Enhancing Speech Performance by Manipulating Language Network Synchronization With tACS: A Potential Treatment for Post-stroke Aphasia

LCNS Laboratory for Cognition and Neural Stimulation

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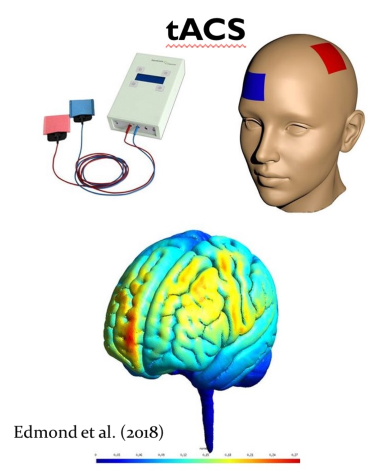
SUMMARY

This study aims to explore the nature of network-level dysfunction in people with aphasia (PWA), particularly relating to spoken-word production, and its possible rehabilitation by transcranial alternating current stimulation (tACS). As we are at the beginning stages of a pilot study, we have worked on troubleshooting devices and testing healthy, neurotypical participants over the summer.

INTRO/BACKGROUND



- Aphasia is the most common cognitive deficit experienced by stroke patients, yet there remain limited sources of treatments that work.
- Aphasia is a language impairment disorder that disrupts a person's ability to produce and/or comprehend language and communicate in general.
  - PWA often report difficulty with retrieving the names of common everyday objects (anomia).
- Past research has shown that NIBS can help improve language performance along with other cognitive processes such as working memory, learning, and cognitive control; however, individuals vary in their response to this treatment approach.[5]
- If anomia can be treated in an aphasic patient, speech and communication, in general, could improve. For this reason, we chose to examine the semantic interference effect (increased noise when mapping from meaning to word representations) and whether such retrieval conflict could be resolved.[1]
- Here, we use tACS, a noninvasive brain stimulation (NIBS) technique that involves running a relatively weak, sinusoidal current through electrodes placed on the scalp, because of its capacity to entrain endogenous cortical oscillations at specific frequency bands, allowing for the enhancement of functional connectivity (FC) in the language network.[4 5]
  - With this entrainment of endogenous oscillations, it becomes possible to modulate specific cognitive processes and improve behavioral performance.
  - To our knowledge, no prior study has examined the potential of tACS to improve language performance in PWA.[3]
- We chose to administer tACS in the alpha frequency band since it's associated with language tasks over the cortex of interest and plays a role in long-range communication between regions in the language network.

HYPOTHESIS/RESEARCH GOALS

- **Main goal:** To investigate whether tACS in the alpha frequency band can enhance language production performance, with the ultimate goal of extending this approach into PWA as a therapeutic tool to facilitate aphasia recovery.
- **We hypothesize** that speech production performance will improve when stimulating the left frontotemporal cortex with alpha tACS due to a decrease in semantic interference. This enhancement of behavioral performance is predicted to occur as a result of enhanced functional connectivity, leading participants to resolve word retrieval competition more efficiently.

METHODOLOGY

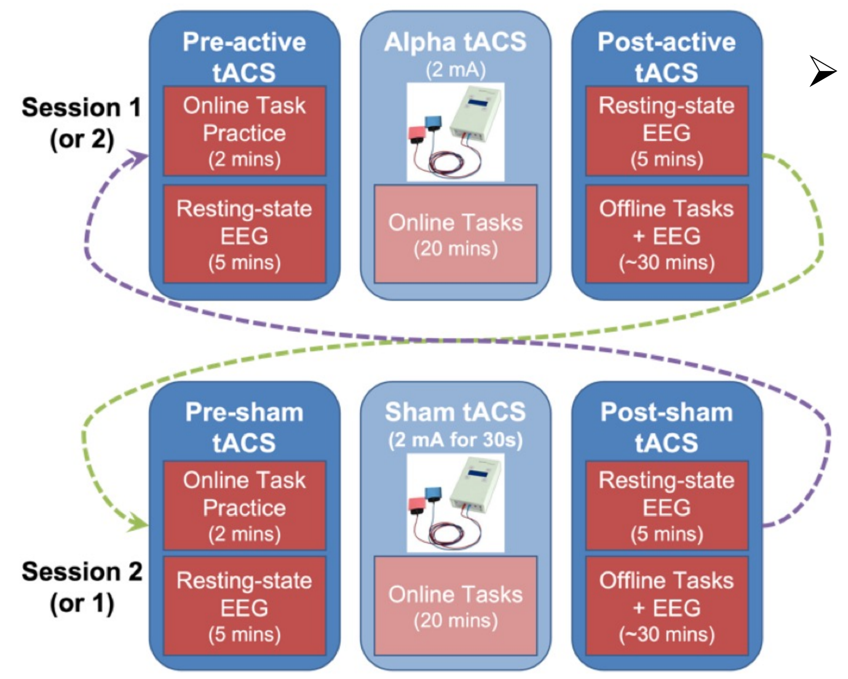


Figure 1. Overview of study design. The order of alpha and sham tACS will be counterbalanced across participants within each group.

- Using a within-subject, double-blind procedure, our study has begun to assess 5 subjects (expected n=25) who have received counterbalanced stimulation (sham/active) over the left frontotemporal cortex for 20 min. Subjects were stimulated over the course of 2 sessions, separated by at least 1 week.

STIMULATION PARAMETERS

- **Wave form:** Sinus
- **Duration:** 20 min
- **Frequency:** alpha frequency (10 Hz)
- **Intensity:** 1.5 mA peak-to-peak

- Participants performed 3 language tasks and one control task (using E-Prime and PsychoPy). Each language task has been shown to engage the left frontotemporal cortex in both neurotypical populations and PWA. For each experimental task, verbal responses and RTs were recorded.

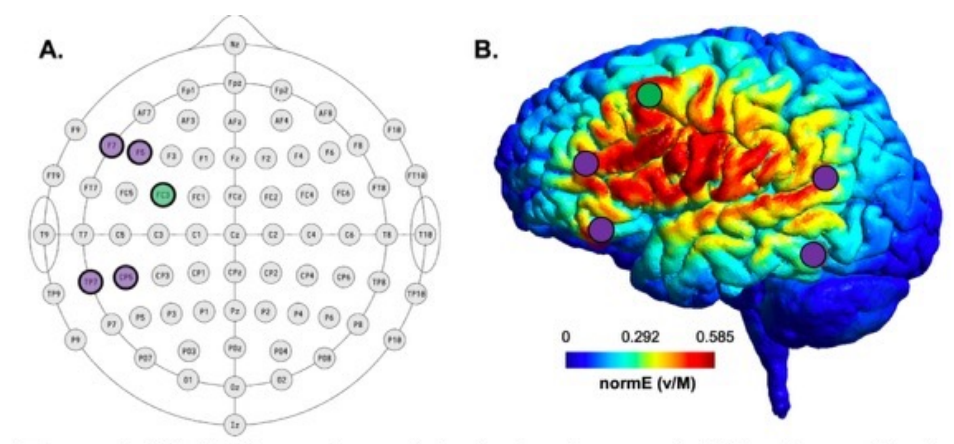
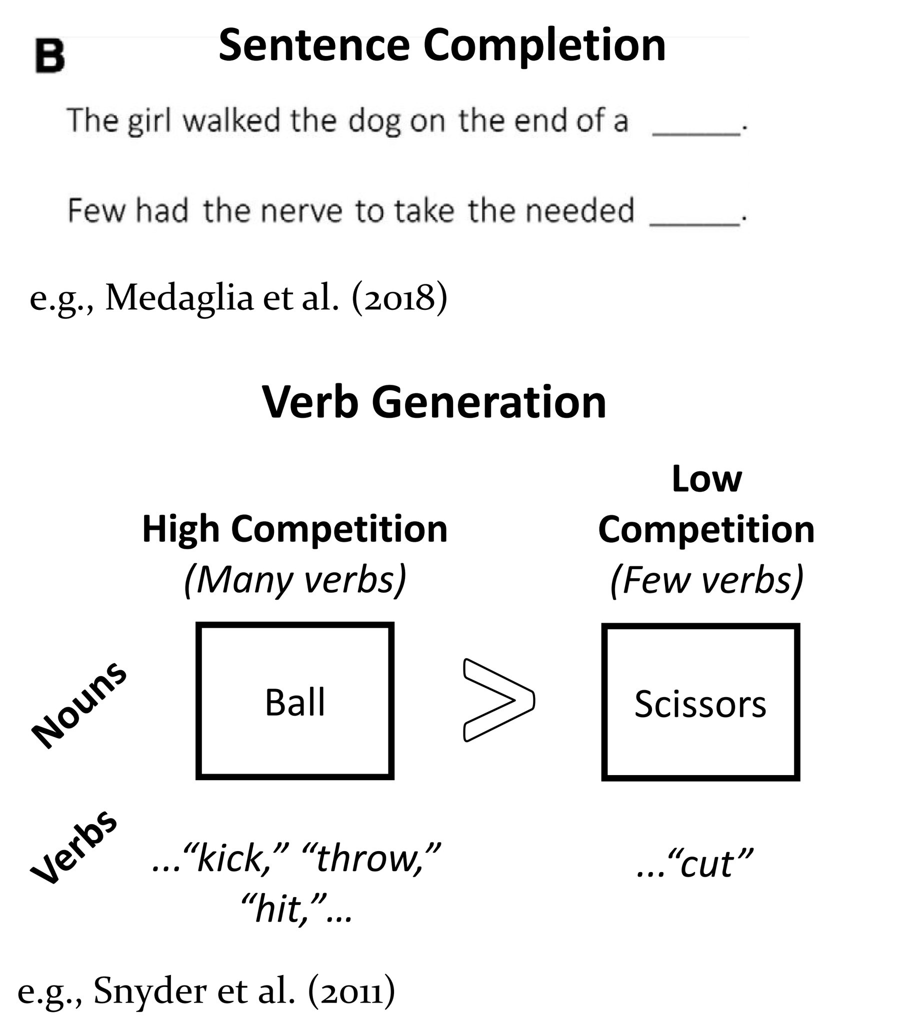
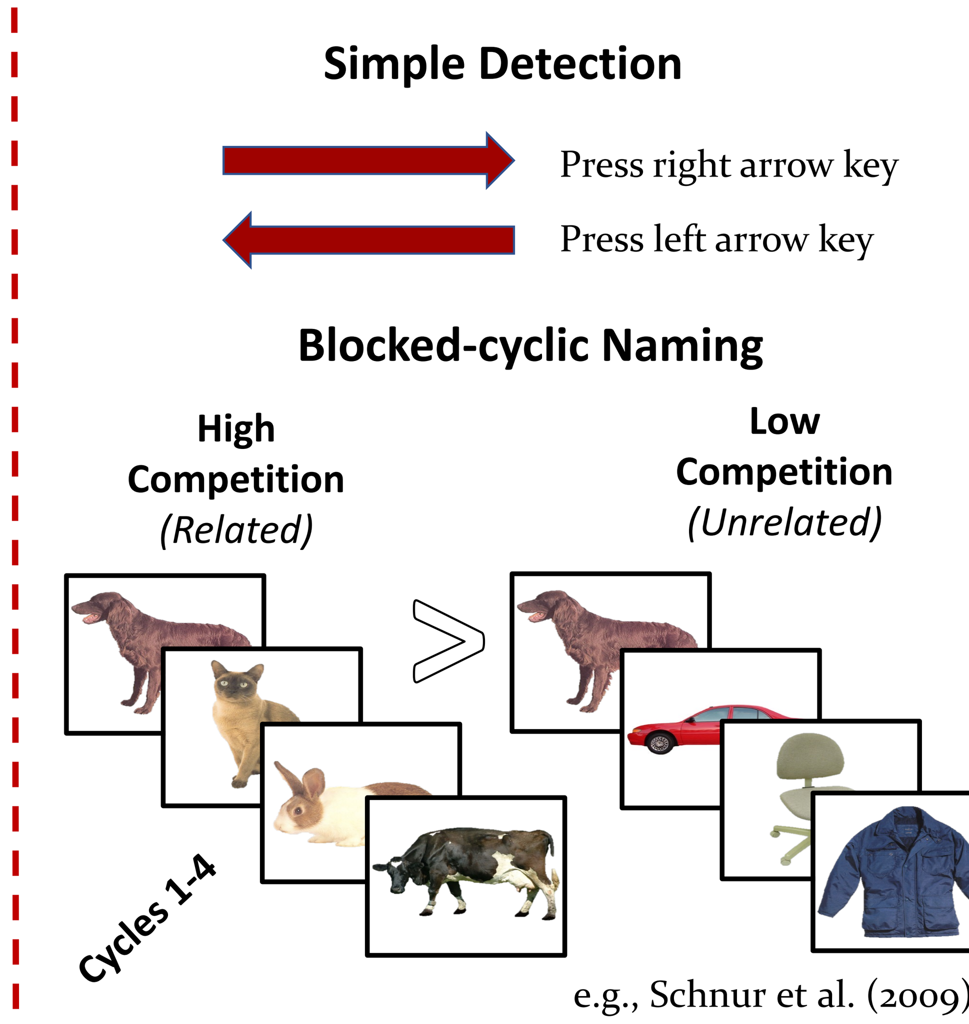


Figure 3. (A) tACS montage of electrode placement; (B) brain model of electrical current intensity of tACS. Anodes (positive polarity) are depicted in purple, whereas the cathode (negative polarity) is depicted in green.

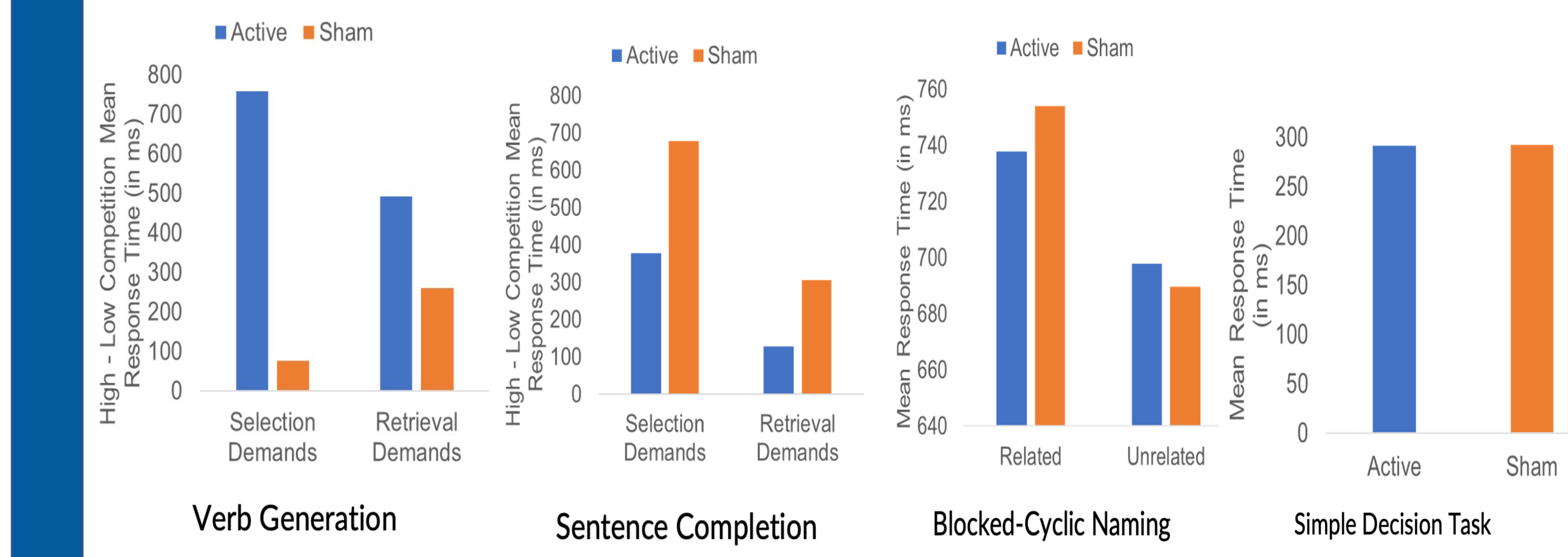
Online Tasks



Offline Tasks



EARLY RESULTS



CONCLUSION/NEXT STEPS

- We plan to continue collecting data throughout the upcoming school year, with a target of 25-30 participants.
- Our primary focus moving forward is resolving issues with our NEURO PRAX EEG device (power spectral analysis and synchronization assessments) to test the effectiveness of tACS in modulating FC and collect individual alpha frequencies for optimized stimulation for each participant.
- We're excited about this novel investigation of tACS in the field and to assess its effectiveness in relation to other NIBS techniques. Not only is this the first study, to our knowledge, to investigate the use of tACS as a clinical treatment for post-stroke aphasia, but it also holds the capability to measure the extent of tACS-induced network modulation and the nature of modulation.

ACKNOWLEDGMENTS

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