activation as assessed by fMRI images

Secondary outcome measure
- Changes from baseline on the Overall Assessment of the Speakers Experience of Stuttering (OASES)

Primary outcome measure 2
- Change in percentage of stuttered syllables produced during speech sample

Other outcome measures
- Changes from baseline on rhythm judgement task
- Changes from baseline on tapping tasks

Figure 3. Outcome measures of the clinical trial (NCT03437512). Of these, the overt speech change measures are reported in this poster.

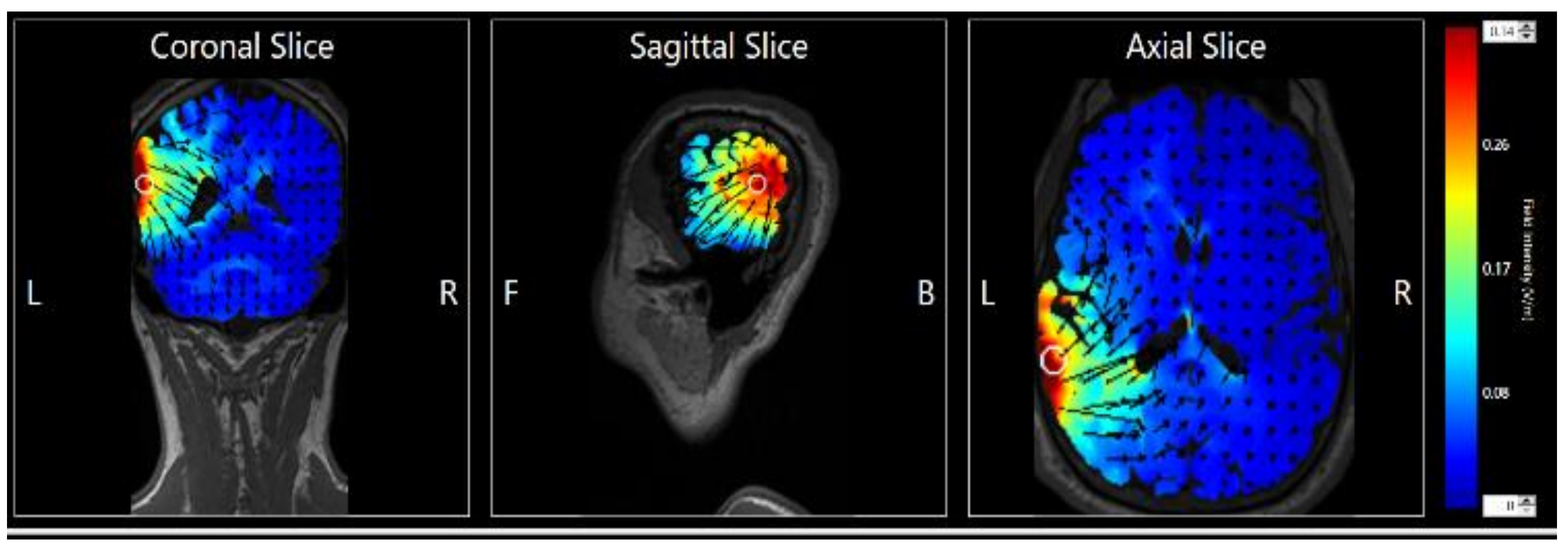

Figure 4. Stimulation location was modeled using computational software (Soterix Medical, Inc.) to maximize stimulation of left pSTG

Preliminary Results

Effect of tDCS on % stuttered syllables for reading (left) and conversation (right) tasks

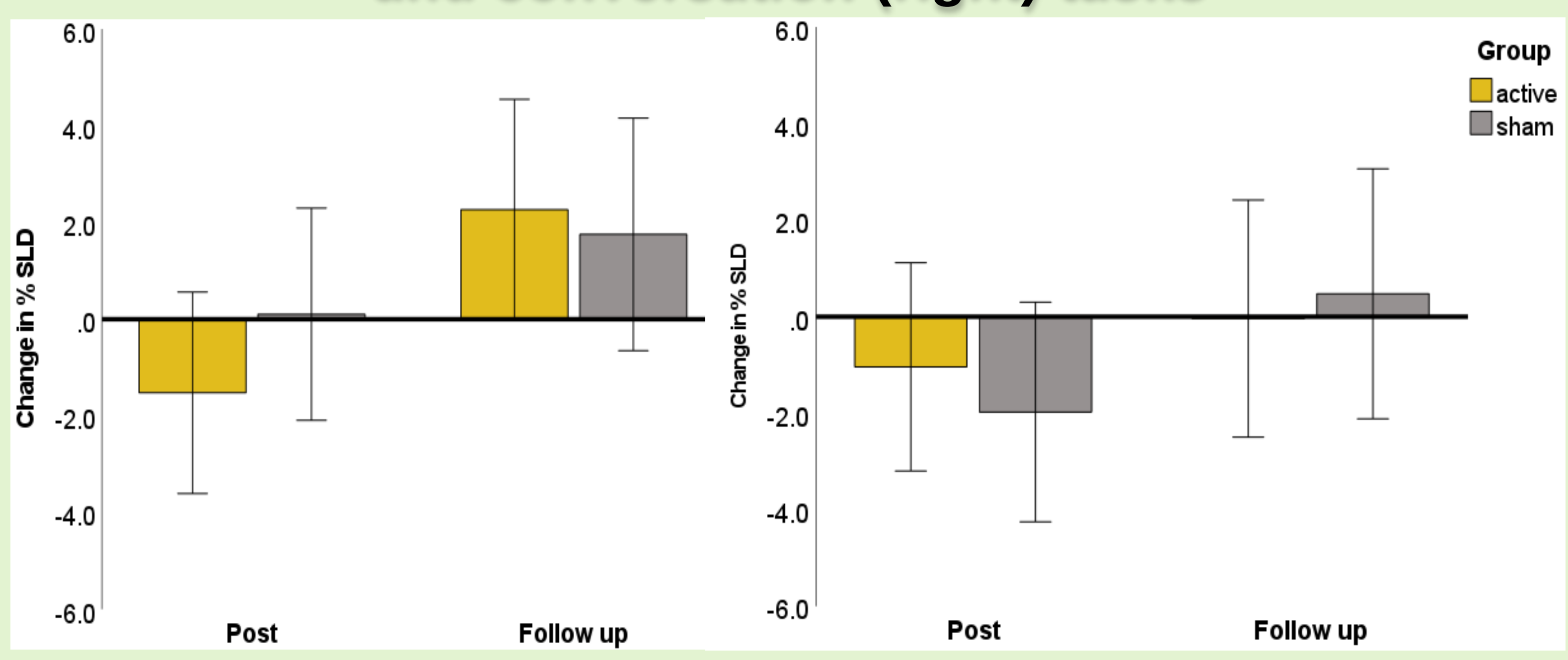

Figure 5. No significant difference between active and sham conditions on % stuttered syllables (p=.936). Change in % stuttered syllables was significantly different between the two post-intervention time points (main effect of time: $F_{(1,17)}$ = 11.215, p = .004) for both groups and a trend for difference between the two speech tasks (main effects of task: $F_{(1,17)}$ = 2.871, p =.108) was found. Analyses conduced with a mixed ANOVA, with a between-subjects factor of group (active, sham) and two within-subjects factors: time (post, follow up) and speech task (reading, conversation).

Effects of HD-tDCS on stuttering severity (SSI-4 score)

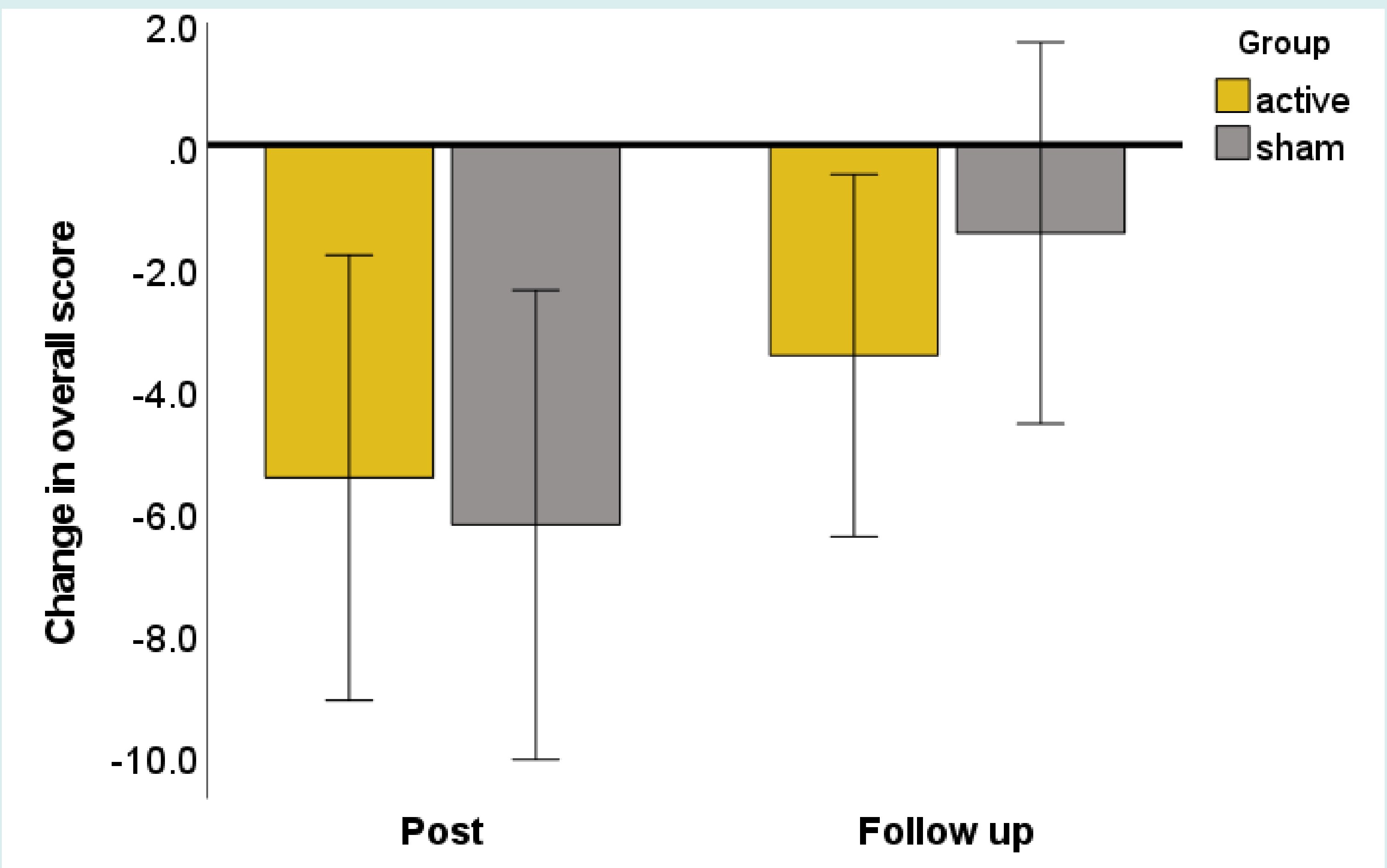

Figure 6. No significant differences between active and sham in stuttering severity as measured with SSI [p = 0.773). Reduction in stuttering severity was significantly larger post intervention compared to follow up, for both groups (significant main effect of time point, $F_{(1,17)}$ = 8.156, p = .011) The interaction between group and time point was not significant $F_{(1,17)}$ = 1.370, p = .258]. Analyses conducted with amixed ANOVA was performed to assess the effect of tDCS on stuttering severity scores with a between-subjects factor of group (active, sham) and a within-subjects factor of time (post, follow up)

Discussion & Future Directions

- HD-tDCS targeting left pSTG did not lead to significant change in stuttering for conversation or reading tasks immediately post stimulation or at follow up visit time points.
- While the current results are preliminary due to incomplete data collection (impact of COVID-19), the findings so far suggest that at least in this small group of subjects, active tDCS targeting left pSTG does not lead to measurable speech fluency changes.
- Overt speech measures have been reported as widely variable within individual speakers who stutter. Thus, tDCS effects may be better captured using performance on the timing tasks, for which data analysis is underway.
- Importantly, analysis of the fMRI data is underway to assess whether any brain activity and/or functional connectivity changes were induced by active HD-tDCS.

Acknowledgements & References

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